Package: bio3d (via r-universe)

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Title Biological Structure Analysis

Version 2.4-5

Author Barry Grant [aut, cre], Xin-Qiu Yao [aut], Lars Skjaerven [aut], Julien Ide [aut]

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LinkingTo Rcpp

Imports Rcpp, parallel, grid, graphics, grDevices, stats, utils

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Depends R (>= 3.1.0)

LazyData yes

Description Utilities to process, organize and explore protein structure, sequence and dynamics data. Features include the ability to read and write structure, sequence and dynamic trajectory data, perform sequence and structure database searches, data summaries, atom selection, alignment, superposition, rigid core identification, clustering, torsion analysis, distance matrix analysis, structure and sequence conservation analysis, normal mode analysis, principal component analysis of heterogeneous structure data, and correlation network analysis from normal mode and molecular dynamics data. In addition, various utility functions are provided to enable the statistical and graphical power of the R environment to work with biological sequence and structural data. Please refer to the URLs below for more information.

Maintainer Barry Grant <bjgrant@ucsd.edu>

License GPL (>= 2)

URL http://thegrantlab.org/bio3d/, https://bitbucket.org/Grantlab/bio3d/

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Contents

bio3d-package . . . 6
aa.index . . . 8
aa.table . . . 9
aa123 . . . 10
aa2index . . . 11
aa2mass . . . 13
aanma . . . 14
aanma.pdbs . . . 17
aln2html . . . 20
angle.xyz . . . 21
as.fasta . . . 22
as.pdb . . . 24
as.select . . . 27
atom.index . . . 28
atom.select . . . 28
atom2ele . . . 32
atom2mass . . . 33
atom2xyz . . . 35
basename.pdb . . . 36
bhattacharyya . . . 37
binding.site . . . 38
biounit . . . 40
blast.pdb . . . 42
bounds . . . 45
bounds.sse . . . 46
bwr.colors . . . 47
cat.pdb . . . 49
chain.pdb . . . 50
check.utility . . . 51
clean.pdb . . . 52
cmap . . . 53
cna . . . 55
cnapath . . . 59
com . . . 62
combine.select . . . 64
community.aln . . . 65
community.tree . . . 67
consensus . . . 69

conserv . . . 71
convert.pdb . . . 72
core.cmap . . . 74
core.find . . . 76
cov.nma . . . 79
covsoverlap . . . 80
dccm . . . 81
dccm.enma . . . 82
dccm.gnm . . . 84
dccm.nma . . . 85
dccm.pca . . . 87
dccm.xyz . . . 88
deformation.nma . . . 91
diag.ind . . . 92
difference.vector . . . 93
dist.xyz . . . 94
dm . . . 96
dssp . . . 98
elements . . . 102
entropy . . . 103
example.data . . . 105
filter.cmap . . . 107
filter.dccm . . . 108
filter.identity . . . 110
filter.rmsd . . . 112
fit.xyz . . . 113
fluct.nma . . . 116
formula2mass . . . 117
gap.inspect . . . 118
geostas . . . 119
get.pdb . . . 124
get.seq . . . 125
gnm . . . 127
hclustplot . . . 129
hmmer . . . 131
identify.cna . . . 134
inner.prod . . . 135
inspect.connectivity . . . 136
is.gap . . . 138
is.mol2 . . . 139
is.pdb . . . 140
is.select . . . 141
is.xyz . . . 142
layout.cna . . . 142
lbio3d . . . 144
load.enmff . . . 144
mask . . . 146
mktrj . . . 148

motif.find . . . 150
mustang . . . 151
network.amendment . . . 153
nma . . . 155
nma.pdb . . . 156
nma.pdbs . . . 160
normalize.vector . . . 163
orient.pdb . . . 164
overlap . . . 165
pairwise . . . 167
pca . . . 168
pca.array . . . 169
pca.pdbs . . . 170
pca.tor . . . 172
pca.xyz . . . 173
pdb.annotate . . . 176
pdb2aln . . . 177
pdb2aln.ind . . . 179
pdb2sse . . . 181
pdbaln . . . 182
pdbfit . . . 184
pdbs2pdb . . . 185
pdbs2sse . . . 187
pdbseq . . . 188
pdbsplit . . . 189
pfam . . . 191
plot.bio3d . . . 193
plot.cmap . . . 196
plot.cna . . . 198
plot.core . . . 200
plot.dccm . . . 202
plot.dmat . . . 205
plot.enma . . . 207
plot.fasta . . . 209
plot.fluct . . . 210
plot.geostas . . . 212
plot.hmmer . . . 214
plot.matrix.loadings . . . 215
plot.nma . . . 216
plot.pca . . . 218
plot.pca.loadings . . . 220
plot.rmsip . . . 221
print.cna . . . 222
print.core . . . 224
print.fasta . . . 225
print.xyz . . . 226
project.pca . . . 227
prune.cna . . . 228

pymol . . . 230
read.all . . . 233
read.cif . . . 235
read.crd . . . 236
read.crd.amber . . . 238
read.crd.charmm . . . 239
read.dcd . . . 240
read.fasta . . . 242
read.fasta.pdb . . . 244
read.mol2 . . . 246
read.ncdf . . . 249
read.pdb . . . 251
read.pdcBD . . . 254
read.pqr . . . 256
read.prmtop . . . 258
rgyr . . . 260
rle2 . . . 262
rmsd . . . 263
rmsf . . . 265
rmsip . . . 266
sdENM . . . 268
seq2aln . . . 269
seqaln . . . 270
seqaln.pair . . . 274
seqbind . . . 275
seqidentity . . . 276
setup.ncore . . . 278
sip . . . 278
sse.bridges . . . 280
store.atom . . . 281
struct.aln . . . 282
torsion.pdb . . . 284
torsion.xyz . . . 286
trim . . . 288
trim.mol2 . . . 290
trim.pdbs . . . 291
trim.xyz . . . 293
unbound . . . 294
uniprot . . . 295
var.xyz . . . 296
vec2resno . . . 297
vmd . . . 298
vmd_colors . . . 300
wrap.tor . . . 301
write.crd . . . 302
write.fasta . . . 303
write.mol2 . . . 305
write.ncdf . . . 306

write.pdb 308
write.pir 310
write.pqr 311

Index **314**

`bio3d-package` *Biological Structure Analysis*

Description

Utilities for the analysis of protein structure and sequence data.

Details

Package:	bio3d
Type:	Package
Version:	2.4-5
Date:	2024-10-25
License:	GPL version 2 or newer
URL:	http://thegrantlab.org/bio3d/

Features include the ability to read and write structure (`read.pdb`, `write.pdb`, `read.fasta.pdb`), sequence (`read.fasta`, `write.fasta`) and dynamics trajectory data (`read.dcd`, `read.ncdf`, `write.ncdf`).

Perform sequence and structure database searches (`blast.pdb`, `hmmer`), atom summaries (`summary.pdb`), atom selection (`atom.select`), alignment (`pdbaln`, `seqaln`, `mustang`) superposition (`rot.lsq`, `fit.xyz`), `pdbfit`), rigid core identification (`core.find`, `plot.core`, `fit.xyz`), dynamic domain analysis (`geostas`), torsion/dihedral analysis (`torsion.pdb`, `torsion.xyz`), clustering (via `hclust`), principal component analysis (`pca.xyz`, `pca.pdbs`, `pca.tor`, `plot.pca`, `plot.pca.loadings`, `mktrj.pca`), dynamical cross-correlation analysis (`dccm`, `plot.dccm`) and correlation network analysis (`cna`, `plot.cna`, `cnapath`) of structure data.

Perform conservation analysis of sequence (`seqaln`, `conserv`, `seqidentity`, `entropy`, `consensus`) and structural (`pdbaln`, `rmsd`, `rmsf`, `core.find`) data.

Perform normal mode analysis (`nma`, `build.hessian`), ensemble normal mode analysis (`nma.pdbs`), mode comparison (`rmsip`) and (`overlap`), atomic fluctuation prediction (`fluct.nma`), cross-correlation analysis (`dccm.nma`), cross-correlation visualization (`pymol.dccm`), deformation analysis (`deformation.nma`), and mode visualization (`pymol.modes`, `mktrj.nma`).

In addition, various utility functions are provided to facilitate manipulation and analysis of biological sequence and structural data (e.g. `get.pdb`, `get.seq`, `aa123`, `aa321`, `pdbseq`, `aln2html`, `atom.select`, `rot.lsq`, `fit.xyz`, `is.gap`, `gap.inspect`, `orient.pdb`, `pairwise`, `plot.bio3d`, `plot.nma`, `plot.blast`, `biounit`, etc.).

Note

The latest version, package vignettes and documentation with worked example outputs can be obtained from the bio3d website:
http://thegrantlab.org/bio3d/.
http://thegrantlab.org/bio3d/reference/.
https://bitbucket.org/Grantlab/bio3d/.

Author(s)

Barry Grant <bjgrant@ucsd.edu> Xin-Qiu Yao <xinqiu.yao@gmail.com> Lars Skjaerven <larsss@gmail.com> Julien Ide <julien.ide.fr@gmail.com>

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2021) *Protein Science* **30**, 20–30.

Examples

```
help(package="bio3d")     # list the functions within the package
#lbio3d()                  # list bio3d function names only

## Or visit:
##   http://thegrantlab.org/bio3d/reference/

## See the individual functions for further documentation and examples, e.g.
#help(read.pdb)

## Or online:
##    http://thegrantlab.org/bio3d/reference/read.pdb.html

## Not run:
##-- See the list of Bio3D demos
demo(package="bio3d")

## Try some out, e.g:
demo(pdb) # PDB Reading, Manipulation, Searching and Alignment
demo(pca) # Principal Component Analysis
demo(md)  # Molecular Dynamics Trajectory Analysis
demo(nma) # Normal Mode Analysis

## See package vignettes and tutorals online:
##   http://thegrantlab.org/bio3d/articles/

## End(Not run)
```

aa.index *AAindex: Amino Acid Index Database*

Description

A collection of published indices, or scales, of numerous physicochemical and biological properties of the 20 standard aminoacids (Release 9.1, August 2006).

Usage

```
data(aa.index)
```

Format

A list of 544 named indeces each with the following components:

1. H, character vector: Accession number.
2. D, character vector: Data description.
3. R, character vector: LITDB entry number.
4. A, character vector: Author(s).
5. T, character vector: Title of the article.
6. J, character vector: Journal reference.
7. C, named numeric vector: Correlation coefficients of similar indeces (with coefficients of 0.8/-0.8 or more/less). The correlation coefficient is calculated with zeros filled for missing values.
8. I, named numeric vector: Amino acid index data.

Source

'AAIndex' was obtained from:
https://www.genome.jp/aaindex/
For a description of the 'AAindex' database see:
https://www.genome.jp/aaindex/aaindex_help.html.

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'AAIndex' is the work of Kanehisa and co-workers:
Kawashima and Kanehisa (2000) *Nucleic Acids Res.* **28**, 374;
Tomii and Kanehisa (1996) *Protein Eng.* **9**, 27–36;
Nakai, Kidera and Kanehisa (1988) *Protein Eng.* **2**, 93–100.

Examples

```
## Load AAindex data
data(aa.index)

## Find all indeces described as "volume"
ind <- which(sapply(aa.index, function(x)
                    length(grep("volume", x$D, ignore.case=TRUE)) != 0))

## find all indeces with author "Kyte"
ind <- which(sapply(aa.index, function(x) length(grep("Kyte", x$A)) != 0))

## examine the index
aa.index[[ind]]$I

## find indeces which correlate with it
all.ind <- names(which(Mod(aa.index[[ind]]$C) >= 0.88))

## examine them all
sapply(all.ind, function (x) aa.index[[x]]$I)
```

`aa.table` *Table of Relevant Amino Acids*

Description

This data set provides the atomic masses of a selection of amino acids regularly occuring in proteins.

Usage

```
aa.table
```

Format

A data frame with the following components.

`aa3` a character vector containing three-letter amino acid code.

`aa1` a character vector containing one-letter amino acid code.

`mass` a numeric vector containing the mass of the respective amino acids.

`formula` a character vector containing the formula of the amino acid in which the mass calculat was based.

`name` a character vector containing the full names of the respective amino acids.

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

aa2mass, aa.index, atom.index, elements,

Examples

```
data(aa.table)
aa.table

## table look up
aa.table["HIS", ]

## read PDB, and fetch residue masses
pdb <- read.pdb(system.file("examples/1hel.pdb", package="bio3d"))
aa2mass(pdb)
```

---

aa123 *Convert Between 1-letter and 3-letter Aminoacid Codes*

Description

Convert between one-letter IUPAC aminoacid codes and three-letter PDB style aminoacid codes.

Usage

```
aa123(aa)
aa321(aa)
```

Arguments

aa	a character vector of individual aminoacid codes.

Details

Standard conversions will map 'A' to 'ALA', 'G' to 'GLY', etc. Non-standard codes in aa will generate a warning and return 'UNK' or 'X'.

Value

A character vector of aminoacid codes.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of IUPAC one-letter codes see:
https://www.insdc.org/documents/feature_table.html#7.4.3

For more information on PDB residue codes see:
http://ligand-expo.rcsb.org/ld-search.html

See Also

read.pdb, read.fasta, pdbseq

Examples

```
# Simple conversion
aa123(c("D","L","A","G","S","H"))
aa321(c("ASP", "LEU", "ALA", "GLY", "SER", "HIS"))

## Not run:
# Extract sequence from a PDB file's ATOM and SEQRES cards
pdb <- read.pdb("1BG2")
s <- aa321(pdb$seqres)                    # SEQRES
a <- aa321(pdb$atom[pdb$calpha,"resid"]) # ATOM

# Write both sequences to a fasta file
write.fasta(alignment=seqbind(s,a), id=c("seqres","atom"), file="eg2.fa")

# Alternative approach for ATOM sequence extraction
pdbseq(pdb)
pdbseq(pdb, aa1=FALSE )

## End(Not run)
```

---

aa2index *Convert an Aminoacid Sequence to AAIndex Values*

Description

Converts sequences to aminoacid indeces from the 'AAindex' database.

Usage

```
aa2index(aa, index = "KYTJ820101", window = 1)
```

Arguments

aa	a protein sequence character vector.
index	an index name or number (default: "KYTJ820101", hydropathy index by Kyte-Doolittle, 1982).
window	a positive numeric value, indicating the window size for smoothing with a sliding window average (default: 1, i.e. no smoothing).

Details

By default, this function simply returns the index values for each amino acid in the sequence. It can also be set to perform a crude sliding window average through the window argument.

Value

Returns a numeric vector.

Author(s)

Ana Rodrigues

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'AAIndex' is the work of Kanehisa and co-workers: Kawashima and Kanehisa (2000) *Nucleic Acids Res.* **28**, 374; Tomii and Kanehisa (1996) *Protein Eng.* **9**, 27–36; Nakai, Kidera and Kanehisa (1988) *Protein Eng.* **2**, 93–100.

For a description of the 'AAindex' database see:
https://www.genome.jp/aaindex/ or the aa.index documentation.

See Also

aa.index, read.fasta

Examples

```
## Residue hydropathy values
seq <- c("R","S","D","X","-","X","R","H","Q","V","L")
aa2index(seq)

## Not run:
## Use a sliding window average
aa2index(aa=seq, index=22, window=3)

## Use an alignment

aln  <- read.fasta(system.file("examples/hivp_xray.fa",package="bio3d"))
prop <- t(apply(aln$ali, 1, aa2index, window=1))

## find and use indices for volume calculations
```

```
i <- which(sapply(aa.index,
       function(x) length(grep("volume", x$D, ignore.case=TRUE)) != 0))
sapply(i, function(x) aa2index(aa=seq, index=x, window=5))

## End(Not run)
```

---

aa2mass *Amino Acid Residues to Mass Converter*

Description

Convert a sequence of amino acid residue names to mass.

Usage

```
aa2mass(pdb, inds=NULL, mass.custom=NULL, addter=TRUE, mmtk=FALSE)
```

Arguments

pdb	a character vector containing the atom names to convert to atomic masses. Alternatively, a object of type pdb can be provided.
inds	atom and xyz coordinate indices obtained from `atom.select` that selects the elements of pdb upon which the calculation should be based.
mass.custom	a list of amino acid residue names and their corresponding masses.
addter	logical, if TRUE terminal atoms are added to final masses.
mmtk	logical, if TRUE use the exact aminoacid residue masses as provided with the MMTK database (for testing purposes).

Details

This function converts amino acid residue names to their corresponding masses. In the case of a non-standard amino acid residue name `mass.custom` can be used to map the residue to the correct mass. User-defined amino acid masses (with argument `mass.custom`) will override mass entries obtained from the database.

See examples for more details.

Value

Returns a numeric vector of masses.

Note

When object of type pdb is provided, non-calpha atom records are omitted from the selection.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

atom.index, atom2mass, aa.index

Examples

```
resi.names <- c("LYS", "ALA", "CYS", "HIS")
masses <- aa2mass(resi.names, addter=FALSE)

## Not run:
## Fetch atomic masses in a PDB object
pdb <- read.pdb("3dnd")
masses <- aa2mass(pdb)

## or
masses <- aa2mass(pdb$atom[1:10,"resid"])

## Dealing with unconventional residues
#pdb <- read.pdb("1xj0")

#mass.cust <- list("CSX"=122.166)
#masses <- aa2mass(pdb, mass.custom=mass.cust)

## End(Not run)
```

---

aanma *All Atom Normal Mode Analysis*

Description

Perform all-atom elastic network model normal modes calculation of a protein structure.

Usage

```
aanma(...)

## S3 method for class 'pdb'
aanma(pdb, pfc.fun = NULL, mass = TRUE, temp = 300,
  keep = NULL, hessian = NULL, outmodes = "calpha", rm.wat = TRUE,
  reduced = FALSE, rtb = FALSE, nmer = 1, ...)

rtb(hessian, pdb, mass = TRUE, nmer = 1, verbose = TRUE)
```

Arguments

...	additional arguments to build.hessian and aa2mass. One useful option here for dealing with unconventional residues is 'mass.custom', see the aa2mass function for details.
pdb	an object of class pdb as obtained from function read.pdb.
pfc.fun	customized pair force constant ('pfc') function. The provided function should take a vector of distances as an argument to return a vector of force constants. If NULL, the default function 'aaenm2' will be employed. (See details below).
mass	logical, if TRUE the Hessian will be mass-weighted.
temp	numerical, temperature for which the amplitudes for scaling the atomic displacement vectors are calculated. Set 'temp=NULL' to avoid scaling.
keep	numerical, final number of modes to be stored. Note that all subsequent analyses are limited to this subset of modes. This option is useful for very large structures and cases where memory may be limited.
hessian	hessian matrix as obtained from build.hessian. For internal purposes and generally not intended for public use.
outmodes	either a character ('calpha' or 'noh') or atom indices as obtained from atom.select specifying the atoms to include in the resulting mode object. (See details below).
rm.wat	logical, if TRUE water molecules will be removed before calculation.
reduced	logical, if TRUE the coarse-grained ('4-bead') ENM will be employed. (See details below).
rtb	logical, if TRUE the rotation-translation block based approximate modes will be calculated. (See details below).
nmer	numerical, defines the number of residues per block (used only when rtb=TRUE).
verbose	logical, if TRUE print detailed processing message

Details

This function builds an elastic network model (ENM) based on all heavy atoms of input pdb, and performs subsequent normal mode analysis (NMA) in various manners. By default, the 'aaenm2' force field (defining of the spring constants between atoms) is used, which was obtained by fitting to a local energy minimum of a crambin model derived from the AMBER99SB force field. It employs a pair force constant function which falls as r^-6, and specific force constants for covalent and intra-residue atom pairs. See also load.enmff for other force field options.

The outmodes argument controls the type of output modes. There are two standard types of output modes: 'noh' and 'calpha'. outmodes='noh' invokes regular all-atom based ENM-NMA. When outmodes='calpha', an effective Hessian with respect to all C-alpha atoms will be first calculated using the same formula as in Hinsen et al. NMA is then performed on this effective C-alpha based Hessian. In addition, users can provide their own atom selection (see atom.select) as the value of outmodes for customized output modes generation.

When reduced=TRUE, only a selection of all heavy atoms is used to build the ENM. More specifically, three to five atoms per residue constitute the model. Here the N, CA, C atoms represent the protein backbone, and zero to two selected side chain atoms represent the side chain (selected based

on side chain size and the distance to CA). This coarse-grained ENM has significantly improved computational efficiency and similar prediction accuracy with respect to the all-atom ENM.

When `rtb=TRUE`, rotation-translation block (RTB) based approximate modes will be calculated. In this method, each residue is assumed to be a rigid body (or 'block') that has only rotational and translational degrees of freedom. Intra-residue deformation is thus ignored. (See Durand et al 1994 and Tama et al. 2000 for more details). N residues per block is also supported, where N=1, 2, 3, etc. (See argument `nmer`). The RTB method has significantly improved computational efficiency and similar prediction accuracy with respect to the all-atom ENM.

By default the function will diagonalize the mass-weighted Hessian matrix. The resulting mode vectors are moreover scaled by the thermal fluctuation amplitudes.

Value

Returns an object of class 'nma' with the following components:

`modes`	numeric matrix with columns containing the normal mode vectors. Mode vectors are converted to unweighted Cartesian coordinates when `mass=TRUE`. Note that the 6 first trivial eigenvectos appear in columns one to six.
`frequencies`	numeric vector containing the vibrational frequencies corresponding to each mode (for `mass=TRUE`).
`force.constants`	numeric vector containing the force constants corresponding to each mode (for `mass=FALSE`)).
`fluctuations`	numeric vector of atomic fluctuations.
`U`	numeric matrix with columns containing the raw eigenvectors. Equals to the `modes` component when `mass=FALSE` and `temp=NULL`.
`L`	numeric vector containing the raw eigenvalues.
`xyz`	numeric matrix of class `xyz` containing the Cartesian coordinates in which the calculation was performed.
`mass`	numeric vector containing the residue masses used for the mass-weighting.
`temp`	numerical, temperature for which the amplitudes for scaling the atomic displacement vectors are calculated.
`triv.modes`	number of trivial modes.
`natoms`	number of C-alpha atoms.
`call`	the matched call.

Author(s)

Lars Skjaerven & Xin-Qiu Yao

References

Hinsen, K. et al. (2000) *Chem. Phys.* **261**, 25. Durand, P. et al. (1994) *Biopolymers* **34**, 759. Tama, F. et al. (2000) *Proteins* **41**, 1.

See Also

nma.pdb for C-alpha based NMA, aanma.pdbs for ensemble all-atom NMA, load.enmff for available ENM force fields, and fluct.nma, mktrj.nma, and dccm.nma for various post-NMA calculations.

Examples

```
## Not run:
   # All-atom NMA takes relatively long time - Don't run by default.

   ## Fetch stucture
   pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

   ## Calculate all-atom normal modes
   modes.aa <- aanma(pdb, outmodes='noh')

   ## Calculate all-atom normal modes with RTB approximation
   modes.aa.rtb <- aanma(pdb, outmodes='noh', rtb=TRUE)

   ## Compare the two modes
   rmsip(modes.aa, modes.aa.rtb)

   ## Calculate C-alpha normal modes.
   modes <- aanma(pdb)

   ## Calculate C-alpha normal modes with reduced ENM.
   modes.cg <- aanma(pdb, reduced=TRUE)

   ## Calculate C-alpha normal modes with RTB approximation
   modes.rtb <- aanma(pdb, rtb=TRUE)

   ## Compare modes
   rmsip(modes, modes.cg)
   rmsip(modes, modes.rtb)

   ## Print modes
   print(modes)

   ## Plot modes
   plot(modes)

   ## Visualize modes
   #m7 <- mktrj.nma(modes, mode=7, file="mode_7.pdb", pdb=pdb)

## End(Not run)
```

---

aanma.pdbs *Ensemble Normal Mode Analysis with All-Atom ENM*

Description

Perform normal mode analysis (NMA) on an ensemble of aligned protein structures using all-atom elastic network model (aaENM).

Usage

```
## S3 method for class 'pdbs'
aanma(pdbs, fit = TRUE, full = FALSE, subspace = NULL,
  rm.gaps = TRUE, ligand = FALSE, outpath = NULL, gc.first = TRUE,
  ncore = NULL, ...)
```

Arguments

pdbs	an 'pdbs' object as obtained from read.all.
fit	logical, if TRUE C-alpha coordinate based superposition is performed prior to normal mode calculations.
full	logical, if TRUE return the complete, full structure, 'nma' objects.
subspace	number of eigenvectors to store for further analysis.
rm.gaps	logical, if TRUE obtain the hessian matrices for only atoms in the aligned positions (non-gap positions in all aligned structures). Thus, gap positions are removed from output.
ligand	logical, if TRUE ligand molecules are also included in the calculation.
outpath	character string specifing the output directory to which the PDB structures should be written.
gc.first	logical, if TRUE will call gc() first before mode calculation for each structure. This is to avoid memory overload when ncore > 1.
ncore	number of CPU cores used to do the calculation.
...	additional arguments to aanma.

Details

This function builds elastic network model (ENM) using all heavy atoms and performs subsequent normal mode analysis (NMA) on a set of aligned protein structures obtained with function read.all. The main purpose is to automate ensemble normal mode analysis using all-atom ENMs.

By default, the effective Hessian for all C-alpha atoms is calculated based on the Hessian built from all heavy atoms (including ligand atoms if ligand=TRUE). Returned values include aligned mode vectors and (when full=TRUE) a list containing the full 'nma' objects one per each structure. When 'rm.gaps=TRUE' the unaligned atoms are ommited from output. With default arguments 'rmsip' provides RMSIP values for all pairwise structures.

When outmodes is provided and is not 'calpha' (e.g. 'noh'. See aanma for more details), the function simply returns a list of 'nma' objects, one per each structure, and no aligned mode vector is returned. In this case, the arguments full, subspace, and rm.gaps are ignored. This is equivalent to a wrapper function repeatedly calling aanma.

Value

Returns a list of 'nma' objects (`outmodes` is provided and is not 'calpha') or an 'enma' object with the following components:

`fluctuations`	a numeric matrix containing aligned atomic fluctuations with one row per input structure.
`rmsip`	a numeric matrix of pair wise RMSIP values (only the ten lowest frequency modes are included in the calculation).
`U.subspace`	a three-dimensional array with aligned eigenvectors (corresponding to the subspace defined by the first N non-trivial eigenvectors ('U') of the 'nma' object).
`L`	numeric matrix containing the raw eigenvalues with one row per input structure.
`full.nma`	a list with a `nma` object for each input structure (available only when `full=TRUE`).

Author(s)

Xin-Qiu Yao & Lars Skjaerven

See Also

For normal mode analysis on single structure PDB: `aanma`

For conventional C-alpha based normal mode analysis: `nma`, `nma.pdbs`.

For the analysis of the resulting 'eNMA' object: `mktrj.enma`, `dccm.enma`, `plot.enma`, `cov.enma`.

Similarity measures: `sip`, `covsoverlap`, `bhattacharyya`, `rmsip`.

Related functionality: `read.all`.

Examples

```
# Needs MUSCLE installed - testing excluded
if(check.utility("muscle")) {

  ## Fetch PDB files and split to chain A only PDB files
  ids <- c("1a70_A", "1czp_A", "1frd_A", "1fxi_A", "1iue_A", "1pfd_A")
  files <- get.pdb(ids, split = TRUE, path = tempdir())

  ## Sequence Alignement
  aln <- pdbaln(files, outfile = tempfile())

  ## Read all pdb coordinates
  pdbs <- read.all(aln)

  ## Normal mode analysis on aligned data
  modes <- aanma(pdbs, rm.gaps=TRUE)

  ## Plot fluctuation data
  plot(modes, pdbs=pdbs)

  ## Cluster on Fluctuation similariy
  sip <- sip(modes)
```

```
  hc <- hclust(dist(sip))
  col <- cutree(hc, k=3)

  ## Plot fluctuation data
  plot(modes, pdbs=pdbs, col=col)

  ## RMSIP is pre-calculated
  heatmap(1-modes$rmsip)

  ## Bhattacharyya coefficient
  bc <- bhattacharyya(modes)
  heatmap(1-bc)

}
```

`aln2html` *Create a HTML Page For a Given Alignment*

Description

Renders a sequence alignment as coloured HTML suitable for viewing with a web browser.

Usage

```
aln2html(aln, file="alignment.html", Entropy=0.5, append=TRUE,
         caption.css="color: gray; font-size: 9pt",
         caption="Produced by <a href=http://thegrantlab.org/bio3d/>Bio3D</a>",
         fontsize="11pt", bgcolor=TRUE, colorscheme="clustal")
```

Arguments

`aln`	an alignment list object with `id` and `ali` components, similar to that generated by `read.fasta`.
`file`	name of output html file.
`Entropy`	conservation 'cuttoff' value below which alignment columns are not coloured.
`append`	logical, if TRUE output will be appended to `file`; otherwise, it will overwrite the contents of `file`.
`caption.css`	a character string of css options for rendering 'caption' text.
`caption`	a character string of text to act as a caption.
`fontsize`	the font size for alignment characters.
`bgcolor`	background colour.
`colorscheme`	conservation colouring scheme, currently only "clustal" is supported with alternative arguments resulting in an entropy shaded alignment.

Value

Called for its effect.

Note

Your web browser should support style sheets.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`read.fasta`, `write.fasta`, `seqaln`

Examples

```
## Not run:
## Read an example alignment
aln <- read.fasta(system.file("examples/hivp_xray.fa",package="bio3d"))

## Produce a HTML file for this alignment
aln2html(aln, append=FALSE, file=file.path("eg.html"))
aln2html(aln, colorscheme="ent", file="eg.html")
## View/open the file in your web browser
#browseURL("eg.html")

## End(Not run)
```

`angle.xyz` *Calculate the Angle Between Three Atoms*

Description

A function for basic bond angle determination.

Usage

```
angle.xyz(xyz, atm.inc = 3)
```

Arguments

`xyz`	a numeric vector of Cartisean coordinates.
`atm.inc`	a numeric value indicating the number of atoms to increment by between successive angle evaluations (see below).

Value

Returns a numeric vector of angles.

Note

With `atm.inc=1`, angles are calculated for each set of three successive atoms contained in `xyz` (i.e. moving along one atom, or three elements of `xyz`, between sucessive evaluations). With `atm.inc=3`, angles are calculated for each set of three successive non-overlapping atoms contained in `xyz` (i.e. moving along three atoms, or nine elements of `xyz`, between sucessive evaluations).

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`torsion.pdb`, `torsion.xyz`, `read.pdb`, `read.dcd`.

Examples

```
## Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Angle between N-CA-C atoms of residue four
inds <- atom.select(pdb, resno=4, elety=c("N","CA","C"))
angle.xyz(pdb$xyz[inds$xyz])

## Basic stats of all N-CA-C bound angles
inds <- atom.select(pdb, elety=c("N","CA","C"))
summary( angle.xyz(pdb$xyz[inds$xyz]) )
#hist( angle.xyz(pdb$xyz[inds$xyz]), xlab="Angle" )
```

---

as.fasta *Alignment to FASTA object*

Description

Convert alignment/sequence in matrix/vector format to FASTA object.

Usage

```
as.fasta(x, id=NULL, ...)
```

Arguments

x	a sequence character matrix/vector (e.g obtained from get.seq or seqbind).
id	a vector of sequence names to serve as sequence identifers. By default the function will use the row names of the alignment if they exists, otherwise ids will be generated.
...	arguments passed to and from functions.

Details

This function provides basic functionality to convert a sequence character matrix/vector to a FASTA object.

Value

Returns a list of class "fasta" with the following components:

ali	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
id	sequence names as identifers.
call	the matched call.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

get.seq, seqaln, seqbind, pdbaln

Examples

```
as.fasta(c("A", "C", "D"))
```

as.pdb *Convert to PDB format*

Description

Convert Tripos Mol2 format, or Amber parameter/topology and coordinate data to PDB format.

Usage

```
as.pdb(...)

## S3 method for class 'mol2'
as.pdb(mol, ...)

## S3 method for class 'prmtop'
as.pdb(prmtop, crd=NULL, inds=NULL, inds.crd=inds, ncore=NULL, ...)

## Default S3 method:
as.pdb(pdb=NULL, xyz=NULL, type=NULL, resno=NULL,
                  resid=NULL, eleno=NULL, elety=NULL, chain=NULL,
                  insert=NULL, alt=NULL, o=NULL, b=NULL, segid=NULL,
                  elesy=NULL, charge=NULL, verbose=TRUE, ...)
```

Arguments

...	arguments passed to and from functions.
mol	a list object of type "mol2" (obtained with read.mol2).
prmtop	a list object of type "prmtop" (obtained with read.prmtop).
crd	a list object of type "crd" (obtained with read.crd.amber).
inds	a list object of type "select" as obtained from atom.select. The indices points to which atoms in the PRMTOP object to convert.
inds.crd	same as the 'inds' argument, but pointing to the atoms in CRD object to convert. By default, this argument equals to 'inds', assuming the same number and sequence of atoms in the PRMTOP and CRD objects.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
pdb	an object of class 'pdb' as obtained from read.pdb.
xyz	a numeric vector/matrix of Cartesian coordinates. If provided, the number of atoms in the new PDB object will be set to ncol(as.xyz(xyz))/3 (see as.xyz). If xyz is not provided the number of atoms will be based on the length of eleno, resno, or resid (in that order).
type	a character vector of record types, i.e. "ATOM" or "HETATM", with length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element character vector can be provided which will be repeated to match the number of atoms.

resno	a numeric vector of residue numbers of length equal to ncol(as.xyz(xyz))/3.
resid	a character vector of residue types/ids of length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element character vector can be provided which will be repeated to match the number of atoms.
eleno	a numeric vector of element/atom numbers of length equal to ncol(as.xyz(xyz))/3.
elety	a character vector of element/atom types of length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element character vector can be provided which will be repeated to match the number of atoms.
chain	a character vector of chain identifiers with length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element character vector can be provided which will be repeated to match the number of atoms.
insert	a character vector of insertion code with length equal to ncol(as.xyz(xyz))/3.
alt	a character vector of alternate record with length equal to ncol(as.xyz(xyz))/3.
o	a numeric vector of occupancy values of length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element numeric vector can be provided which will be repeated for to match the number of atoms.
b	a numeric vector of B-factors of length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element numeric vector can be provided which will be repeated to match the number of atoms.
segid	a character vector of segment id of length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element character vector can be provided which will be repeated to match the number of atoms.
elesy	a character vector of element symbol of length equal to ncol(as.xyz(xyz))/3. Alternatively, a single element character vector can be provided which will be repeated to match the number of atoms.
charge	a numeric vector of atomic charge of length equal to ncol(as.xyz(xyz))/3.
verbose	logical, if TRUE details of the PDB generation process is printed to screen.

Details

This function converts Tripos Mol2 format, Amber formatted parameter/topology (PRMTOP) and coordinate objects, and vector data to a PDB object.

While as.pdb.mol2 and as.pdb.prmtop converts specific objects to a PDB object, as.pdb.default provides basic functionality to convert raw data such as vectors of e.g. residue numbers, residue identifiers, Cartesian coordinates, etc to a PDB object. When pdb is provided the returned PDB object is built from the input object with fields replaced by any input vector arguments. e.g. as.pdb(pdb, xyz=crd) will return the same PDB object, with only the Cartesian coordinates changed to crd.

Value

Returns a list of class "pdb" with the following components:

atom	a data.frame containing all atomic coordinate ATOM data, with a row per ATOM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).

xyz	a numeric matrix of ATOM coordinate data of class xyz.
calpha	logical vector with length equal to nrow(atom) with TRUE values indicating a C-alpha "elety".
call	the matched call.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. https://ambermd.org/FileFormats.php

See Also

read.crd, read.ncdf, atom.select, read.pdb

Examples

```
## Vector(s) to PDB object
pdb <- as.pdb(resno=1:6, elety="CA", resid="ALA", chain="A")
pdb

## Not run:
## Read a PRMTOP file
prmtop <- read.prmtop(system.file("examples/crambin.prmtop", package="bio3d"))

## Read Amber coordinates
crds <- read.crd(system.file("examples/crambin.inpcrd", package="bio3d"))

## Atom selection
ca.inds <- atom.select(prmtop, "calpha")

## Convert to PDB format
pdb <- as.pdb(prmtop, crds, inds=ca.inds)


## Read a single entry MOL2 file
## (returns a single object)
mol <- read.mol2( system.file("examples/aspirin.mol2", package="bio3d") )

## Convert to PDB
pdb <- as.pdb(mol)

## End(Not run)
```

`as.select` *Convert Atomic Indices to a Select Object*

Description

Convert atomic indices to a select object with 'atom' and 'xyz' components.

Usage

```
as.select(x, ...)
```

Arguments

`x`	a numeric vector containing atomic indices to be converted to a 'select' object. Alternatively, a logical vector can be provided.
`...`	arguments passed to and from functions.

Details

Convert atomic indices to a select object with 'atom' and 'xyz' components.

Value

Returns a list of class `"select"` with the following components:

`atom`	a numeric matrix of atomic indices.
`xyz`	a numeric matrix of xyz indices.
`call`	the matched call.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`atom.select`, `read.pdb`

Examples

```
as.select(c(1,2,3))
```

atom.index *Atom Names/Types*

Description

This data set gives for various atom names/types the corresponding atomic symbols.

Usage

```
atom.index
```

Format

A data frame with the following components.

`name` a character vector containing atom names/types.

`symb` a character vector containing atomic symbols.

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`elements`, `atom.index`, `atom2ele`

Examples

```
data(atom.index)
atom.index

# Get the atomic symbol of some atoms
atom.names <- c("CA", "O", "N", "OXT")
atom.index[match(atom.names, atom.index$name), "symb"]
```

atom.select *Atom Selection from PDB and PRMTOP Structure Objects*

Description

Return the 'atom' and 'xyz' coordinate indices of 'pdb' or 'prmtop' structure objects corresponding to the intersection of a hierarchical selection.

Usage

```
atom.select(...)

## S3 method for class 'pdb'
atom.select(pdb, string = NULL,
                          type  = NULL, eleno = NULL, elety = NULL,
                          resid = NULL, chain = NULL, resno = NULL,
                          insert = NULL, segid = NULL,
                          operator = "AND", inverse = FALSE,
                          value = FALSE, verbose=FALSE, ...)
## S3 method for class 'pdbs'
atom.select(pdbs, string = NULL,
                           resno = NULL, chain = NULL, resid = NULL,
                           operator="AND", inverse = FALSE,
                           value = FALSE, verbose=FALSE, ...)
## S3 method for class 'mol2'
atom.select(mol, string=NULL,
                           eleno = NULL, elena = NULL, elety = NULL,
                           resid = NULL, chain = NULL, resno = NULL,
                           statbit = NULL,
      operator = "AND", inverse = FALSE,
                           value = FALSE, verbose=FALSE,  ...)

## S3 method for class 'prmtop'
atom.select(prmtop, ...)

## S3 method for class 'select'
print(x, ...)
```

Arguments

`...`	arguments passed to `atom.select.pdb`, `atom.select.prmtop`, or `print`.
`pdb`	a structure object of class "pdb", obtained from `read.pdb`.
`pdbs`	a numeric matrix of aligned C-alpha xyz Cartesian coordinates as obtained with `read.fasta.pdb` or `pdbaln`.
`string`	a single selection keyword from `calpha` `cbeta` `backbone` `sidechain` `protein` `nucleic` `ligand` `water` `h` or `noh`.
`type`	a single element character vector for selecting 'ATOM' or 'HETATM' record types.
`eleno`	a numeric vector of element numbers.
`elena`	a character vector of atom names.
`elety`	a character vector of atom names.
`resid`	a character vector of residue name identifiers.
`chain`	a character vector of chain identifiers.
`resno`	a numeric vector of residue numbers.

insert	a character vector of insert identifiers. Non-insert residues can be selected with NA or '' values. The default value of NULL will select both insert and non-insert residues.
segid	a character vector of segment identifiers. Empty segid values can be selected with NA or '' values. The default value of NULL will select both empty and non-empty segment identifiers.
operator	a single element character specifying either the AND or OR operator by which individual selection components should be combined. Allowed values are '"AND"' and '"OR"'.
verbose	logical, if TRUE details of the selection are printed.
inverse	logical, if TRUE the inversed selection is retured (i.e. all atoms NOT in the selection).
value	logical, if FALSE, vectors containing the (integer) indices of the matches determined by atom.select are returned, and if TRUE, a pdb object containing the matching atoms themselves is returned.
mol	a structure object of class "mol2", obtained from read.mol2.
statbit	a character vector of statbit identifiers.
prmtop	a structure object of class "prmtop", obtained from read.prmtop.
x	a atom.select object as obtained from atom.select.

Details

This function allows for the selection of atom and coordinate data corresponding to the intersection of various input criteria.

Input selection criteria include selection string keywords (such as "calpha", "backbone", "sidechain", "protein", "nucleic", "ligand", etc.) and individual named selection components (including 'chain', 'resno', 'resid', 'elety' etc.).

For example, atom.select(pdb, "calpha") will return indices for all C-alpha (CA) atoms found in protein residues in the pdb object, atom.select(pdb, "backbone") will return indices for all protein N,CA,C,O atoms, and atom.select(pdb, "cbeta") for all protein N,CA,C,O,CB atoms.

Note that keyword string shortcuts can be combined with individual selection components, e.g. atom.select(pdb, "protein", chain="A") will select all protein atoms found in chain A.

Selection criteria are combined according to the provided operator argument. The default operator AND (or &) will combine by intersection while OR (or |) will take the union.

For example, atom.select(pdb, "protein", elety=c("N", "CA", "C"), resno=65:103) will select the N, CA, C atoms in the protein residues 65 through 103, while atom.select(pdb, "protein", resid="ATP", operator="OR") will select all protein atoms as well as any ATP residue(s).

Other string shortcuts include: "calpha", "back", "backbone", "cbeta", "protein", "notprotein", "ligand", "water", "notwater", "h", "noh", "nucleic", and "notnucleic".

In addition, the combine.select function can further combine atom selections using 'AND', 'OR', or 'NOT' logical operations.

Value

Returns a list of class "select" with the following components:

atom	a numeric matrix of atomic indices.
xyz	a numeric matrix of xyz indices.
call	the matched call.

Note

Protein atoms are defined as any atom in a residue matching the residue name in the attached aa.table data frame. See aa.table$aa3 for a complete list of residue names.

Nucleic atoms are defined as all atoms found in residues with names A, U, G, C, T, I, DA, DU, DG, DC, DT, or DI.

Water atoms/residues are defined as those with residue names H2O, OH2, HOH, HHO, OHH, SOL, WAT, TIP, TIP, TIP3, or TIP4.

Author(s)

Barry Grant, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, as.select, combine.select, trim.pdb, write.pdb, read.prmtop, read.crd, read.dcd, read.ncdf.

Examples

```
##- PDB example
# Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

# Select protein atoms of chain A
atom.select(pdb, "protein", chain="A")

# Select all atoms except from the protein
atom.select(pdb, "protein", inverse=TRUE, verbose=TRUE)

# Select all C-alpha atoms with residues numbers between 43 and 54
sele <- atom.select(pdb, "calpha", resno=43:54, verbose=TRUE)

# Access the PDB data with the selection indices
print( pdb$atom[ sele$atom, "resid" ] )
print( pdb$xyz[ sele$xyz ] )

# Trim PDB to selection
ca.pdb <- trim.pdb(pdb, sele)
```

```
## Not run:

##- PRMTOP example
prmtop <- read.prmtop(system.file("examples/crambin.prmtop", package="bio3d"))

## Atom selection
ca.inds <- atom.select(prmtop, "calpha")


## End(Not run)
```

`atom2ele` *Atom Names/Types to Atomic Symbols Converter*

Description

Convert atom names/types into atomic symbols

Usage

```
atom2ele(...)

## Default S3 method:
atom2ele(x, elety.custom=NULL, rescue=TRUE, ...)

## S3 method for class 'pdb'
atom2ele(pdb, inds=NULL, ...)
```

Arguments

`x`	a character vector containing atom names/types to be converted.
`elety.custom`	a customized data.frame containing atom names/types and corresponding atomic symbols.
`rescue`	logical, if TRUE the atomic symbols will be converted based on matching with `bio3d::elements$symb`.
`pdb`	an object of class 'pdb' for which `elety` will be converted.
`inds`	an object of class 'select' indicating a subset of the pdb object to be used (see `atom.select` and `trim.pdb`).
`...`	further arguments passed to or from other methods.

Details

The default method searchs for the atom names/types in the `atom.index` data set and returns their corresponding atomic symbols. If `elety.custom` is specified it is combined with `atom.index` (using `rbind`) before searching. Therefore, `elety.custom` must contains columns named `name` and `symb`.

The S3 method for object of class 'pdb', pass `pdb$atom[,"elety"]` to the default method.

Value

Return a character vector of atomic symbols

Author(s)

Julien Ide, Lars Skjaerven

See Also

atom.index, elements, read.pdb, atom2mass, formula2mass

Examples

```
atom.names <- c("CA", "O", "N", "OXT")
atom2ele(atom.names)


# PDB server connection required - testing excluded
try({

## Get atomic symbols from a PDB object with a customized data set
pdb <- read.pdb("3RE0",verbose=FALSE)
lig <- trim(pdb, "ligand")

## maps PT1 to Pt, CL2 to Cl, C4A to C
atom2ele(lig)

## map atom name to element manually
myelety <- data.frame(name = "CL2", symb = "Cl")
atom2ele(lig, elety.custom = myelety)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

atom2mass *Atom Names/Types to Mass Converter*

Description

Convert atom names/types into atomic masses.

Usage

```
atom2mass(...)
## Default S3 method:
atom2mass(x, mass.custom=NULL, elety.custom=NULL,
                              grpby=NULL, rescue=TRUE, ...)
## S3 method for class 'pdb'
atom2mass(pdb, inds=NULL, mass.custom=NULL,
                         elety.custom=NULL, grpby=NULL, rescue=TRUE, ...)
```

Arguments

x	a character vector containing atom names/types to be converted.
mass.custom	a customized data.frame containing atomic symbols and corresponding masses.
elety.custom	a customized data.frame containing atom names/types and corresponding atomic symbols.
grpby	a 'factor', as returned by as.factor, used to group the atoms.
rescue	logical, if TRUE the atomic symbols will be mapped to the first character of the atom names/types.
pdb	an object of class 'pdb' for which elety will be converted.
inds	an object of class 'select' indicating a subset of the pdb object to be used (see atom.select and trim.pdb).
...	.

Details

The default method first convert atom names/types into atomic symbols using the atom2ele function. Then, atomic symbols are searched in the elements data set and their corresponding masses are returned. If mass.custom is specified it is combined with elements (using rbind) before searching. Therefore, mass.custom must have columns named symb and mass (see examples). If grpby is specified masses are splitted (using split) to compute the mass of groups of atoms defined by grpby.

The S3 method for object of class 'pdb', pass pdb$atom$elety to the default method.

Value

Return a numeric vector of masses.

Author(s)

Julien Ide, Lars Skjaerven

See Also

elements, atom.index, atom2ele, read.pdb

Examples

```
atom.names <- c("CA", "O", "N", "OXT")
atom2mass(atom.names)


# PDB server connection required - testing excluded
try({

## Get atomic symbols from a PDB object with a customized data set
pdb <- read.pdb("3RE0", verbose=FALSE)
inds <- atom.select(pdb, resno=201, verbose=FALSE)

## selected atoms
print(pdb$atom$elety[inds$atom])

## default will map CL2 to C
atom2mass(pdb, inds)

## map element CL2 correctly to Cl
myelety  <- data.frame(name = c("CL2","PT1","N1","N2"), symb = c("Cl","Pt","N","N"))
atom2mass(pdb, inds, elety.custom = myelety)

## custom masses
mymasses <- data.frame(symb = c("Cl","Pt"), mass = c(35.45, 195.08))
atom2mass(pdb, inds, elety.custom = myelety, mass.custom = mymasses)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

`atom2xyz` *Convert Between Atom and xyz Indices*

Description

Basic functions to convert between xyz and their corresponding atom indices.

Usage

```
atom2xyz(num)
xyz2atom(xyz.ind)
```

Arguments

`num`	a numeric vector of atom indices.
`xyz.ind`	a numeric vector of xyz indices.

Value

A numeric vector of either xyz or atom indices.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

atom.select, read.pdb

Examples

```
xyz.ind <- atom2xyz(c(1,10,15))
xyz2atom( xyz.ind )
```

---

basename.pdb *Manipulate PDB File Names*

Description

Removes all of the path up to and including the last path separator (if any) and the final '.pdb' extension.

Usage

```
basename.pdb(x, mk4 = FALSE, ext=".pdb")
```

Arguments

x	character vector of PDB file names, containing path and extensions.
mk4	logical, if TRUE the output will be truncated to the first 4 characters of the basename. This is frequently convenient for matching RCSB PDB identifier conventions (see examples below).
ext	character, specifying the file extension, e.g. '.pdb' or '.mol2'.

Details

This is a simple utility function for the common task of PDB file name manipulation. It is used internally in several bio3d functions and van be thought of as basename for PDB files.

Value

A character vector of the same length as the input 'x'.

Paths not containing any separators are taken to be in the current directory.

If an element of input is 'x' is 'NA', so is the result.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

basename, dirname

Examples

```
basename.pdb("/somedir/somewhere/1bg2_myfile.pdb")
basename.pdb("/somedir/somewhere/1bg2_myfile.pdb", TRUE)
```

---

bhattacharyya *Bhattacharyya Coefficient*

Description

Calculate the Bhattacharyya Coefficient as a similarity between two modes objects.

Usage

```
bhattacharyya(...)

## S3 method for class 'enma'
bhattacharyya(enma, covs=NULL, ncore=NULL, ...)

## S3 method for class 'array'
bhattacharyya(covs, ncore=NULL, ...)

## S3 method for class 'matrix'
bhattacharyya(a, b, q=90, n=NULL, ...)

## S3 method for class 'nma'
bhattacharyya(...)

## S3 method for class 'pca'
bhattacharyya(...)
```

Arguments

enma	an object of class "enma" obtained from function nma.pdbs.
covs	an array of covariance matrices of equal dimensions.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
a	covariance matrix to be compared with b.
b	covariance matrix to be compared with a.
q	a numeric value (in percent) determining the number of modes to be compared.
n	the number of modes to be compared.
...	arguments passed to associated functions.

Details

Bhattacharyya coefficient provides a means to compare two covariance matrices derived from NMA or an ensemble of conformers (e.g. simulation or X-ray conformers).

Value

Returns the similarity coefficient(s).

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Fuglebakk, E. et al. (2013) *JCTC* **9**, 5618–5628.

See Also

Other similarity measures: sip, covsoverlap, rmsip.

---

binding.site *Binding Site Residues*

Description

Determines the interacting residues between two PDB entities.

Usage

```
binding.site(a, b=NULL, a.inds=NULL, b.inds=NULL, cutoff=5,
             hydrogens=TRUE, byres=TRUE, verbose=FALSE)
```

Arguments

a	an object of class pdb as obtained from function read.pdb.
b	an object of class pdb as obtained from function read.pdb.
a.inds	atom and xyz coordinate indices obtained from atom.select that selects the elements of a upon which the calculation should be based.
b.inds	atom and xyz coordinate indices obtained from atom.select that selects the elements of b upon which the calculation should be based.
cutoff	distance cutoff
hydrogens	logical, if FALSE hydrogen atoms are omitted from the calculation.
byres	logical, if TRUE all atoms in a contacting residue is returned.
verbose	logical, if TRUE details of the selection are printed.

Details

This function reports the residues of a closer than a cutoff to b. This is a wrapper function calling the underlying function dist.xyz.

If b=NULL then b.inds should be elements of a upon which the calculation is based (typically chain A and B of the same PDB file).

If b=a.inds=b.inds=NULL the function will use atom.select with arguments "protein" and "ligand" to determine receptor and ligand, respectively.

Value

Returns a list with the following components:

inds	object of class select with atom and xyz components.
inds$atom	atom indices of a.
inds$xyz	xyz indices of a.
resnames	a character vector of interacting residues.
resno	a numeric vector of interacting residues numbers.
chain	a character vector of the associated chain identifiers of "resno".
call	the matched call.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, atom.select, dm

Examples

```
# PDB server connection required - testing excluded
try({

pdb <- read.pdb('3dnd')

## automatically identify 'protein' and 'ligand'
bs <- binding.site(pdb)

bs$resnames
#pdb$atom[bs$inds$atom, ]

# provide indices
rec.inds <- atom.select(pdb, chain="A", resno=1:350)
lig.inds <- atom.select(pdb, chain="A", resno=351)
bs <- binding.site(pdb, a.inds=rec.inds, b.inds=lig.inds)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}



## Not run:
  # Interaction between peptide and protein
  rec.inds <- atom.select(pdb, chain='A', resno=c(1:350))
  lig.inds <- atom.select(pdb, chain='I', resno=c(5:24))
  bs <- binding.site(pdb, a.inds=rec.inds, b.inds=lig.inds)

## End(Not run)


 # Redundant testing excluded
 try({

  # Interaction between two PDB entities
  #rec <- read.pdb("receptor.pdb")
  #lig <- read.pdb("ligand.pdb")
  rec <- trim.pdb(pdb, inds=rec.inds)
  lig <- trim.pdb(pdb, inds=lig.inds)
  bs <- binding.site(rec, lig, hydrogens=FALSE)

  }, silent=TRUE)
```

---

biounit *Biological Units Construction*

Description

Construct biological assemblies/units based on a 'pdb' object.

Usage

```
biounit(pdb, biomat = NULL, multi = FALSE, ncore = NULL)
```

Arguments

pdb	an object of class pdb as obtained from function read.pdb.
biomat	a list object as returned by read.pdb (pdb$remark$biomat), containing matrices for symmetry operation on individual chains to build biological units. It will override the matrices stored in pdb.
multi	logical, if TRUE the biological unit is returned as a 'multi-model' pdb object with each symmetric copy a distinct structural 'MODEL'. Otherwise, all copies are represented as separated chains.
ncore	number of CPU cores used to do the calculation. By default (ncore=NULL), use all available CPU cores.

Details

A valid structural/simulation study should be performed on the biological unit of a protein system. For example, the alpha2-beta2 tetramer form of hemoglobin. However, canonical PDB files usually contain the asymmetric unit of the crystal cell, which can be:

1. One biological unit
2. A portion of a biological unit
3. Multiple biological units

The function performs symmetry operations to the coordinates based on the transformation matrices stored in a 'pdb' object returned by read.pdb, and returns biological units stored as a list of pdb objects.

Value

a list of pdb objects with each representing an individual biological unit.

Author(s)

Xin-Qiu Yao

See Also

read.pdb

Examples

```
# PDB server connection required - testing excluded
try({

pdb <- read.pdb("2dn1")
biounit <- biounit(pdb)
pdb
biounit

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}

## Not run:
   biounit <- biounit(read.pdb("2bfu"), multi=TRUE)
   write.pdb(biounit[[1]], file="biounit.pdb")
   # open the pdb file in VMD to have a look on the biological unit

## End(Not run)
```

`blast.pdb` *NCBI BLAST Sequence Search and Summary Plot of Hit Statistics*

Description

Run NCBI blastp, on a given sequence, against the PDB, NR and swissprot sequence databases. Produce plots that facilitate hit selection from the match statistics of a BLAST result.

Usage

```
blast.pdb(seq, database = "pdb", time.out = NULL, chain.single=TRUE)

get.blast(urlget, time.out = NULL, chain.single=TRUE)

## S3 method for class 'blast'
plot(x, cutoff = NULL, cut.seed=NULL, cluster=TRUE, mar=c(2, 5, 1, 1), cex=1.5, ...)
```

Arguments

`seq`	a single element or multi-element character vector containing the query sequence. Alternatively a 'fasta' object from function `get.seq` or 'pdb' object from function `read.pdb` can be provided.
`database`	a single element character vector specifying the database against which to search. Current options are 'pdb', 'nr' and 'swissprot'.
`time.out`	integer specifying the number of seconds to wait for the blast reply before a time out occurs.

urlget	the URL to retrieve BLAST results; Usually it is returned by blast.pdb if time.out is set and met.
chain.single	logical, if TRUE double NCBI character PDB database chain identifiers are simplified to lowercase '1WF4_GG' > '1WF4_g'. If FALSE no conversion to match RCSB PDB files is performed.
x	BLAST results as obtained from the function blast.pdb.
cutoff	A numeric cutoff value, in terms of minus the log of the evalue, for returned hits. If null then the function will try to find a suitable cutoff near 'cut.seed' which can be used as an initial guide (see below).
cut.seed	A numeric seed cutoff value, used for initial cutoff estimation. If null then a seed position is set to the point of largest drop-off in normalized scores (i.e. the biggest jump in E-values).
cluster	Logical, if TRUE (and 'cutoff' is null) a clustering of normalized scores is performed to partition hits in groups by similarity to query. If FALSE the partition point is set to the point of largest drop-off in normalized scores.
mar	A numerical vector of the form c(bottom, left, top, right) which gives the number of lines of margin to be specified on the four sides of the plot.
cex	a numerical single element vector giving the amount by which plot labels should be magnified relative to the default.
...	extra plotting arguments.

Details

The blast.pdb function employs direct HTTP-encoded requests to the NCBI web server to run BLASTP, the protein search algorithm of the BLAST software package.

BLAST, currently the most popular pairwise sequence comparison algorithm for database searching, performs gapped local alignments via a heuristic strategy: it identifies short nearly exact matches or hits, bidirectionally extends non-overlapping hits resulting in ungapped extended hits or high-scoring segment pairs(HSPs), and finally extends the highest scoring HSP in both directions via a gapped alignment (Altschul et al., 1997)

For each pairwise alignment BLAST reports the raw score, bitscore and an E-value that assess the statistical significance of the raw score. Note that unlike the raw score E-values are normalized with respect to both the substitution matrix and the query and database lengths.

Here we also return a corrected normalized score (mlog.evalue) that in our experience is easier to handle and store than conventional E-values. In practice, this score is equivalent to minus the natural log of the E-value. Note that, unlike the raw score, this score is independent of the substitution matrix and and the query and database lengths, and thus is comparable between BLASTP searches.

Examining plots of BLAST alignment lengths, scores, E-values and normalized scores (-log(E-Value) from the blast.pdb function can aid in the identification sensible hit similarity thresholds. This is facilitated by the plot.blast function.

If a 'cutoff' value is not supplied then a basic hierarchical clustering of normalized scores is performed with initial group partitioning implemented at a hopefully sensible point in the vicinity of 'h=cut.seed'. Inspection of the resultant plot can then be use to refine the value of 'cut.seed' or indeed 'cutoff'. As the 'cutoff' value can vary depending on the desired application and indeed the properties of the system under study it is envisaged that 'plot.blast' will be called multiple times to aid selection of a suitable 'cutoff' value. See the examples below for further details.

Value

The function `blast.pdb` returns a list with three components, `hit.tbl`, `raw`, and `url`. The function `plot.blast` produces a plot on the active graphics device and returns a list object with four components, `hits`, `pdb.id`, `acc`, and `inds`. See below:

`hit.tbl` a data frame summarizing BLAST results for each reported hit. It contains following major columns:

- 'bitscore', a numeric vector containing the raw score for each alignment.
- 'evalue', a numeric vector containing the E-value of the raw score for each alignment.
- 'mlog.evalue', a numeric vector containing minus the natural log of the E-value.
- 'acc', a character vector containing the accession database identifier of each hit.
- 'pdb.id', a character vector containing the PDB database identifier of each hit.

`raw` a data frame containing the raw BLAST output. Note multiple hits may appear in the same row.

`url` a single element character vector with the NCBI result URL and RID code. This can be passed to the get.blast function.

`hits` an ordered matrix detailing the subset of hits with a normalized score above the chosen cutoff. Database identifiers are listed along with their cluster group number.

`pdb.id` a character vector containing the PDB database identifier of each hit above the chosen threshold.

`acc` a character vector containing the accession database identifier of each hit above the chosen threshold.

`inds` a numeric vector containing the indices of the hits relative to the input blast object.

Note

Online access is required to query NCBI blast services.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'BLAST' is the work of Altschul et al.: Altschul, S.F. et al. (1990) *J. Mol. Biol.* **215**, 403–410.

Full details of the 'BLAST' algorithm, along with download and installation instructions can be obtained from:
https://www.ncbi.nlm.nih.gov/BLAST/.

See Also

plot.blast, hmmer, seqaln, get.pdb

Examples

```
## Not run:
pdb <- read.pdb("4q21")
blast <- blast.pdb( pdbseq(pdb) )

head(blast$hit.tbl)
top.hits <- plot(blast)
head(top.hits$hits)

## Use 'get.blast()' to retrieve results at a later time.
#x <- get.blast(blast$url)
#head(x$hit.tbl)

# Examine and download 'best' hits
top.hits <- plot.blast(blast, cutoff=188)
head(top.hits$hits)
#get.pdb(top.hits)

## End(Not run)
```

---

bounds *Bounds of a Numeric Vector*

Description

Find the 'bounds' (i.e. start, end and length) of consecutive numbers within a larger set of numbers in a given vector.

Usage

```
bounds(nums, dup.inds=FALSE, pre.sort=TRUE)
```

Arguments

nums	a numeric vector.
dup.inds	logical, if TRUE the bounds of consecutive duplicated elements are returned.
pre.sort	logical, if TRUE the input vector is ordered prior to bounds determination.

Details

This is a simple utility function useful for summarizing the contents of a numeric vector. For example: find the start position, end position and lengths of secondary structure elements given a vector of residue numbers obtained from a DSSP secondary structure prediction.

By setting 'dup.inds' to TRUE then the indices of the first (start) and last (end) duplicated elements of the vector are returned. For example: find the indices of atoms belonging to a particular residue given a vector of residue numbers (see below).

Value

Returns a three column matrix listing starts, ends and lengths.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Examples

```
test <- c(seq(1,5,1),8,seq(10,15,1))
bounds(test)

test <- rep(c(1,2,4), times=c(2,3,4))
bounds(test, dup.ind=TRUE)
```

`bounds.sse` *Obtain A SSE Object From An SSE Sequence Vector*

Description

Inverse process of the funciton `pdb2sse`.

Usage

```
bounds.sse(x, pdb = NULL)
```

Arguments

x	a character vector indicating SSE for each amino acid residue.
pdb	an object of class pdb as obtained from function `read.pdb`. Can be ignored if x has 'names' attribute for residue labels.

Details

call for its effects.

Value

a 'sse' object.

Note

In both `$helix` and `$sheet`, an additional `$id` component is added to indicate the original numbering of the sse. This is particularly useful in e.g. `trim.pdb()` function.

Author(s)

Xin-Qiu Yao & Barry Grant

See Also

pdb2sse

Examples

```
# PDB server connection required - testing excluded
try({

pdb <- read.pdb("1a7l")
sse <- pdb2sse(pdb)
sse.ind <- bounds.sse(sse)
sse.ind

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

`bwr.colors` *Color Palettes*

Description

Create a vector of 'n' "contiguous" colors forming either a Blue-White-Red or a White-Gray-Black color palette.

Usage

```
bwr.colors(n)
mono.colors(n)
```

Arguments

`n`	the number of colors in the palette (>=1).

Details

The function bwr.colors returns a vector of n color names that range from blue through white to red.

The function mono.colors returns color names ranging from white to black. Note: the first element of the returned vector will be NA.

Value

Returns a character vector, cv, of color names. This can be used either to create a user-defined color palette for subsequent graphics with palette(cv), or as a col= specification in graphics functions and par.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

The bwr.colors function is derived from the gplots package function colorpanel by Gregory R. Warnes.

See Also

vmd_colors, cm.colors, colors, palette, hsv, rgb, gray, col2rgb

Examples

```
# Redundant testing excluded

# Color a distance matrix
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
d <- dm(pdb,"calpha")

plot(d, color.palette=bwr.colors)

plot(d,
     resnum.1 = pdb$atom[pdb$calpha,"resno"],
     color.palette = mono.colors,
     xlab="Residue Number", ylab="Residue Number")
```

cat.pdb *Concatenate Multiple PDB Objects*

Description

Produce a new concatenated PDB object from two or more smaller PDB objects.

Usage

```
cat.pdb(..., renumber=FALSE, rechain=TRUE)
```

Arguments

...	two or more PDB structure objects obtained from read.pdb.
renumber	logical, if 'TRUE' residues will be renumbered.
rechain	logical, if 'TRUE' molecules will be assigned new chain identifiers.

Details

This is a basic utility function for creating a concatenated PDB object based on multipe smaller PDB objects.

Value

Returns an object of class "pdb". See read.pdb for further details.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, atom.select, write.pdb, trim.pdb

Examples

```
## Not run:
## Read a PDB file from the RCSB online database
pdb1 <- read.pdb("1etl")
pdb2 <- read.pdb("1hel")

## Concat
new.pdb <- cat.pdb(pdb1, pdb2, pdb1, rechain=TRUE, renumber=TRUE)
```

```
## Write to file
write.pdb(new.pdb, file="concat.pdb")

## End(Not run)
```

`chain.pdb` *Find Possible PDB Chain Breaks*

Description

Find possible chain breaks based on connective Calpha or peptide bond (C-N) atom separation.

Usage

```
chain.pdb(pdb, ca.dist = 4, bond=TRUE, bond.dist=1.5, blank = "X", rtn.vec = TRUE)
```

Arguments

`pdb`	a PDB structure object obtained from `read.pdb`.
`ca.dist`	the maximum distance that separates Calpha atoms considered to be in the same chain.
`bond`	logical, if TRUE inspect peptide bond (C-N) instead of Calpha-Calpha distances whenever possible.
`bond.dist`	cutoff value for C-N distance separation.
`blank`	a character to assign non-protein atoms.
`rtn.vec`	logical, if TRUE then the one-letter chain vector consisting of the 26 upper-case letters of the Roman alphabet is returned.

Details

This is a basic function for finding possible chain breaks in PDB structure files, i.e. connective Calpha atoms that are further than `ca.dist` apart or peptide bond (C-N) atoms separated by at least `bond.dist`.

Value

Prints basic chain information and if `rtn.vec` is TRUE returns a character vector of chain ids consisting of the 26 upper-case letters of the Roman alphabet plus possible `blank` entries for non-protein atoms.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, atom.select, trim.pdb, write.pdb

Examples

```
# PDB server connection required - testing excluded
try({

full.pdb <- read.pdb( get.pdb("5p21", URLonly=TRUE) )
inds <- atom.select(full.pdb, resno=c(10:20,30:33))
cut.pdb <- trim.pdb(full.pdb, inds)
chain.pdb(cut.pdb)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

check.utility *Check on Missing Utility Programs*

Description

Internally used in examples, tests, or vignettes.

Usage

```
check.utility(x = c("muscle", "clustalo", "dssp", "stride",
              "mustang", "makeup"), quiet = TRUE)
```

Arguments

x	Names of one or more utility programs to check.
quiet	logical, if TRUE no warning or message printed.

Details

Check if requested utility programs are availabe or not.

Value

logical, TRUE if programs are available and FALSE if any one of them is missing.

Examples

```
check.utility(c("muscle", "dssp"), quiet=FALSE)
if(!check.utility("mustang"))
   cat(" The utility program, MUSTANG, is missing on your system\n")
```

clean.pdb *Inspect And Clean Up A PDB Object*

Description

Inspect alternative coordinates, chain breaks, bad residue numbering, non-standard/unknow amino acids, etc. Return a 'clean' pdb object with fixed residue numbering and optionally relabeled chain IDs, corrected amino acid names, removed water, ligand, or hydrogen atoms. All changes are recorded in a log in the returned object.

Usage

```
clean.pdb(pdb, consecutive = TRUE, force.renumber = FALSE,
  fix.chain = FALSE, fix.aa = FALSE, rm.wat = FALSE, rm.lig = FALSE,
  rm.h = FALSE, verbose = FALSE)
```

Arguments

pdb	an object of class pdb as obtained from function read.pdb.
consecutive	logical, if TRUE renumbering will result in consecutive residue numbers spanning all chains. Otherwise new residue numbers will begin at 1 for each chain.
force.renumber	logical, if TRUE atom and residue records are renumbered even if no 'insert' code is found in the pdb object.
fix.chain	logical, if TRUE chains are relabeled based on chain breaks detected.
fix.aa	logical, if TRUE non-standard amino acid names are converted into equivalent standard names.
rm.wat	logical, if TRUE water atoms are removed.
rm.lig	logical, if TRUE ligand atoms are removed.
rm.h	logical, if TRUE hydrogen atoms are removed.
verbose	logical, if TRUE details of the conversion process are printed.

Details

call for its effects.

Value

a 'pdb' object with an additional $log component storing all the processing messages.

Author(s)

Xin-Qiu Yao & Barry Grant

See Also

read.pdb

Examples

```
# PDB server connection required - testing excluded
try({

pdb <- read.pdb("1a7l")
clean.pdb(pdb)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

cmap *Contact Map*

Description

Construct a Contact Map for Given Protein Structure(s).

Usage

```
cmap(...)

## Default S3 method:
cmap(...)

## S3 method for class 'xyz'
cmap(xyz, grpby = NULL, dcut = 4, scut = 3, pcut=1, binary=TRUE,
        mask.lower = TRUE, collapse=TRUE, gc.first=FALSE, ncore=1, nseg.scale=1, ...)

## S3 method for class 'pdb'
cmap(pdb, inds = NULL, verbose = FALSE, ...)

## S3 method for class 'pdbs'
cmap(pdbs, rm.gaps=FALSE, all.atom=FALSE, ...)
```

Arguments

xyz	numeric vector of xyz coordinates or a numeric matrix of coordinates with a row per structure/frame.
grpby	a vector counting connective duplicated elements that indicate the elements of xyz that should be considered as a group (e.g. atoms from a particular residue).
dcut	a cutoff distance value below which atoms are considered in contact.
scut	a cutoff neighbour value which has the effect of excluding atoms that are sequentially within this value.

pcut	a cutoff probability of structures/frames showing a contact, above which atoms are considered in contact with respect to the ensemble. Ignored if binary=FALSE.
binary	logical, if FALSE the raw matrix containing fraction of frames that two residues are in contact is returned.
mask.lower	logical, if TRUE the lower matrix elements (i.e. those below the diagonal) are returned as NA.
collapse	logical, if FALSE an array of contact maps for all frames is returned.
gc.first	logical, if TRUE will call gc() first before calculation of distance matrix. This is to solve the memory overload problem when ncore > 1 and xyz has many rows, with a bit sacrifice on speed.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
nseg.scale	split input data into specified number of segments prior to running multiple core calculation. See fit.xyz.
pdb	a structure object of class "pdb", obtained from read.pdb.
inds	a list object of ATOM and XYZ indices as obtained from atom.select.
verbose	logical, if TRUE details of the selection are printed.
pdbs	a 'pdbs' object as returned by read.fasta.pdb, read.all, or pdbaln.
rm.gaps	logical, if TRUE gapped positions are removed in the returned value.
all.atom	logical, if TRUE all-atom coordinates from read.all are used.
...	arguments passed to and from functions.

Details

A contact map is a simplified distance matrix. See the distance matrix function dm for further details.

Function "cmap.pdb" is a wrapper for "cmap.xyz" which selects all 'notwater' atoms and calculates the contact matrix grouped by residue number.

Value

Returns a N by N numeric matrix composed of zeros and ones, where one indicates a contact between selected atoms.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

dm, dccm, dist, dist.xyz

Examples

```
##- Read PDB file
pdb <- read.pdb( system.file("examples/hivp.pdb", package="bio3d") )

## Atom Selection indices
inds <- atom.select(pdb, "calpha")

## Reference contact map
ref.cont <- cmap( pdb$xyz[inds$xyz], dcut=6, scut=3 )
plot.cmap(ref.cont)

## Not run:
##- Read Traj file
trj <- read.dcd( system.file("examples/hivp.dcd", package="bio3d") )
## For each frame of trajectory
sum.cont <- NULL
for(i in 1:nrow(trj)) {

  ## Contact map for frame 'i'
  cont <- cmap(trj[i,inds$xyz], dcut=6, scut=3)

  ## Product with reference
  prod.cont <- ref.cont * cont
  sum.cont <- c(sum.cont, sum(prod.cont,na.rm=TRUE))
}

plot(sum.cont, typ="l")

## End(Not run)
```

---

cna *Protein Dynamic Correlation Network Construction and Community Analysis.*

Description

This function builds both residue-based and community-based undirected weighted network graphs from an input correlation matrix, as obtained from the functions 'dccm', 'dccm.nma', and 'dccm.enma'. Community detection/clustering is performed on the initial residue based network to determine the community organization and network structure of the community based network.

Usage

```
  cna(cij, ...)
  ## S3 method for class 'dccm'
cna(cij, cutoff.cij=0.4, cm=NULL,  vnames=colnames(cij),
      cluster.method="btwn", collapse.method="max",
      cols=vmd_colors(), minus.log=TRUE, ...)
  ## S3 method for class 'ensmb'
cna(cij, ..., ncore = NULL)
```

Arguments

cij	A numeric array with 2 dimensions (nXn) containing atomic correlation values, where "n" is the residue number. The matrix elements should be in between 0 and 1 (atomic correlations). Can be also a set of correlation matrices for ensemble network analysis. See 'dccm' function in bio3d package for further details.
...	Additional arguments passed to the methods cna.dccm and cna.ensmb.
cutoff.cij	Numeric element specifying the cutoff on cij matrix values. Coupling below cutoff.cij are set to 0.
cm	(optinal) A numeric array with 2 dimensions (nXn) containing binary contact values, where "n" is the residue number. The matrix elements should be 1 if two residues are in contact and 0 if not in contact. See the 'cmap' function in bio3d package for further details.
vnames	A vector of names for each column in the input cij. This will be used for referencing residues in a similar way to residue numbers in later analysis.
cluster.method	A character string specifying the method for community determination. Supported methods are: btwn="Girvan-Newman betweenness" walk="Random walk" greed="Greedy algorithm for modularity optimization" infomap="Infomap algorithm for community detection"
collapse.method	A single element character vector specifing the 'cij' collapse method, can be one of 'max', 'median', 'mean', or 'trimmed'. By defualt the 'max' method is used to collapse the input residue based 'cij' matrix into a smaller community based network by taking the maximium 'abs(cij)' value between communities as the comunity-to-community cij value for clustered network construction.
cols	A vector of colors assigned to network nodes.
minus.log	Logical, indicating whether '-log(abs(cij))' values should be used for network construction.
ncore	Number of CPU cores used to do the calculation. By default, use all available cores.

Details

The input to this function should be a correlation matrix as obtained from the 'dccm', 'dccm.mean' or 'dccm.nma' and related functions. Optionally, a contact map 'cm' may also given as input to filter the correlation matrix resulting in the exclusion of network edges between non-contacting atom pairs (as defined in the contact map).

Internally this function calls the igraph package functions 'graph.adjacency', 'edge.betweenness.community', 'walktrap.community', 'fastgreedy.community', and 'infomap.community'. The first constructs an undirected weighted network graph. The second performs Girvan-Newman style clustering by calculating the edge betweenness of the graph, removing the edge with the highest edge betweenness score, calculates modularity (i.e. the difference between the current graph partition and the partition of a random graph, see Newman and Girvan, Physical Review E (2004), Vol 69, 026113), then

recalculating edge betweenness of the edges and again removing the one with the highest score, etc. The returned community partition is the one with the highest overall modularity value. 'walktrap.community' implements the Pons and Latapy algorithm based on the idea that random walks on a graph tend to get "trapped" into densely connected parts of it, i.e. a community. The random walk process is used to determine a distance between nodes. Nodes with low distance values are joined in the same community. 'fastgreedy.community' instead determines the community structure based on the optimization of the modularity. In the starting state each node is isolated and belongs to a separated community. Communities are then joined together (according to the network edges) in pairs and the modularity is calculated. At each step the join resulting in the highest increase of modularity is chosen. This process is repeated until a single community is obtained, then the partitioning with the highest modularity score is selected. 'infomap.community' finds community structure that minimizes the expected description length of a random walker trajectory.

Value

Returns a list object that includes igraph network and community objects with the following components:

`network`	An igraph residue-wise graph object. See below for more details.
`communities`	An igraph residue-wise community object. See below for more details.
`communitiy.network`	An igraph community-wise graph object. See below for more details.
`community.cij`	Numeric square matrix containing the absolute values of the atomic correlation input matrix for each community as obtained from 'cij' via application of 'collapse.method'.
`cij`	Numeric square matrix containing the absolute values of the atomic correlation input matrix.

If an ensemble of correlation matrices is provided, a list of 'cna' object, of the 'ecna' class, will be returned.

Author(s)

Guido Scarabelli and Barry Grant

See Also

`plot.cna`, `summary.cna`, `vmd.cna`, `graph.adjacency`, `edge.betweenness.community`, `walktrap.community`, `fastgreedy.community`, `infomap.community`

Examples

```
# PDB server connection required - testing excluded

if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

try({
```

```
##-- Build a correlation network from NMA results
## Read example PDB
pdb <- read.pdb("4Q21")

## Perform NMA
modes <- nma(pdb)
#plot(modes, sse=pdb)

## Calculate correlations
cij <- dccm(modes)
#plot(cij, sse=pdb)

## Build, and betweenness cluster, a network graph
net <- cna(cij, cutoff.cij=0.35)
#plot(net, pdb)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}

## within VMD set 'coloring method' to 'Chain' and 'Drawing method' to Tube
#vmd.cna(net, trim.pdb(pdb, atom.select(pdb,"calpha")), launch=TRUE )

##-- Build a correlation network from MD results
## Read example trajectory file
trtfile <- system.file("examples/hivp.dcd", package="bio3d")
trj <- read.dcd(trtfile)

## Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

## select residues 24 to 27 and 85 to 90 in both chains
inds <- atom.select(pdb, resno=c(24:27,85:90), elety='CA')

## lsq fit of trj on pdb
xyz <- fit.xyz(pdb$xyz, trj, fixed.inds=inds$xyz, mobile.inds=inds$xyz)

## calculate dynamical cross-correlation matrix
cij <- dccm(xyz)

## Build, and betweenness cluster, a network graph
net <- cna(cij)

# Plot coarse grained network based on dynamically coupled communities
xy <- plot.cna(net)
plot.dccm(cij, margin.segments=net$communities$membership)


##-- Begin to examine network structure - see CNA vignette for more details
net
summary(net)
```

```
attributes(net)
table( net$communities$members )

}
```

---

cnapath *Suboptimal Path Analysis for Correlation Networks*

Description

Find k shortest paths between a pair of nodes, source and sink, in a correlation network.

Usage

```
cnapath(cna, from, to=NULL, k=10, collapse=TRUE, ncore=NULL, ...)
## S3 method for class 'cnapath'
summary(object, ..., pdb = NULL, label = NULL, col = NULL,
   plot = FALSE, concise = FALSE, cutoff = 0.1, normalize = TRUE, weight = FALSE)
## S3 method for class 'cnapath'
print(x, ...)
## S3 method for class 'cnapath'
plot(x, ...)
## S3 method for class 'ecnapath'
plot(x, ...)
```

Arguments

cna	A 'cna' object or a list of 'cna' objects obtained from cna.
from	Integer vector or matrix indicating node id(s) of source. If is matrix and to is NULL, the first column represents source and the second sink.
to	Integer vector indicating node id(s) of sink. All combinations of from and to values will be used as source/sink pairs.
k	Integer, number of suboptimal paths to identify.
collapse	Logical, if TRUE results from all source/sink pairs are merged with a single 'cnapath' object returned.
ncore	Number of CPU cores used to do the calculation. By default (NULL), use all detected CPU cores.
object	A 'cnapath' class of object obtained from cnapath. Multiple 'object' input is allowed for comparing paths from different networks.
pdb	A 'pdb' class of object obtained from read.pdb and is used as the reference for node residue ids (in summary.cnapath) or for molecular visulaization with VMD (in vmd.cnapath).
label	Character, label for paths identified from different networks.
col	Colors for plotting statistical results for paths identified from different networks.

plot	Logical, if TRUE path length distribution and node degeneracy will be plotted.
concise	Logical, if TRUE only 'on path' residues will be displayed in the node degeneracy plot.
cutoff	Numeric, nodes with node degeneracy larger than cutoff are shown in the output.
normalize	Logical, if TRUE node degeneracy is divided by the total (weighted) number of paths.
weight	Logical, if TRUE each path is weighted by path length in calculating the node degeneracty.
x	A 'cnapath' class object, or a list of such objects, as obtained from function cnapath.
...	Additional arguments passed to igraph function get.shortest.paths (in the function cnapath), passed to summary.cnapath (in print.cnapath), as additional paths for comparison (in summary.cnapath).

Value

The function cnapath returns a (or a list of) 'cnapath' class of list containing following three components:

path	a list object containing all identified suboptimal paths. Each entry of the list is a sequence of node ids for the path.
epath	a list object containing all identified suboptimal paths. Each entry of the list is a sequence of edge ids for the path.
dist	a numeric vector of all path lengths.

The function summary.cnapath returns a matrix of (normalized) node degeneracy for 'on path' residues.

Author(s)

Xin-Qiu Yao

References

Yen, J.Y. (1971) *Management Science* **17**, 712–716.

See Also

cna, cna.dccm, vmd.cna, vmd.cnapath, get.shortest.paths.

Examples

```
# Redundant testing excluded

if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {
```

```
attach(transducin)
inds = match(c("1TND_A", "1TAG_A"), pdbs$id)

npdbs <- trim(pdbs, row.inds=inds)
gaps.res <- gap.inspect(npdbs$ali)

modes <- nma(npdbs)
cij <- dccm(modes)
net <- cna(cij, cutoff.cij=0.3)

# get paths
pa1 <- cnapath(net[[1]], from = 314, to=172, k=50)
pa2 <- cnapath(net[[2]], from = 314, to=172, k=50)

# print the information of a path
pa1

# print two paths simultaneously
pas <- list(pa1, pa2)
names(pas) <- c("GTP", "GDP")
print.cnapath(pas)

# Or, for the same effect,
# summary(pa1, pa2, label=c("GTP", "GDP"))

try({

# replace node numbers with residue name and residue number in the PDB file
pdb <- read.pdb("1tnd")
pdb <- trim.pdb(pdb, atom.select(pdb, chain="A", resno=npdbs$resno[1, gaps.res$f.inds]))
print.cnapath(pas, pdb=pdb)

# plot path length distribution and node degeneracy
print.cnapath(pas, pdb = pdb, col=c("red", "darkgreen"), plot=TRUE)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}

# View paths in 3D molecular graphic with VMD
#vmd.cnapath(pa1, pdb, launch = TRUE)
#vmd.cnapath(pa1, pdb, colors = 7, launch = TRUE)
#vmd.cnapath(pa1, pdb, spline=TRUE, colors=c("pink", "red"), launch = TRUE)
#pdb2 <- read.pdb("1tag")
#pdb2 <- trim.pdb(pdb2, atom.select(pdb2, chain="A", resno=npdbs$resno[2, gaps.res$f.inds]))
#vmd.cnapath(pa2, pdb2, launch = TRUE)

detach(transducin)

}
```

com *Center of Mass*

Description

Calculate the center of mass of a PDB object.

Usage

```
com(...)

## S3 method for class 'pdb'
com(pdb, inds=NULL, use.mass=TRUE, ...)

## S3 method for class 'xyz'
com(xyz, mass=NULL, ...)
```

Arguments

pdb	an object of class pdb as obtained from function read.pdb.
inds	atom and xyz coordinate indices obtained from atom.select that selects the elements of pdb upon which the calculation should be based.
use.mass	logical, if TRUE the calculation will be mass weighted (center of mass).
...	additional arguments to atom2mass.
xyz	a numeric vector or matrix of Cartesian coordinates (e.g. an object of type xyz).
mass	a numeric vector containing the masses of each atom in xyz.

Details

This function calculates the center of mass of the provided PDB structure / Cartesian coordiantes. Atom names found in standard amino acids in the PDB are mapped to atom elements and their corresponding relative atomic masses.

In the case of an unknown atom name elety.custom and mass.custom can be used to map an atom to the correct atomic mass. See examples for more details.

Alternatively, the atom name will be mapped automatically to the element corresponding to the first character of the atom name. Atom names starting with character H will be mapped to hydrogen atoms.

Value

Returns the Cartesian coordinates at the center of mass.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, atom2mass

Examples

```
# PDB server connection required - testing excluded
try({

## Stucture of PKA:
pdb <- read.pdb("3dnd")

## Center of mass:
com(pdb)

## Center of mass of a selection
inds <- atom.select(pdb, chain="I")
com(pdb, inds)

## using XYZ Cartesian coordinates
xyz <- pdb$xyz[, inds$xyz]
com.xyz(xyz)

## with mass weighting
com.xyz(xyz, mass=atom2mass(pdb$atom[inds$atom, "elety"]) )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}


## Not run:
## Unknown atom names
pdb <- read.pdb("3dnd")
inds <- atom.select(pdb, resid="LL2")
mycom <- com(pdb, inds, rescue=TRUE)
#warnings()


## Map atom names manually
pdb <- read.pdb("3RE0")
inds <- atom.select(pdb, resno=201)

myelety  <- data.frame(name = c("CL2","PT1","N1","N2"), symb = c("Cl","Pt","N","N"))
mymasses <- data.frame(symb = c("Cl","Pt"), mass = c(35.45, 195.08))
mycom    <- com(pdb, inds, elety.custom=myelety, mass.custom=mymasses)

## End(Not run)
```

`combine.select` *Combine Atom Selections From PDB Structure*

Description

Do "and", "or", or "not" set operations between two or more atom selections made by `atom.select`

Usage

```
combine.select(sel1=NULL, sel2=NULL, ..., operator="AND", verbose=TRUE)
```

Arguments

`sel1`	an atom selection object of class `"select"`, obtained from `atom.select`.
`sel2`	a second atom selection object of class `"select"`, obtained from `atom.select`.
`...`	more select objects for the set operation.
`operator`	name of the set operation.
`verbose`	logical, if TRUE details of the selection combination are printed.

Details

The value of `operator` should be one of following: (1) "AND", "and", or "&" for set intersect, (2) "OR", "or", "|", or "+" for set union, (3) "NOT", "not", "!", or "-" for set difference `sel1 - sel2 - sel3 ...`.

Value

Returns a list of class `"select"` with components:

`atom`	atom indices of selected atoms.
`xyz`	xyz indices of selected atoms.
`call`	the matched call.

Author(s)

Xin-Qiu Yao

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`atom.select`, `as.select` `read.pdb`, `trim.pdb`

Examples

```
# Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## - Build atom selections to be operated
# Select C-alpha atoms of entire system
ca.global.inds <- atom.select(pdb, "calpha")

# Select C-beta atoms of entire protein
cb.global.inds <- atom.select(pdb, "protein", elety="CB")

# Select backbone atoms of entire system
bb.global.inds <- atom.select(pdb, "backbone")

# Select all atoms with residue number from 46 to 50
aa.local.inds <- atom.select(pdb, resno=46:50)


# Do set intersect:
# - Return C-alpha atoms with residue number from 46 to 50
ca.local.inds <- combine.select(ca.global.inds, aa.local.inds)
print( pdb$atom[ ca.local.inds$atom, ] )

# Do set subtract:
# - Return side-chain atoms with residue number from 46 to 50
sc.local.inds <- combine.select(aa.local.inds, bb.global.inds, operator="-")
print( pdb$atom[ sc.local.inds$atom, ] )

# Do set union:
# - Return C-alpha and side-chain atoms with residue number from 46 to 50
casc.local.inds <- combine.select(ca.local.inds, sc.local.inds, operator="+")
print( pdb$atom[ casc.local.inds$atom, ] )

# More than two selections:
# - Return side-chain atoms (but not C-beta) with residue number from 46 to 50
sc2.local.inds <- combine.select(aa.local.inds, bb.global.inds, cb.global.inds, operator="-")
print( pdb$atom[ sc2.local.inds$atom, ] )
```

`community.aln` *Align communities from two or more networks*

Description

Find equivalent communities from two or more networks and re-assign colors to them in a consistent way across networks. A 'new.membership' vector is also generated for each network, which maps nodes to community IDs that are renumbered according to the community equivalency.

Usage

```
community.aln(x, ..., aln = NULL)
```

Arguments

x, ...	two or more objects of class cna (if the numbers of nodes are different, an alignment 'fasta' object is required for the aln argument; See below) as obtained from function cna. Alternatively, a list of cna objects can be given to x.
aln	alignment for comparing networks with different numbers of nodes.

Details

This function facilitates the inspection on the variance of the community partition in a group of similar networks. The original community numbering (and so the colors of communities in the output of plot.cna and vmd.cna) can be inconsistent across networks, i.e. equivalent communities may display different colors, impeding network comparison. The function calculates the dissimilarity between all communities and clusters communities with 'hclust' funciton. In each cluster, 0 or 1 community per network is included. The color attribute of communities is then re-assigned according to the clusters through all networks. In addition, a 'new.membership' vector is generated for each network, which mapps nodes to new community IDs that are numbered consistently across networks.

Value

Returns a list of updated cna objects.

See Also

cna, plot.cna, vmd.cna

Examples

```
# Needs MUSCLE installed - testing excluded
if(check.utility("muscle")) {

  if (!requireNamespace("igraph", quietly = TRUE)) {
    message('Need igraph installed to run this example')
  } else {

  ## Fetch PDB files and split to chain A only PDB files
  ids <- c("1tnd_A", "1tag_A")
  files <- get.pdb(ids, split = TRUE, path = tempdir())

  ## Sequence Alignement
  pdbs <- pdbaln(files, outfile = tempfile())

  ## Normal mode analysis on aligned data
  modes <- nma(pdbs, rm.gaps=TRUE)

  ## Dynamic Cross Correlation Matrix
  cijs <- dccm(modes)$all.dccm

  ## Correlation Network
  nets <- cna(cijs, cutoff.cij=0.3)
```

```
  ## Align network communities
  nets.aln <- community.aln(nets)

  ## plot all-residue and coarse-grained (community) networks
  pdb <- pdbs2pdb(pdbs, inds=1, rm.gaps=TRUE)[[1]]
  op <- par(no.readonly=TRUE)

  # before alignment
  par(mar=c(0.1, 0.1, 0.1, 0.1), mfrow=c(2,2))
  invisible( lapply(nets, function(x)
     plot(x, layout=layout.cna(x, pdb=pdb, k=3, full=TRUE)[, 1:2],
              full=TRUE)) )
  invisible( lapply(nets, function(x)
     plot(x, layout=layout.cna(x, pdb=pdb, k=3)[, 1:2])) )

  # after alignment
  par(mar=c(0.1, 0.1, 0.1, 0.1), mfrow=c(2,2))
  invisible( lapply(nets.aln, function(x)
     plot(x, layout=layout.cna(x, pdb=pdb, k=3, full=TRUE)[, 1:2],
              full=TRUE)) )
  invisible( lapply(nets.aln, function(x)
     plot(x, layout=layout.cna(x, pdb=pdb, k=3)[, 1:2])) )

  par(op)

  }
}
```

`community.tree` *Reconstruction of the Girvan-Newman Community Tree for a CNA Class Object.*

Description

This function reconstructs the community tree of the community clustering analysis performed by the 'cna' function. It allows the user to explore different network community partitions.

Usage

```
community.tree(x, rescale=FALSE)
```

Arguments

`x`	A protein network graph object as obtained from the 'cna' function.
`rescale`	Logical, indicating whether to rescale the community names starting from 1. If FALSE, the community names will start from N+1, where N is the number of nodes.

Details

The input of this function should be a 'cna' class object containing 'network' and 'communities' attributes.

This function reconstructs the community residue memberships for each modularity value. The purpose is to facilitate inspection of alternate community partitioning points, which in practice often corresponds to a value close to the maximum of the modularity, but not the maximum value itself.

Value

Returns a list object that includes the following components:

`modularity`	A numeric vector containing the modularity values.
`tree`	A numeric matrix containing in each row the community residue memberships corresponding to a modularity value. The rows are ordered according to the 'modularity' object.
`num.of.comms`	A numeric vector containing the number of communities per modularity value. The vector elements are ordered according to the 'modularity' object.

Author(s)

Guido Scarabelli

See Also

`cna`, `network.amendment`, `summary.cna`

Examples

```
# PDB server connection required - testing excluded

if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

try({

###-- Build a CNA object
pdb <- read.pdb("4Q21")
modes <- nma(pdb)
cij <- dccm(modes)
net <- cna(cij, cutoff.cij=0.2)


##-- Reconstruct the community membership vector for each clustering step.
tree <- community.tree(net, rescale=TRUE)

## Plot modularity vs number of communities
plot( tree$num.of.comms, tree$modularity )
```

```
## Inspect the maximum modularity value partitioning
max.mod.ind <- which.max(tree$modularity)

## Number of communities (k) at max modularity
tree$num.of.comms[ max.mod.ind ]

## Membership vector at this partition point
tree$tree[max.mod.ind,]

# Should be the same as that contained in the original CNA network object
net$communities$membership == tree$tree[max.mod.ind,]

# Inspect a new membership partitioning (at k=7)
memb.k7 <- tree$tree[ tree$num.of.comms == 7, ]

## Produce a new k=7 community network
net.7 <- network.amendment(net, memb.k7)
plot(net.7, pdb)
#view.cna(net.7, trim.pdb(pdb, atom.select(pdb,"calpha")), launch=TRUE )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
}
```

---

consensus *Sequence Consensus for an Alignment*

Description

Determines the consensus sequence for a given alignment at a given identity cutoff value.

Usage

```
consensus(alignment, cutoff = 0.6)
```

Arguments

alignment	an alignment object created by the read.fasta function or an alignment character matrix.
cutoff	a numeric value beteen 0 and 1, indicating the minimum sequence identity threshold for determining a consensus amino acid. Default is 0.6, or 60 percent residue identity.

Value

A vector containing the consensus sequence, where '-' represents positions with no consensus (i.e. under the cutoff)

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta

Examples

```
#-- Read HIV protease alignment
aln <- read.fasta(system.file("examples/hivp_xray.fa",package="bio3d"))

# Generate consensus
con <- consensus(aln)
print(con$seq)

# Plot residue frequency matrix
##png(filename = "freq.png", width = 1500, height = 780)
col <- mono.colors(32)
aa  <- rev(rownames(con$freq))

image(x=1:ncol(con$freq),
      y=1:nrow(con$freq),
      z=as.matrix(rev(as.data.frame(t(con$freq)))),
      col=col, yaxt="n", xaxt="n",
      xlab="Alignment Position", ylab="Residue Type")

# Add consensus along the axis
axis(side=1, at=seq(0,length(con$seq),by=5))
axis(side=2, at=c(1:22), labels=aa)
axis(side=3, at=c(1:length(con$seq)), labels =con$seq)
axis(side=4, at=c(1:22), labels=aa)
grid(length(con$seq), length(aa))
box()

# Add consensus sequence
for(i in 1:length(con$seq)) {
  text(i, which(aa==con$seq[i]),con$seq[i],col="white")
}

# Add lines for residue type separation
abline(h=c(2.5,3.5, 4.5, 5.5, 3.5, 7.5, 9.5,
         12.5, 14.5, 16.5, 19.5), col="gray")
```

conserv *Score Residue Conservation At Each Position in an Alignment*

Description

Quantifies residue conservation in a given protein sequence alignment by calculating the degree of amino acid variability in each column of the alignment.

Usage

```
conserv(x, method = c("similarity","identity","entropy22","entropy10"),
        sub.matrix = c("bio3d", "blosum62", "pam30", "other"),
        matrix.file = NULL, normalize.matrix = TRUE)
```

Arguments

x	an alignment list object with id and ali components, similar to that generated by read.fasta.
method	the conservation assesment method.
sub.matrix	a matrix to score conservation.
matrix.file	a file name of an arbitary user matrix.
normalize.matrix	logical, if TRUE the matrix is normalized pior to assesing conservation.

Details

To assess the level of sequence conservation at each position in an alignment, the "similarity", "identity", and "entropy" per position can be calculated.

The "similarity" is defined as the average of the similarity scores of all pairwise residue comparisons for that position in the alignment, where the similarity score between any two residues is the score value between those residues in the chosen substitution matrix "sub.matrix".

The "identity" i.e. the preference for a specific amino acid to be found at a certain position, is assessed by averaging the identity scores resulting from all possible pairwise comparisons at that position in the alignment, where all identical residue comparisons are given a score of 1 and all other comparisons are given a value of 0.

"Entropy" is based on Shannons information entropy. See the entropy function for further details.

Note that the returned scores are normalized so that conserved columns score 1 and diverse columns score 0.

Value

Returns a numeric vector of scores

Note

Each of these conservation scores has particular strengths and weaknesses. For example, entropy elegantly captures amino acid diversity but fails to account for stereochemical similarities. By employing a combination of scores and taking the union of their respective conservation signals we expect to achieve a more comprehensive analysis of sequence conservation (Grant, 2007).

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Grant, B.J. et al. (2007) *J. Mol. Biol.* **368**, 1231–1248.

See Also

read.fasta, read.fasta.pdb

Examples

```
## Read an example alignment
aln <- read.fasta(system.file("examples/hivp_xray.fa",package="bio3d"))

## Score conservation
conserv(x=aln$ali, method="similarity", sub.matrix="bio3d")
##conserv(x=aln$ali,method="entropy22", sub.matrix="other")
```

---

convert.pdb *Renumber and Convert Between Various PDB formats*

Description

Renumber and convert between CHARMM, Amber, Gromacs and Brookhaven PDB formats.

Usage

```
convert.pdb(pdb, type=c("original", "pdb", "charmm", "amber", "gromacs"),
                renumber = FALSE, first.resno = 1, first.eleno = 1,
                consecutive=TRUE, rm.h = TRUE, rm.wat = FALSE,
                verbose=TRUE)
```

Arguments

pdb	a structure object of class "pdb", obtained from read.pdb.
type	output format, one of 'original', 'pdb', 'charmm', 'amber', or 'gromacs'. The default option of 'original' results in no conversion.
renumber	logical, if TRUE atom and residue records are renumbered using 'first.resno' and 'first.eleno'.
first.resno	first residue number to be used if 'renumber' is TRUE.
first.eleno	first element number to be used if 'renumber' is TRUE.
consecutive	logical, if TRUE renumbering will result in consecutive residue numbers spanning all chains. Otherwise new residue numbers will begin at 'first.resno' for each chain.
rm.h	logical, if TRUE hydrogen atoms are removed.
rm.wat	logical, if TRUE water atoms are removed.
verbose	logical, if TRUE details of the conversion process are printed.

Details

Convert atom names and residue names, renumber atom and residue records, strip water and hydrogen atoms from pdb objects.

Format type can be one of "ori", "pdb", "charmm", "amber" or "gromacs".

Value

Returns a list of class "pdb", with the following components:

atom	a character matrix containing all atomic coordinate ATOM data, with a row per ATOM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
het	a character matrix containing atomic coordinate records for atoms within "non-standard" HET groups (see atom).
helix	'start', 'end' and 'length' of H type sse, where start and end are residue numbers "resno".
sheet	'start', 'end' and 'length' of E type sse, where start and end are residue numbers "resno".
seqres	sequence from SEQRES field.
xyz	a numeric vector of ATOM coordinate data.
calpha	logical vector with length equal to nrow(atom) with TRUE values indicating a C-alpha "elety".

Note

For both atom and het list components the column names can be used as a convenient means of data access, namely: Atom serial number "eleno" , Atom type "elety", Alternate location indicator "alt", Residue name "resid", Chain identifier "chain", Residue sequence number "resno", Code for insertion of residues "insert", Orthogonal coordinates "x", Orthogonal coordinates "y", Orthogonal coordinates "z", Occupancy "o", and Temperature factor "b". See examples for further details.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

atom.select, write.pdb, read.dcd, read.fasta.pdb, read.fasta

Examples

```
## Not run:

# Read a PDB file
pdb <- read.pdb("4q21")
pdb
head( pdb$atom[pdb$calpha,"resno"] )

# Convert to CHARMM format
new <- convert.pdb(pdb, type="amber", renumber=TRUE, first.resno=22 )
head( new$atom[new$calpha,"resno"] )

# Write a PDB file
#write.pdb(new, file="tmp4amber.pdb")


## End(Not run)
```

---

core.cmap *Identification of Contact Map Core Positions*

Description

Find core positions that have the largest number of contact with neighboring residues.

Usage

```
core.cmap(pdbs, write.pdb = FALSE, outfile="core.pdb",
          cutoff = NULL, refine = FALSE, ncore = NULL, ...)
```

Arguments

pdbs	an alignment data structure of class 'pdbs' as obtained with read.fasta.pdb or pdbaln, or a numeric matrix of aligned C-alpha xyz Cartesian coordinates.
write.pdb	logical, if TRUE core coordinate files, containing only core positions for each iteration, are written to a location specified by outpath.
outfile	character string specifying the output directory when write.pdb is 'TRUE'.
cutoff	numeric value speciyfing the inclusion criteria for core positions.
refine	logical, if TRUE explore core positions determined by multiple eigenvectors. By default only the eigenvector describing the largest variation is used.
ncore	number of CPU cores used to do the calculation. By default (ncore=NULL) use all cores detected.
...	arguments passed to and from functions.

Details

This function calculates eigenvector centrality of the weighted contact network built based on input structure data and uses it to determine the core positions.

In this context, core positions correspond to the most invariant C-alpha atom positions across an aligned set of protein structures. Traditionally one would use the core.find function to for their identification and then use these positions as the basis for improved structural superposition. This more recent function utilizes a much faster approach and is thus preferred in time sensitive applications such as shiny apps.

Value

Returns a list of class "select" containing 'atom' and 'xyz' indices.

Author(s)

Xin-Qiu Yao

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

core.find, read.fasta.pdb, fit.xyz

Examples

```
## Not run:
##-- Generate a small kinesin alignment and read corresponding structures
pdbfiles <- get.pdb(c("1bg2","2ncd","1i6i","1i5s"), URLonly=TRUE)
pdbs <- pdbaln(pdbfiles)

##-- Find 'core' positions
core <- core.cmap(pdbs)
```

```
xyz <- pdbfit(pdbs, core, outpath="corefit_structures")

## End(Not run)
```

`core.find` *Identification of Invariant Core Positions*

Description

Perform iterated rounds of structural superposition to identify the most invariant region in an aligned set of protein structures.

Usage

```
core.find(...)

## S3 method for class 'pdbs'
core.find(pdbs, shortcut = FALSE, rm.island = FALSE,
          verbose = TRUE, stop.at = 15, stop.vol = 0.5,
          write.pdbs = FALSE, outpath="core_pruned",
          ncore = 1, nseg.scale = 1, progress = NULL, ...)

## Default S3 method:
core.find(xyz, ...)

## S3 method for class 'pdb'
core.find(pdb, verbose=TRUE, ...)
```

Arguments

`pdbs`	a numeric matrix of aligned C-alpha xyz Cartesian coordinates. For example an alignment data structure obtained with `read.fasta.pdb` or `pdbaln`.
`shortcut`	if TRUE, remove more than one position at a time.
`rm.island`	remove isolated fragments of less than three residues.
`verbose`	logical, if TRUE a "core_pruned" directory containing 'core structures' for each iteraction is written to the current directory.
`stop.at`	minimal core size at which iterations should be stopped.
`stop.vol`	minimal core volume at which iterations should be stopped.
`write.pdbs`	logical, if TRUE core coordinate files, containing only core positions for each iteration, are written to a location specified by `outpath`.
`outpath`	character string specifying the output directory when `write.pdbs` is TRUE.
`ncore`	number of CPU cores used to do the calculation. `ncore>1` requires package 'parallel' installed.
`nseg.scale`	split input data into specified number of segments prior to running multiple core calculation. See `fit.xyz`.

progress	progress bar for use with shiny web app.
xyz	a numeric matrix of xyz Cartesian coordinates, e.g. obtained from read.dcd or read.ncdf.
pdb	an object of type pdb as obtained from function read.pdb with multiple frames (>=4) stored in its xyz component. Note that the function will attempt to identify C-alpha and phosphate atoms (for protein and nucleic acids, respectively) in which the calculation should be based.
...	arguments passed to and from functions.

Details

This function attempts to iteratively refine an initial structural superposition determined from a multiple alignment. This involves iterated rounds of superposition, where at each round the position(s) displaying the largest differences is(are) excluded from the dataset. The spatial variation at each aligned position is determined from the eigenvalues of their Cartesian coordinates (i.e. the variance of the distribution along its three principal directions). Inspired by the work of Gerstein *et al.* (1991, 1995), an ellipsoid of variance is determined from the eigenvalues, and its volume is taken as a measure of structural variation at a given position.

Optional "core PDB files" containing core positions, upon which superposition is based, can be written to a location specified by outpath by setting write.pdbs=TRUE. These files are useful for examining the core filtering process by visualising them in a graphics program.

Value

Returns a list of class "core" with the following components:

volume	total core volume at each fitting iteration/round.
length	core length at each round.
resno	residue number of core residues at each round (taken from the first aligned structure) or, alternatively, the numeric index of core residues at each round.
step.inds	atom indices of core atoms at each round.
atom	atom indices of core positions in the last round.
xyz	xyz indices of core positions in the last round.
c1A.atom	atom indices of core positions with a total volume under 1 Angstrom^3.
c1A.xyz	xyz indices of core positions with a total volume under 1 Angstrom^3.
c1A.resno	residue numbers of core positions with a total volume under 1 Angstrom^3.
c0.5A.atom	atom indices of core positions with a total volume under 0.5 Angstrom^3.
c0.5A.xyz	xyz indices of core positions with a total volume under 0.5 Angstrom^3.
c0.5A.resno	residue numbers of core positions with a total volume under 0.5 Angstrom^3.

Note

The relevance of the 'core positions' identified by this procedure is dependent upon the number of input structures and their diversity.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Gerstein and Altman (1995) *J. Mol. Biol.* **251**, 161–175.

Gerstein and Chothia (1991) *J. Mol. Biol.* **220**, 133–149.

See Also

read.fasta.pdb, plot.core, fit.xyz

Examples

```
## Not run:
##-- Generate a small kinesin alignment and read corresponding structures
pdbfiles <- get.pdb(c("1bg2","2ncd","1i6i","1i5s"), URLonly=TRUE)
pdbs <- pdbaln(pdbfiles)

##-- Find 'core' positions
core <- core.find(pdbs)
plot(core)

##-- Fit on these relatively invarient subset of positions
#core.inds <- print(core, vol=1)
core.inds <- print(core, vol=0.5)
xyz <- pdbfit(pdbs, core.inds, outpath="corefit_structures")

##-- Compare to fitting on all equivalent positions
xyz2 <- pdbfit(pdbs)

## Note that overall RMSD will be higher but RMSF will
##  be lower in core regions, which may equate to a
##  'better fit' for certain applications
gaps <- gap.inspect(pdbs$xyz)
rmsd(xyz[,gaps$f.inds])
rmsd(xyz2[,gaps$f.inds])

plot(rmsf(xyz[,gaps$f.inds]), typ="l", col="blue", ylim=c(0,9))
points(rmsf(xyz2[,gaps$f.inds]), typ="l", col="red")

## End(Not run)

## Not run:
##-- Run core.find() on a multimodel PDB file
pdb <- read.pdb('1d1d', multi=TRUE)
core <- core.find(pdb)

##-- Run core.find() on a trajectory
trtfile <- system.file("examples/hivp.dcd", package="bio3d")
```

```
trj <- read.dcd(trtfile)

## Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

## select calpha coords from a manageable number of frames
ca.ind <- atom.select(pdb, "calpha")$xyz
frames <- seq(1, nrow(trj), by=10)

core <- core.find( trj[frames, ca.ind], write.pdbs=TRUE )

## have a look at the various cores "vmd -m core_pruned/*.pdb"

## Lets use a 6A^3 core cutoff
inds <- print(core, vol=6)
write.pdb(xyz=pdb$xyz[inds$xyz],resno=pdb$atom[inds$atom,"resno"], file="core.pdb")


##- Fit trj onto starting structure based on core indices
xyz <- fit.xyz( fixed = pdb$xyz,
                mobile = trj,
                fixed.inds  = inds$xyz,
                mobile.inds = inds$xyz)

##write.pdb(pdb=pdb, xyz=xyz, file="new_trj.pdb")
##write.ncdf(xyz, "new_trj.nc")


## End(Not run)
```

---

cov.nma *Calculate Covariance Matrix from Normal Modes*

Description

Calculate the covariance matrix from a normal mode object.

Usage

```
## S3 method for class 'nma'
cov(nma)
## S3 method for class 'enma'
cov(enma, ncore=NULL)
```

Arguments

nma	an nma object as obtained from function nma.pdb.

enma	an enma object as obtained from function nma.pdbs.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.

Details

This function calculates the covariance matrix from a nma object as obtained from function nma.pdb or covariance matrices from a enma object as obtain from function nma.pdbs.

Value

Returns the calculated covariance matrix (function cov.nma), or covariance matrices (function cov.enma).

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Fuglebakk, E. et al. (2013) *JCTC* **9**, 5618–5628.

See Also

nma

---

covsoverlap *Covariance Overlap*

Description

Calculate the covariance overlap obtained from NMA.

Usage

```
covsoverlap(...)

## S3 method for class 'enma'
covsoverlap(enma, ncore=NULL, ...)

## S3 method for class 'nma'
covsoverlap(a, b, subset=NULL, ...)
```

Arguments

enma	an object of class "enma" obtained from function nma.pdbs.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
a	a list object with elements 'U' and 'L' (e.g. as obtained from function nma) containing the eigenvectors and eigenvalues, respectively, to be compared with b.
b	a list object with elements 'U' and 'L' (e.g. as obtained from function nma) containing the eigenvectors and eigenvalues, respectively, to be compared with a.
subset	the number of modes to consider.
...	arguments passed to associated functions.

Details

Covariance overlap is a measure for the similarity between two covariance matrices, e.g. obtained from NMA.

Value

Returns the similarity coefficient(s).

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Romo, T.D. et al. (2011) *Proteins* **79**, 23–34.

See Also

Other similarity measures: sip, covsoverlap, bhattacharyya.

---

dccm *DCCM: Dynamical Cross-Correlation Matrix*

Description

Determine the cross-correlations of atomic displacements.

Usage

```
dccm(x, ...)
```

Arguments

x	a numeric matrix of Cartesian coordinates with a row per structure/frame which will br passed to dccm.xyz(). Alternatively, an object of class nma as obtained from function nma that will be passed to the dccm.nma() function, see below for examples.
...	additional arguments passed to the methods dccm.xyz, dccm.pca, dccm.nma, and dccm.enma.

Details

dccm is a generic function calling the corresponding function determined by the class of the input argument x. Use methods("dccm") to get all the methods for dccm generic:

dccm.xyz will be used when x is a numeric matrix containing Cartesian coordinates (e.g. trajectory data).

dccm.pca will calculate the cross-correlations based on an pca object.

dccm.nma will calculate the cross-correlations based on an nma object. Similarly, dccm.enma will calculate the correlation matrices based on an ensemble of nma objects (as obtained from function nma.pdbs).

plot.dccm and pymol.dccm provides convenient functionality to plot a correlation map, and visualize the correlations in the structure, respectively.

See examples for each corresponding function for more details.

Author(s)

Barry Grant, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

dccm.xyz, dccm.nma, dccm.enma, dccm.pca, plot.dccm, pymol.dccm.

---

dccm.enma *Cross-Correlation for Ensemble NMA (eNMA)*

Description

Calculate the cross-correlation matrices from an ensemble of NMA objects.

Usage

```
## S3 method for class 'enma'
dccm(x, ncore = NULL, na.rm=FALSE, ...)
```

Arguments

x	an object of class enma as obtained from function nma.pdbs.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
na.rm	logical, if FALSE the DCCM might containt NA values (applies only when the enma object is calculated with argument 'rm.gaps=FALSE').
...	additional arguments passed to dccm.nma.

Details

This is a wrapper function for calling dccm.nma on a collection of 'nma' objects as obtained from function nma.pdbs.

See examples for more details.

Value

Returns a list with the following components:

all.dccm	an array or list containing the correlation matrices for each 'nma' object. An array is returned when the 'enma' object is calculated with 'rm.gaps=TRUE', and a list is used when 'rm.gaps=FALSE'.
avg.dccm	a numeric matrix containing the average correlation matrix. The average is only calculated when the 'enma' object is calculated with 'rm.gaps=TRUE'.

Author(s)

Lars Skjaerven

References

Wynsberghe. A.W.V, Cui, Q. *Structure* **14**, 1647–1653. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma, dccm.nma, plot.dccm

Examples

```
## Needs MUSCLE installed - testing excluded

if(check.utility("muscle")) {

## Fetch PDB files and split to chain A only PDB files
ids <- c("1a70_A", "1czp_A", "1frd_A", "1fxi_A", "1iue_A", "1pfd_A")
files <- get.pdb(ids, split = TRUE, path = tempdir())

## Sequence/Structure Alignement
pdbs <- pdbaln(files, outfile = tempfile())
```

```
## Normal mode analysis on aligned data
modes <- nma(pdbs)

## Calculate all 6 correlation matrices
cij <- dccm(modes)

## Plot correlations for first structure
plot.dccm(cij$all.dccm[,,1])

}
```

---

dccm.gnm *Dynamic Cross-Correlation from Gaussian Network Model*

Description

Calculate the cross-correlation matrix from Gaussian network model normal modes analysis.

Usage

```
## S3 method for class 'gnm'
dccm(x, ...)

## S3 method for class 'egnm'
dccm(x, ...)
```

Arguments

x	an object of class 'gnm' or 'egnm' as obtained from gnm.
...	additional arguments (currently ignored).

Details

This function calculates the cross-correlation matrix from Gaussian network model (GNM) normal modes analysis (NMA) obtained from gnm. It returns a matrix of residue-wise cross-correlations whose elements, Cij, may be displayed in a graphical representation frequently termed a dynamical cross-correlation map, or DCCM. (See more details in help(dccm.nma)).

Value

Returns a cross-correlation matrix.

Author(s)

Xin-Qiu Yao & Lars Skjaerven

References

Bahar, I. et al. (1997) *Folding Des.* **2**, 173.

See Also

gnm, dccm.nma, dccm.enma, plot.dccm.

Examples

```
if(!requireNamespace("lattice", quietly=TRUE)) {
   message("Need lattice installed to run this example")
} else {

## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate normal modes
modes <- gnm(pdb)

## Calculate correlation matrix
cm <- dccm(modes)

## Plot correlation map
plot(cm, sse = pdb, contour = FALSE, col.regions = bwr.colors(20),
     at = seq(-1, 1, 0.1))

}
```

---

dccm.nma *Dynamic Cross-Correlation from Normal Modes Analysis*

Description

Calculate the cross-correlation matrix from Normal Modes Analysis.

Usage

```
## S3 method for class 'nma'
dccm(x, nmodes = NULL, ncore = NULL, progress = NULL, ...)
```

Arguments

x	an object of class nma as obtained from function nma.
nmodes	numerical, number of modes to consider.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
progress	progress bar for use with shiny web app.
...	additional arguments ?

Details

This function calculates the cross-correlation matrix from Normal Modes Analysis (NMA) obtained from nma of a protein structure. It returns a matrix of residue-wise cross-correlations whose elements, Cij, may be displayed in a graphical representation frequently termed a dynamical cross-correlation map, or DCCM.

If Cij = 1 the fluctuations of residues i and j are completely correlated (same period and same phase), if Cij = -1 the fluctuations of residues i and j are completely anticorrelated (same period and opposite phase), and if Cij = 0 the fluctuations of i and j are not correlated.

Value

Returns a cross-correlation matrix.

Author(s)

Lars Skjaerven

References

Wynsberghe. A.W.V, Cui, Q. *Structure* **14**, 1647–1653. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma, plot.dccm

Examples

```
if(!requireNamespace("lattice", quietly=TRUE)) {
   message("Need lattice installed to run this example")
} else {

## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate normal modes
modes <- nma(pdb)

## Calculate correlation matrix
cm <- dccm.nma(modes)

## Plot correlation map
plot(cm, sse = pdb, contour = FALSE, col.regions = bwr.colors(20),
     at = seq(-1, 1, 0.1))

}
```

dccm.pca *Dynamical Cross-Correlation Matrix from Principal Component Analysis*

Description

Calculate the cross-correlation matrix from principal component analysis (PCA).

Usage

```
## S3 method for class 'pca'
dccm(x, pc = NULL, method = c("pearson", "lmi"), ncore = NULL, ...)
```

Arguments

x	an object of class pca as obtained from function pca.xyz.
pc	numerical, indices of PCs to be included in the calculation. If all negative, PCs complementary to abs(pc) are included.
method	method to calculate the cross-correlation. Currently supports Pearson and linear mutual information (LMI).
ncore	number of CPU cores used to do the calculation. By default (ncore = NULL), use all available cores detected.
...	Additional arguments to be passed (currently ignored).

Details

This function calculates the cross-correlation matrix from principal component analysis (PCA) obtained from pca.xyz of a set of protein structures. It is an alternative way to calculate correlation in addition to the conventional way from xyz coordinates directly. But, in this new way one can freely chooses the PCs to be included in the calculation (e.g. for filtering out PCs with small eigenvalues).

Value

Returns a cross-correlation matrix with values in a range from -1 to 1 (Pearson) or from 0 to 1 (LMI).

Author(s)

Xin-Qiu Yao

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca.xyz, plot.dccm, dccm, dccm.xyz, dccm.nma, dccm.enma.

Examples

```
if(!requireNamespace("lattice", quietly=TRUE)) {
   message("Need lattice installed to run this example")
} else {

##-- Read example trajectory file
trtfile <- system.file("examples/hivp.dcd", package="bio3d")
trj <- read.dcd(trtfile)

## Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

## Select residues 24 to 27 and 85 to 90 in both chains
inds <- atom.select(pdb, resno=c(24:27,85:90), elety='CA')

## lsq fit of trj on pdb
xyz <- fit.xyz(pdb$xyz, trj, fixed.inds=inds$xyz, mobile.inds=inds$xyz)

## Do PCA
pca <- pca.xyz(xyz)

## DCCM: only use first 10 PCs
cij <- dccm(pca, pc = c(1:10))

## Plot DCCM
plot(cij)

## DCCM: remove first 10 PCs
cij <- dccm(pca, pc = -c(1:10))

## Plot DCCM
plot(cij)

}
```

---

dccm.xyz *Dynamical Cross-Correlation Matrix from Cartesian Coordinates*

Description

Determine the cross-correlations of atomic displacements.

Usage

```
## S3 method for class 'xyz'
dccm(x, reference = NULL, grpby=NULL, method=c("pearson", "lmi"),
                  ncore=1, nseg.scale=1, ...)
```

Arguments

x	a numeric matrix of Cartesian coordinates with a row per structure/frame.
reference	The reference structure about which displacements are analysed.
grpby	a vector counting connective duplicated elements that indicate the elements of xyz that should be considered as a group (e.g. atoms from a particular residue).
method	method to calculate the cross-correlation. Currently supports Pearson and linear mutual information (LMI).
ncore	number of CPU cores used to do the calculation. ncore=NULL will use all the cores detected.
nseg.scale	split input data into specified number of segments prior to running multiple core calculation. See fit.xyz.
...	Additional arguments to be passed (currently ignored).

Details

The extent to which the atomic fluctuations/displacements of a system are correlated with one another can be assessed by examining the magnitude of all pairwise cross-correlation coefficients (see McCammon and Harvey, 1986).

This function returns a matrix of all atom-wise cross-correlations whose elements, Cij, may be displayed in a graphical representation frequently termed a dynamical cross-correlation map, or DCCM.

If Cij = 1 the fluctuations of atoms i and j are completely correlated (same period and same phase), if Cij = -1 the fluctuations of atoms i and j are completely anticorrelated (same period and opposite phase), and if Cij = 0 the fluctuations of i and j are not correlated.

Typical characteristics of DCCMs include a line of strong cross-correlation along the diagonal, cross-correlations emanating from the diagonal, and off-diagonal cross-correlations. The high diagonal values occur where i = j, where Cij is always equal to 1.00. Positive correlations emanating from the diagonal indicate correlations between contiguous residues, typically within a secondary structure element or other tightly packed unit of structure. Typical secondary structure patterns include a triangular pattern for helices and a plume for strands. Off-diagonal positive and negative correlations may indicate potentially interesting correlations between domains of non-contiguous residues.

If method = "pearson", the conventional Pearson's inner-product correlaiton calculation will be invoked, in which only the diagnol of each atom-atom variance-covariance sub-matrix is considered.

If method = "lmi", then the linear mutual information cross-correlation will be calculated. 'LMI' considers both diagnol and off-diagnol entries in the sub-matrices, and so even captures the correlation of atoms moving in orthognal directions.

Value

Returns a cross-correlation matrix with values in a range from -1 to 1 (Pearson) or from 0 to 1 (LMI).

Author(s)

Xin-Qiu Yao, Hongyang Li, Gisle Saelensminde, and Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

McCammon, A. J. and Harvey, S. C. (1986) *Dynamics of Proteins and Nucleic Acids*, Cambridge University Press, Cambridge.

Lange, O.F. and Grubmuller, H. (2006) *PROTEINS: Structure, Function, and Bioinformatics* **62**:1053–1061.

See Also

cor for examining xyz cross-correlations, dccm, dccm.nma, dccm.pca, dccm.enma.

Examples

```
if (!requireNamespace("lattice", quietly = TRUE)) {
   message('Need lattice installed to run this example')
} else {

##-- Read example trajectory file
trtfile <- system.file("examples/hivp.dcd", package="bio3d")
trj <- read.dcd(trtfile)

## Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

## select residues 24 to 27 and 85 to 90 in both chains
inds <- atom.select(pdb, resno=c(24:27,85:90), elety='CA')

## lsq fit of trj on pdb
xyz <- fit.xyz(pdb$xyz, trj, fixed.inds=inds$xyz, mobile.inds=inds$xyz)

## DCCM (slow to run so restrict to Calpha)
cij <- dccm(xyz)

## Plot DCCM
plot(cij)

## Or

lattice::contourplot(cij, region = TRUE, labels=FALSE, col="gray40",
            at=c(-1, -0.75, -0.5, -0.25, 0.25, 0.5, 0.75, 1),
            xlab="Residue No.", ylab="Residue No.",
            main="DCCM: dynamic cross-correlation map")

## LMI matrix
cij <- dccm(xyz, method='lmi')

## Plot LMI matrix
#plot(cij)
col.scale <- colorRampPalette(c("gray95", "cyan"))(5)
plot(cij, at=seq(0.4,1, length=5), col.regions=col.scale)
```

```
}
```

`deformation.nma` *Deformation Analysis*

Description

Calculate deformation energies from Normal Mode Analysis.

Usage

```
deformation.nma(nma, mode.inds = NULL, pfc.fun = NULL, ncore = NULL)
```

Arguments

`nma`	a list object of class `"nma"` (obtained with `nma`).
`mode.inds`	a numeric vector of mode indices in which the calculation should be based.
`pfc.fun`	customized pair force constant ('pfc') function. The provided function should take a vector of distances as an argument to return a vector of force constants. See `nma` for examples.
`ncore`	number of CPU cores used to do the calculation. `ncore>1` requires package 'parallel' installed.

Details

Deformation analysis provides a measure for the amount of local flexibility of the protein structure - i.e. atomic motion relative to neighbouring atoms. It differs from 'fluctuations' (e.g. RMSF values) which provide amplitudes of the absolute atomic motion.

Deformation energies are calculated based on the `nma` object. By default the first 20 non-trivial modes are included in the calculation.

See examples for more details.

Value

Returns a list with the following components:

`ei`	numeric matrix containing the energy contribution (E) from each atom (i; row-wise) at each mode index (column-wise).
`sums`	deformation energies corresponding to each mode.

Author(s)

Lars Skjaerven

References

Hinsen, K. (1998) *Proteins* **33**, 417–429. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma

Examples

```
# Running the example takes some time - testing excluded

## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate (vibrational) normal modes
modes <- nma(pdb)

## Calculate deformation energies
def.energies <- deformation.nma(modes)


## Not run:
## Fluctuations of first non-trivial mode
def.energies <- deformation.nma(modes, mode.inds=seq(7, 16))

write.pdb(pdb=NULL, xyz=modes$xyz,
          b=def.energies$ei[,1])

## End(Not run)
```

---

diag.ind *Diagonal Indices of a Matrix*

Description

Returns a matrix of logicals the same size of a given matrix with entries 'TRUE' in the upper triangle close to the diagonal.

Usage

```
diag.ind(x, n = 1, diag = TRUE)
```

Arguments

x	a matrix.
n	the number of elements from the diagonal to include.
diag	logical. Should the diagonal be included?

Details

Basic function useful for masking elements close to the diagonal of a given matrix.

Value

Returns a matrix of logicals the same size of a given matrix with entries 'TRUE' in the upper triangle close to the diagonal.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

diag, lower.tri, upper.tri, matrix

Examples

```
diag.ind( matrix(,ncol=5,nrow=5), n=3 )
```

---

difference.vector *Difference Vector*

Description

Define a difference vector between two conformational states.

Usage

```
difference.vector(xyz, xyz.inds=NULL, normalize=FALSE)
```

Arguments

xyz	numeric matrix of Cartesian coordinates with a row per structure.
xyz.inds	a vector of indices that selects the elements of columns upon which the calculation should be based.
normalize	logical, if TRUE the difference vector is normalized.

Details

Squared overlap (or dot product) is used to measure the similiarity between a displacement vector (e.g. a difference vector between two conformational states) and mode vectors obtained from principal component or normal modes analysis.

Value

Returns a numeric vector of the structural difference (normalized if desired).

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

overlap

Examples

```
attach(kinesin)

# Ignore gap containing positions
gaps.pos <- gap.inspect(pdbs$xyz)

#-- Do PCA
pc.xray <- pca.xyz(pdbs$xyz[, gaps.pos$f.inds])

# Define a difference vector between two structural states
diff.inds <- c(grep("d1v8ka", pdbs$id),
               grep("d1goja", pdbs$id))

## Calculate the difference vector
dv <- difference.vector( pdbs$xyz[diff.inds,], gaps.pos$f.inds )

# Calculate the squared overlap between the PCs and the difference vector
o <- overlap(pc.xray, dv)

detach(kinesin)
```

---

dist.xyz *Calculate the Distances Between the Rows of Two Matrices*

Description

Compute the pairwise euclidean distances between the rows of two matrices.

Usage

```
dist.xyz(a, b = NULL, all.pairs=TRUE, ncore=1, nseg.scale=1)
```

Arguments

a	a 'xyz' object, numeric data matrix, or vector.
b	an optional second 'xyz' object, data matrix, or vector.
all.pairs	logical, if TRUE all pairwise distances between the rows of 'a' and all rows of 'b' are computed, if FALSE only the distances between coresponding rows of 'a' and 'b' are computed.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
nseg.scale	split input data into specified number of segments prior to running multiple core calculation. See fit.xyz.

Details

This function returns a matrix of euclidean distances between each row of 'a' and all rows of 'b'. Input vectors are coerced to three dimensional matrices (representing the Cartesian coordinates x, y and z) prior to distance computation. If 'b' is not provided then the pairwise distances between all rows of 'a' are computed.

Value

Returns a matrix of pairwise euclidean distances between each row of 'a' and all rows of 'b'.

Note

This function will choke if 'b' has too many rows.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

dm, dist

Examples

```
dist.xyz( c(1,1,1, 3,3,3), c(3,3,3, 2,2,2, 1,1,1))
dist.xyz( c(1,1,1, 3,3,3), c(3,3,3, 2,2,2, 1,1,1), all.pairs=FALSE)
```

dm *Distance Matrix Analysis*

Description

Construct a distance matrix for a given protein structure.

Usage

```
dm(...)

## S3 method for class 'pdb'
dm(pdb, inds = NULL, grp = TRUE, verbose=TRUE, ...)
## S3 method for class 'pdbs'
dm(pdbs, rm.gaps=FALSE, all.atom=FALSE,
                        aligned.atoms.only=NULL, ...)

## S3 method for class 'xyz'
dm(xyz, grpby = NULL, scut = NULL, mask.lower = TRUE,
                  gc.first=FALSE, ncore=1, ...)
```

Arguments

pdb	a pdb structure object as returned by read.pdb or a numeric vector of 'xyz' coordinates.
inds	atom and xyz coordinate indices obtained from atom.select that selects the elements of pdb upon which the calculation should be based.
grp	logical, if TRUE atomic distances will be grouped according to their residue membership. See 'grpby'.
verbose	logical, if TRUE possible warnings are printed.
pdbs	a 'pdbs' object as returned by read.fasta.pdb, read.all, or pdbaln.
rm.gaps	logical, if TRUE gapped positions are removed in the returned value.
all.atom	logical, if TRUE all-atom coordinates from read.all are used.
aligned.atoms.only	logical, if TRUE only equivalent (aligned) atoms are considered. Only meaningful when all.atom=TRUE. Default: FALSE.
xyz	a numeric vector or matrix of Cartesian coordinates.
grpby	a vector counting connective duplicated elements that indicate the elements of xyz that should be considered as a group (e.g. atoms from a particular residue).
scut	a cutoff neighbour value which has the effect of excluding atoms, or groups, that are sequentially within this value.
mask.lower	logical, if TRUE the lower matrix elements (i.e. those below the diagonal) are returned as NA.

gc.first	logical, if TRUE will call gc() first before calculation of distance matrix. This is to solve the memory overload problem when ncore > 1 and xyz has many rows/columns, with a bit sacrifice on speed.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
...	arguments passed to and from functions.

Details

Distance matrices, also called distance plots or distance maps, are an established means of describing and comparing protein conformations (e.g. Phillips, 1970; Holm, 1993).

A distance matrix is a 2D representation of 3D structure that is independent of the coordinate reference frame and, ignoring chirality, contains enough information to reconstruct the 3D Cartesian coordinates (e.g. Havel, 1983).

Value

Returns a numeric matrix of class "dmat", with all N by N distances, where N is the number of selected atoms. With multiple frames the output is provided in a three dimensional array.

Note

The input selection can be any character string or pattern interpretable by the function atom.select. For example, shortcuts "calpha", "back", "all" and selection strings of the form /segment/chain/residue number/residue name/element number/element name/; see atom.select for details.

If a coordinate vector is provided as input (rather than a pdb object) the selection option is redundant and the input vector should be pruned instead to include only desired positions.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Phillips (1970) *Biochem. Soc. Symp.* **31**, 11–28.

Holm (1993) *J. Mol. Biol.* **233**, 123–138.

Havel (1983) *Bull. Math. Biol.* **45**, 665–720.

See Also

plot.dmat, read.pdb, atom.select

Examples

```
# PDB server connection required - testing excluded
try({

##--- Distance Matrix Plot
pdb <- read.pdb( "4q21" )
k <- dm(pdb,inds="calpha")
filled.contour(k, nlevels = 10)

## NOTE: FOLLOWING EXAMPLE NEEDS MUSCLE INSTALLED
if(check.utility("muscle")) {

##--- DDM: Difference Distance Matrix
# Downlaod and align two PDB files
pdbs <- pdbaln( get.pdb( c( "4q21", "521p"), path = tempdir() ), outfile = tempfile() )

# Get distance matrix
a <- dm.xyz(pdbs$xyz[1,])
b <- dm.xyz(pdbs$xyz[2,])

# Calculate DDM
c <- a - b

# Plot DDM
plot(c,key=FALSE, grid=FALSE)

plot(c, axis.tick.space=10,
     resnum.1=pdbs$resno[1,],
     resnum.2=pdbs$resno[2,],
     grid.col="black",
     xlab="Residue No. (4q21)", ylab="Residue No. (521p)")
}

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}



## Not run:
##-- Residue-wise distance matrix based on the
##   minimal distance between all available atoms
l <- dm.xyz(pdb$xyz, grpby=pdb$atom[,"resno"], scut=3)

## End(Not run)
```

---

dssp *Secondary Structure Analysis with DSSP or STRIDE*

Description

Secondary structure assignment according to the method of Kabsch and Sander (DSSP) or the method of Frishman and Argos (STRIDE).

Usage

```
dssp(...)

## S3 method for class 'pdb'
dssp(pdb, exefile = "dssp", resno=TRUE, full=FALSE, verbose=FALSE, ...)

## S3 method for class 'pdbs'
dssp(pdbs, ...)

## S3 method for class 'xyz'
dssp(xyz, pdb, ...)

stride(pdb, exefile = "stride", resno=TRUE)

## S3 method for class 'sse'
print(x, ...)
```

Arguments

pdb	a structure object of class "pdb", obtained from read.pdb.
exefile	file path to the 'DSSP' or 'STRIDE' program on your system (i.e. how is 'DSSP' or 'STRIDE' invoked).
resno	logical, if TRUE output is in terms of residue numbers rather than residue index (position in sequence).
full	logical, if TRUE bridge pairs and hbonds columns are parsed.
verbose	logical, if TRUE 'DSSP' warning and error messages are printed.
pdbs	a list object of class "pdbs" (obtained with pdbaln or read.fasta.pdb).
xyz	a trajectory object of class "xyz", obtained from read.ncdf, read.dcd, read.crd.
x	an sse object obtained from dssp.pdb or stride.
...	additional arguments to and from functions.

Details

This function calls the 'DSSP' or 'STRIDE' program to define secondary structure and psi and phi torsion angles.

Value

Returns a list with the following components:

helix	'start', 'end', 'length', 'chain' and 'type' of helix, where start and end are residue numbers or residue index positions depending on the value of "resno" input argument.
sheet	'start', 'end' and 'length' of E type sse, where start and end are residue numbers "resno".
turn	'start', 'end' and 'length' of T type sse, where start and end are residue numbers "resno".
phi	a numeric vector of phi angles.
psi	a numeric vector of psi angles.
acc	a numeric vector of solvent accessibility.
sse	a character vector of secondary structure type per residue.
hbonds	a 10 or 16 column matrix containing the bridge pair records as well as backbone NH–>O and O–>NH H-bond records. (Only available for dssp

Note

A system call is made to the 'DSSP' or 'STRIDE' program, which must be installed on your system and in the search path for executables. See http://thegrantlab.org/bio3d/articles/online/install_vignette/Bio3D_install.html for instructions of how to install these programs.

For the hbonds list component the column names can be used as a convenient means of data access, namely:
Bridge pair 1 "BP1",
Bridge pair 2 "BP2",
Backbone H-bond (NH–>O) "NH-O.1",
H-bond energy of NH–>O "E1",
Backbone H-bond (O–>NH) "O-HN.1",
H-bond energy of O–>NH "E2",
Backbone H-bond (NH–>O) "NH-O.2",
H-bond energy of NH–>O "E3",
Backbone H-bond (O–>NH) "O-HN.2",
H-bond energy of O–>NH "E4".

If 'resno=TRUE' the following additional columns are included:
Chain ID of resno "BP1": "ChainBP1",
Chain ID of resno "BP2": "ChainBP2",
Chain ID of resno "O-HN.1": "Chain1",
Chain ID of resno "NH-O.2": "Chain2",
Chain ID of resno "O-HN.1": "Chain3",
Chain ID of resno "NH-O.2": "Chain4".

Author(s)

Barry Grant, Lars Skjaerven (dssp.pdbs)

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'DSSP' is the work of Kabsch and Sander: Kabsch and Sander (1983) *Biopolymers.* **12**, 2577–2637.

For information on obtaining 'DSSP', see:
https://swift.cmbi.umcn.nl/gv/dssp/.

'STRIDE' is the work of Frishman and Argos: Frishman and Argos (1995) *Proteins.* **3**, 566–579.

For information on obtaining the 'STRIDE' program, see:
https://webclu.bio.wzw.tum.de/stride/install.html, or copy it from an installation of VMD.

See Also

read.pdb, torsion.pdb, torsion.xyz, plot.bio3d,

read.ncdf, read.dcd, read.prmtop, read.crd,

Examples

```
## Not run:
##- PDB example
# Read a PDB file
pdb <- read.pdb("1bg2")
sse <- dssp(pdb)
sse2 <- stride(pdb)

## Short summary
sse
sse2

# Helix data
sse$helix

# Precent SSE content
sum(sse$helix$length)/sum(pdb$calpha) * 100
sum(sse$sheet$length)/sum(pdb$calpha) * 100



##- PDBs example
aln  <- read.fasta( system.file("examples/kif1a.fa",package="bio3d") )
pdbs <- read.fasta.pdb( aln )

## Aligned PDB defined secondary structure
pdbs$sse

## Aligned DSSP defined secondary structure
sse <- dssp(pdbs)


##- XYZ Trajectory
pdb <- read.pdb("2mda", multi=TRUE)
dssp.xyz(pdb$xyz, pdb)
```

```
## Note. for large MD trajectories you may want to skip some frames, e.g.
xyz <- rbind(pdb$xyz, pdb$xyz)       ## dummy trajectory
frames <- seq(1, to=nrow(xyz), by=4) ## frame numbers to examine
ss <- dssp.xyz(xyz[frames, ], pdb)      ## matrix of sse frame x residue


## End(Not run)
```

`elements` *Periodic Table of the Elements*

Description

This data set gives various information on chemical elements.

Usage

```
elements
```

Format

A data frame containing for each chemical element the following information.

`num` atomic number

`symb` elemental symbol

`areneg` Allred and Rochow electronegativity (0.0 if unknown)

`rcov` covalent radii (in Angstrom) (1.6 if unknown)

`rbo` "bond order" radii

`rvdw` van der Waals radii (in Angstrom) (2.0 if unknown)

`maxbnd` maximum bond valence (6 if unknown)

`mass` IUPAC recommended atomic masses (in amu)

`elneg` Pauling electronegativity (0.0 if unknown)

`ionization` ionization potential (in eV) (0.0 if unknown)

`elaffinity` electron affinity (in eV) (0.0 if unknown)

`red` red value for visualization

`green` green value for visualization

`blue` blue value for visualization

`name` element name

Source

Open Babel (2.3.1) file: element.txt

Created from the Blue Obelisk Cheminformatics Data Repository
Direct Source: http://www.blueobelisk.org/
http://www.blueobelisk.org/repos/blueobelisk/elements.xml includes furhter bibliographic citation information

- Allred and Rochow Electronegativity from http://www.hull.ac.uk/chemistry/electroneg.php?type=Allred-Rochow
- Covalent radii from http://dx.doi.org/10.1039/b801115j
- Van der Waals radii from http://dx.doi.org/10.1021/jp8111556

Examples

```
data(elements)
elements

# Get the mass of some elements
symb <- c("C","O","H")
elements[match(symb,elements[,"symb"]),"mass"]

# Get the van der Waals radii of some elements
symb <- c("C","O","H")
elements[match(symb,elements[,"symb"]),"rvdw"]
```

---

entropy *Shannon Entropy Score*

Description

Calculate the sequence entropy score for every position in an alignment.

Usage

```
entropy(alignment)
```

Arguments

alignment	sequence alignment returned from read.fasta or an alignment character matrix.

Details

Shannon's information theoretic entropy (Shannon, 1948) is an often-used measure of residue diversity and hence residue conservation.

Value

Returns a list with five components:

`H`	standard entropy score for a 22-letter alphabet.
`H.10`	entropy score for a 10-letter alphabet (see below).
`H.norm`	normalized entropy score (for 22-letter alphabet), so that conserved (low entropy) columns (or positions) score 1, and diverse (high entropy) columns score 0.
`H.10.norm`	normalized entropy score (for 10-letter alphabet), so that conserved (low entropy) columns score 1 and diverse (high entropy) columns score 0.
`freq`	residue frequency matrix containing percent occurrence values for each residue type.

Note

In addition to the standard entropy score (based on a 22-letter alphabet of the 20 standard aminoacids, plus a gap character '-' and a mask character 'X'), an entropy score, `H.10`, based on a 10-letter alphabet is also returned.

For `H.10`, residues from the 22-letter alphabet are classified into one of 10 types, loosely following the convention of Mirny and Shakhnovich (1999): Hydrophobic/Aliphatic [V,I,L,M], Aromatic [F,W,Y], Ser/Thr [S,T], Polar [N,Q], Positive [H,K,R], Negative [D,E], Tiny [A,G], Proline [P], Cysteine [C], and Gaps [-,X].

The residue code 'X' is useful for handling non-standard aminoacids.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Shannon (1948) *The System Technical J.* **27**, 379–422.

Mirny and Shakhnovich (1999) *J. Mol. Biol.* **291**, 177–196.

See Also

`consensus`, `read.fasta`

Examples

```
# Read HIV protease alignment
aln <- read.fasta(system.file("examples/hivp_xray.fa",package="bio3d"))

# Entropy and consensus
h   <- entropy(aln)
con <- consensus(aln)
```

```
names(h$H)=con$seq
print(h$H)

# Entropy for sub-alignment (positions 1 to 20)
h.sub <- entropy(aln$ali[,1:20])

# Plot entropy and residue frequencies (excluding positions >=60 percent gaps)
H <- h$H.norm
H[ apply(h$freq[21:22,],2,sum)>=0.6 ] = 0

col <- mono.colors(32)
aa  <- rev(rownames(h$freq))
oldpar <- par(no.readonly=TRUE)
layout(matrix(c(1,2),2,1,byrow = TRUE), widths = 7,
       heights = c(2, 8), respect = FALSE)

# Plot 1: entropy
par(mar = c(0, 4, 2, 2))
barplot(H, border="white", ylab = "Entropy",
        space=0, xlim=c(3.7, 97.3),yaxt="n" )
axis(side=2, at=c(0.2,0.4, 0.6, 0.8))
axis(side=3, at=(seq(0,length(con$seq),by=5)-0.5),
     labels=seq(0,length(con$seq),by=5))
box()

# Plot2: residue frequencies
par(mar = c(5, 4, 0, 2))
image(x=1:ncol(con$freq),
      y=1:nrow(con$freq),
      z=as.matrix(rev(as.data.frame(t(con$freq)))),
      col=col, yaxt="n", xaxt="n",
      xlab="Alignment Position", ylab="Residue Type")
axis(side=1, at=seq(0,length(con$seq),by=5))
axis(side=2, at=c(1:22), labels=aa)
axis(side=3, at=c(1:length(con$seq)), labels =con$seq)
axis(side=4, at=c(1:22), labels=aa)
grid(length(con$seq), length(aa))
box()

for(i in 1:length(con$seq)) {
  text(i, which(aa==con$seq[i]),con$seq[i],col="white")
}
abline(h=c(3.5, 4.5, 5.5, 3.5, 7.5, 9.5,
         12.5, 14.5, 16.5, 19.5), col="gray")

par(oldpar)
```

`example.data` *Bio3d Example Data*

Description

These data sets contain the results of running various Bio3D functions on example kinesin and transducin structural data, and on a short coarse-grained MD simulation data for HIV protease. The main purpose of including this data (which may be generated by the user by following the extended examples documented within the various Bio3D functions) is to speed up example execution. It should allow users to more quickly appreciate the capabilities of functions that would otherwise require raw data download, input and processing before execution.

Note that related datasets formed the basis of the work described in (Grant, 2007) and (Yao & Grant, 2013) for `kinesin` and `transducin` examples, respectively.

Usage

```
data(kinesin)
data(transducin)
data(hivp)
```

Format

Three objects from analysis of the `kinesin` and `transducin` sequence and structure data:

1. pdbs is a list of class `pdbs` containing aligned PDB structure data. In the case of transducin this is the output of running `pdbaln` on a set of 53 G[alpha]i structures from the PDB database (see `pdbs$id` or `annotation` described below for details). The coordinates are fitted onto the first structure based on `"core"` positions obtained from `core.find` and superposed using the function `pdbfit`.
2. core is a list of class `"core"` obtained by running the function `core.find` on the `pdbs` object as described above.
3. annotation is a character matrix describing the nucleotide state and bound ligand species for each structure in `pdbs` as obtained from the function `pdb.annotate`.

One object named `net` in the hivp example data stores the correlation network obtained from the analysis of the MD simulation trajectory of HIV protease using the `cna` function. The original trajectory file can be accessed by the command 'system.file("examples/hivp.dcd", package="bio3d")'.

Source

A related but more extensive dataset formed the basis of the work described in (Grant, 2007) and (Yao & Grant, 2013) for `kinesin` and `transducin` examples, respectively.

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Grant, B.J. et al. (2007) *J. Mol. Biol.* **368**, 1231–1248.

Yao, X.Q. et al. (2013) *Biophys. J.* **105**, L08–L10.

filter.cmap *Contact Map Consensus Filtering*

Description

This function filters a tridimensional contact matrix (NxNxZ), where N is the residue number and Z is the simulation number) selecting only contacts present in at least P simulations.

Usage

```
filter.cmap(cm, cutoff.sims = NULL)
```

Arguments

cm	An array of dimensions NxNxZ or a list of NxN matrices containing binary contact values as obtained from cmap. Here, 'N' is the residue number and 'Z' the simulation number. The matrix elements should be 1 if two residues are in contact and 0 if they are not in contact.
cutoff.sims	A single element numeric vector corresponding to the minimum number of simulations a contact between two residues must be present. If not, it will be set to 0 in the output matrix.

Value

The output matrix is a nXn binary matrix (n = residue number). Elements equal to 1 correspond to residues in contact, elements equal to 0 to residues not in contact.

See Also

cmap, plot.cmap

Examples

```
## Not run:
   ## load example data
  pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
  pdb <- read.pdb(pdbfile)

  trtfile <- system.file("examples/hivp.dcd", package="bio3d")
  trj <- read.dcd(trtfile, verbose=FALSE)

  ## split the trj example in two
  num.of.frames <- dim(trj)[1]
  trj1 <- trj[1:(num.of.frames/2),]
  trj2 <- trj[((num.of.frames/2)+1):num.of.frames,]

  ## Lets work with Calpha atoms only
  ca.inds <- atom.select(pdb, "calpha")
```

```
  #noh.inds <- atom.select(pdb, "noh")

  ## calculate single contact map matrices
  cms <- list()
  cms[[1]] <- cmap(trj1[,ca.inds$xyz], pcut=0.3, scut=0, dcut=7, mask.lower=FALSE)
  cms[[2]] <- cmap(trj1[,ca.inds$xyz], pcut=0.3, scut=0, dcut=7, mask.lower=FALSE)

  ## calculate average contact matrix
  cm.filter <- filter.cmap(cms, cutoff.sims=2)

  ## plot the result
  par(pty="s", mfcol=c(1,3))
  plot.cmap(cms[[1]])
  plot.cmap(cms[[2]])
  plot.cmap(cm.filter)

## End(Not run)
```

`filter.dccm` *Filter for Cross-correlation Matrices (Cij)*

Description

This function builds various cij matrix for correlation network analysis

Usage

```
filter.dccm(x, cutoff.cij = NULL, cmap = NULL, xyz = NULL, fac = NULL,
    cutoff.sims = NULL, collapse = TRUE, extra.filter = NULL, ...)
```

Arguments

`x`	A matrix (nXn), a numeric array with 3 dimensions (nXnXm), a list with m cells each containing nXn matrix, or a list with 'all.dccm' component, containing atomic correlation values, where "n" is the number of residues and "m" the number of calculations. The matrix elements should be in between -1 and 1. See 'dccm' function in bio3d package for further details.
`cutoff.cij`	Threshold for each individual correlation value. If NULL, a guessed value will be used. See below for details.
`cmap`	logical or numerical matrix indicating the contact map. If logical and TRUE, contact map will be calculated with input `xyz`.
`xyz`	XYZ coordinates, or a 'pdbs' object obtained from `pdbaln` or `read.fasta.pdb`, for contact map calculations.
`fac`	factor indicating distinct categories of input correlation matrices.
`cutoff.sims`	Threshold for the number of simulations with observed correlation value above `cutoff.cij` for the same residue/atomic pairs. See below for details.
`collapse`	logical, if TRUE the mean matrix will be returned.

extra.filter	Filter to apply in addition to the model chosen.
...	extra arguments passed to function cmap.

Details

If cmap is TRUE or provided a numerical matrix, the function inspects a set of cross-correlation matrices, or DCCM, and decides edges for correlation network analysis based on:

1. min(abs(cij)) >= cutoff.cij, or 2. max(abs(cij)) >= cutoff.cij && residues contact each other based on results from cmap.

Otherwise, the function filters DCCMs with cutoff.cij and return the mean of correlations present in at least cutoff.sims calculated matrices.

An internally guessed cuoff.cij is used if cutoff.cij=NULL is provided. By default, the cutoff is determined by keeping 5% of all residue pairs connected.

Value

Returns a matrix of class "dccm" or a 3D array of filtered cross-correlations.

Author(s)

Xin-Qiu Yao, Guido Scarabelli & Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

cna, dccm, dccm.nma, dccm.xyz, cmap, plot.dccm

Examples

```
## Not run:

# Example of transducin
attach(transducin)

gaps.pos <- gap.inspect(pdbs$xyz)
modes <- nma.pdbs(pdbs, ncore=NULL)
dccms <- dccm.enma(modes, ncore=NULL)

cij <- filter.dccm(dccms, xyz=pdbs)

# Example protein kinase
# Select Protein Kinase PDB IDs
ids <- c("4b7t_A", "2exm_A", "1opj_A", "4jaj_A", "1a9u_A",
                 "1tki_A", "1csn_A", "1lp4_A")

# Download and split by chain ID
files <- get.pdb(ids, path = "raw_pdbs", split=TRUE)
```

```
# Alignment of structures
pdbs <- pdbaln(files) # Sequence identity
summary(c(seqidentity(pdbs)))

# NMA on all structures
modes <- nma.pdbs(pdbs, ncore=NULL)

# Calculate correlation matrices for each structure
cij <- dccm(modes)

# Set DCCM plot panel names for combined figure
dimnames(cij$all.dccm) = list(NULL, NULL, ids)
plot.dccm(cij$all.dccm)

# Filter to display only correlations present in all structures
cij.all <- filter.dccm(cij, cutoff.sims = 8, cutoff.cij = 0)
plot.dccm(cij.all, main = "Consensus Residue Cross Correlation")

detach(transducin)

## End(Not run)
```

`filter.identity` *Percent Identity Filter*

Description

Identify and filter subsets of sequences at a given sequence identity cutoff.

Usage

```
filter.identity(aln = NULL, ide = NULL, cutoff = 0.6, verbose = TRUE, ...)
```

Arguments

`aln`	sequence alignment list, obtained from `seqaln` or `read.fasta`, or an alignment character matrix. Not used if 'ide' is given.
`ide`	an optional identity matrix obtained from `seqidentity`.
`cutoff`	a numeric identity cutoff value ranging between 0 and 1.
`verbose`	logical, if TRUE print details of the clustering process.
`...`	additional arguments passed to and from functions.

Details

This function performs hierarchical cluster analysis of a given sequence identity matrix 'ide', or the identity matrix calculated from a given alignment 'aln', to identify sequences that fall below a given identity cutoff value 'cutoff'.

Value

Returns a list object with components:

ind	indices of the sequences below the cutoff value.
tree	an object of class "hclust", which describes the tree produced by the clustering process.
ide	a numeric matrix with all pairwise identity values.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, seqaln, seqidentity, entropy, consensus

Examples

```
attach(kinesin)

ide.mat <- seqidentity(pdbs)

# Histogram of pairwise identity values
op <- par(no.readonly=TRUE)
par(mfrow=c(2,1))
hist(ide.mat[upper.tri(ide.mat)], breaks=30,xlim=c(0,1),
     main="Sequence Identity", xlab="Identity")

k <- filter.identity(ide=ide.mat, cutoff=0.6)
ide.cut <- seqidentity(pdbs$ali[k$ind,])
hist(ide.cut[upper.tri(ide.cut)], breaks=10, xlim=c(0,1),
     main="Sequence Identity", xlab="Identity")

#plot(k$tree, axes = FALSE, ylab="Sequence Identity")
#print(k$ind) # selected
par(op)
detach(kinesin)
```

`filter.rmsd` *RMSD Filter*

Description

Identify and filter subsets of conformations at a given RMSD cutoff.

Usage

```
filter.rmsd(xyz = NULL, rmsd.mat = NULL, cutoff = 0.5,
            fit = TRUE, verbose = TRUE, inds = NULL, method = "complete",
            ...)
```

Arguments

`xyz`	a numeric matrix or list object containing multiple coordinates for pairwise comparison, such as that obtained from `read.fasta.pdb`. Not used if `rmsd.mat` is given.
`rmsd.mat`	an optional matrix of RMSD values obtained from `rmsd`.
`cutoff`	a numeric rmsd cutoff value.
`fit`	logical, if TRUE coordinate superposition is performed prior to RMSD calculation.
`verbose`	logical, if TRUE progress details are printed.
`inds`	a vector of indices that selects the elements of `xyz` upon which the calculation should be based. By default, all the non-gap sites in `xyz`.
`method`	the agglomeration method to be used. See function `hclust` for more information.
`...`	additional arguments passed to and from functions.

Details

This function performs hierarchical cluster analysis of a given matrix of RMSD values 'rmsd.mat', or an RMSD matrix calculated from a given coordinate matrix 'xyz', to identify conformers that fall below a given RMSD cutoff value 'cutoff'.

Value

Returns a list object with components:

`ind`	indices of the conformers (rows) below the cutoff value.
`tree`	an object of class `"hclust"`, which describes the tree produced by the clustering process.
`rmsd.mat`	a numeric matrix with all pairwise RMSD values.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

rmsd, read.pdb, read.fasta.pdb, read.dcd

Examples

```
## Not run:
attach(kinesin)

k <- filter.rmsd(xyz=pdbs,cutoff=0.5)
pdbs$id[k$ind]
hclustplot(k$tree, h=0.5, ylab="RMSD")
abline(h=0.5, col="gray")

detach(kinesin)

## End(Not run)
```

---

fit.xyz *Coordinate Superposition*

Description

Coordinate superposition with the Kabsch algorithm.

Usage

```
fit.xyz(fixed, mobile,
        fixed.inds  = NULL,
        mobile.inds = NULL,
        verbose=FALSE,
        prefix= "", pdbext = "",
        outpath = "fitlsq", full.pdbs=FALSE,
        ncore = 1, nseg.scale = 1, ...)

rot.lsq(xx, yy,
        xfit = rep(TRUE, length(xx)), yfit = xfit,
        verbose = FALSE)
```

Arguments

fixed	numeric vector of xyz coordinates.
mobile	numeric vector, numeric matrix, or an object with an xyz component containing one or more coordinate sets.
fixed.inds	a vector of indices that selects the elements of fixed upon which fitting should be based.
mobile.inds	a vector of indices that selects the elements of mobile upon which fitting should be based.
full.pdbs	logical, if TRUE "full" coordinate files (i.e. all atoms) are written to the location specified by outpath.
prefix	prefix to mobile$id to locate "full" input PDB files. Only required if full.pdbs is TRUE.
pdbext	the file name extension of the input PDB files.
outpath	character string specifing the output directory when full.pdbs is TRUE.
xx	numeric vector corresponding to the moving 'subject' coordinate set.
yy	numeric vector corresponding to the fixed 'target' coordinate set.
xfit	logical vector with the same length as xx, with TRUE elements corresponding to the subset of positions upon which fitting is to be performed.
yfit	logical vector with the same length as yy, with TRUE elements corresponding to the subset of positions upon which fitting is to be performed.
verbose	logical, if TRUE more details are printed.
...	other parameters for read.pdb.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
nseg.scale	split input data into specified number of segments prior to running multiple core calculation.

Details

The function fit.xyz is a wrapper for the function rot.lsq, which performs the actual coordinate superposition. The function rot.lsq is an implementation of the Kabsch algorithm (Kabsch, 1978) and evaluates the optimal rotation matrix to minimize the RMSD between two structures.

Since the Kabsch algorithm assumes that the number of points are the same in the two input structures, care should be taken to ensure that consistent atom sets are selected with fixed.inds and mobile.inds.

Optionally, "full" PDB file superposition and output can be accomplished by setting full.pdbs=TRUE. In that case, the input (mobile) passed to fit.xyz should be a list object obtained with the function read.fasta.pdb, since the components id, resno and xyz are required to establish correspondences. See the examples below.

In dealing with large vector and matrix, running on multiple cores, especially when ncore>>1, may ask for a large portion of system memory. To avoid the overuse of memory, input data is first split into segments (for xyz matrix, the splitting is along the row). The number of data segments is equal to nseg.scale*nseg.base, where nseg.base is an integer determined by the dimension of the data.

Value

Returns moved coordinates.

Author(s)

Barry Grant with `rot.lsq` contributions from Leo Caves

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Kabsch *Acta Cryst* (1978) **A34**, 827–828.

See Also

`rmsd`, `read.pdb`, `read.fasta.pdb`, `read.dcd`

Examples

```
# PDB server connection required - testing excluded
try({

##--- Read an alignment & Fit aligned structures
aln  <- read.fasta(system.file("examples/kif1a.fa",package="bio3d"))
pdbs <- read.fasta.pdb(aln)

gaps <- gap.inspect(pdbs$xyz)

xyz <- fit.xyz( fixed  = pdbs$xyz[1,],
                mobile = pdbs$xyz,
                fixed.inds  = gaps$f.inds,
                mobile.inds = gaps$f.inds )

#rmsd( xyz[, gaps$f.inds] )
#rmsd( pdbs$xyz[, gaps$f.inds] )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}

## Not run:
##-- Superpose again this time outputing PDBs
xyz <- fit.xyz( fixed = pdbs$xyz[1,],
                mobile = pdbs,
                fixed.inds  = gaps$f.inds,
                mobile.inds = gaps$f.inds,
                outpath = "rough_fit",
                full.pdbs = TRUE)

## End(Not run)
```

```
try({

##--- Fit two PDBs
A <- read.pdb("1bg2")
A.ind <- atom.select(A, resno=c(256:269), elety='CA')

B <- read.pdb("2kin")
B.ind <- atom.select(B, resno=c(257:270), elety='CA')

xyz <- fit.xyz(fixed=A$xyz, mobile=B$xyz,
               fixed.inds=A.ind$xyz,
               mobile.inds=B.ind$xyz)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}

## Not run:
# Write out moved PDB
C <- B; C$xyz = xyz
write.pdb(pdb=C, file = "moved.pdb")

## End(Not run)
```

`fluct.nma` *NMA Fluctuations*

Description

Calculates the atomic fluctuations from normal modes analysis.

Usage

```
fluct.nma(nma, mode.inds=NULL)
```

Arguments

`nma`	a list object of class `"nma"` (obtained with `nma`).
`mode.inds`	a numeric vector containing the the mode numbers in which the calculation should be based.

Details

Atomic fluctuations are calculated based on the `nma` object. By default all modes are included in the calculation.

See examples for more details.

Value

Returns a numeric vector of atomic fluctuations.

Author(s)

Lars Skjaerven

References

Hinsen, K. et al. (2000) *Chemical Physics* **261**, 25–37. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma

Examples

```
## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate (vibrational) normal modes
modes <- nma(pdb)

## Fluctuations
f <- fluct.nma(modes)

## Fluctuations of first non-trivial mode
f <- fluct.nma(modes, mode.inds=c(7,8))
```

---

formula2mass *Chemical Formula to Mass Converter*

Description

Compute the molar mass associated to a chemical formula.

Usage

```
formula2mass(form, sum.mass = TRUE)
```

Arguments

form	a character string containing a chemical formula on the form: 'C3 H5 N O1'.
sum.mass	logical, should the mass of each element be summed.

Details

Compute the molar mass (in g.mol-1) associated to a chemical formula.

Value

Return a single element numeric vector containing the mass corresponding to a given chemical formula.

Author(s)

Lars Skjaerven

See Also

atom2ele, atom2mass

Examples

```
#formula2mass("C5 H6 N O3")
```

---

gap.inspect *Alignment Gap Summary*

Description

Report the number of gaps per sequence and per position for a given alignment.

Usage

```
gap.inspect(x)
```

Arguments

x	a matrix or an alignment data structure obtained from read.fasta or read.fasta.pdb.

Details

Reports the number of gap characters per row (i.e. sequence) and per column (i.e. position) for a given alignment. In addition, the indices for gap and non-gap containing coloums are returned along with a binary matrix indicating the location of gap positions.

Value

Returns a list object with the following components:

row	a numeric vector detailing the number of gaps per row (i.e. sequence).
col	a numeric vector detailing the number of gaps per column (i.e. position).
t.inds	indices for gap containing coloums
f.inds	indices for non-gap containing coloums
bin	a binary numeric matrix with the same dimensions as the alignment, with 0 at non-gap positions and 1 at gap positions.

Note

During alignment, gaps are introduced into sequences that are believed to have undergone deletions or insertions with respect to other sequences in the alignment. These gaps, often referred to as indels, can be represented with 'NA', a '-' or '.' character.

This function gives an overview of gap occurrence and may be useful when considering positions or sequences that could/should be excluded from further analysis.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, read.fasta.pdb

Examples

```
aln <- read.fasta( system.file("examples/hivp_xray.fa",
                  package = "bio3d") )

gap.stats <- gap.inspect(aln$ali)
gap.stats$row # Gaps per sequence
gap.stats$col # Gaps per position
##gap.stats$bin # Binary matrix (1 for gap, 0 for aminoacid)
##aln[,gap.stats$f.inds] # Alignment without gap positions

plot(gap.stats$col, typ="h", ylab="No. of Gaps")
```

---

geostas *GeoStaS Domain Finder*

Description

Identifies geometrically stable domains in biomolecules

Usage

```
geostas(...)

## Default S3 method:
geostas(...)

## S3 method for class 'xyz'
geostas(xyz, amsm = NULL, k = 3, pairwise = TRUE,
```

```
      clustalg = "kmeans", fit = TRUE, ncore = NULL, verbose=TRUE, ...)

## S3 method for class 'nma'
geostas(nma, m.inds = 7:11, verbose=TRUE, ...)

## S3 method for class 'enma'
geostas(enma, pdbs = NULL, m.inds = 1:5, verbose=TRUE, ...)

## S3 method for class 'pdb'
geostas(pdb, inds = NULL, verbose=TRUE, ...)

## S3 method for class 'pdbs'
geostas(pdbs, verbose=TRUE, ...)

amsm.xyz(xyz, ncore = NULL)

## S3 method for class 'geostas'
print(x, ...)
```

Arguments

...	arguments passed to and from functions, such as kmeans, and hclust which are called internally in geostas.xyz.
xyz	numeric matrix of xyz coordinates as obtained e.g. by read.ncdf, read.dcd, or mktrj.
amsm	a numeric matrix as obtained by amsm.xyz (convenient e.g. for re-doing only the clustering analysis of the 'AMSM' matrix).
k	an integer scalar or vector with the desired number of groups.
pairwise	logical, if TRUE use pairwise clustering of the atomic movement similarity matrix (AMSM), else columnwise.
clustalg	a character string specifing the clustering algorithm. Allowed values are 'kmeans' and 'hclust'.
fit	logical, if TRUE coordinate superposition on identified core atoms is performed prior to the calculation of the AMS matrix.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
verbose	logical, if TRUE details of the geostas calculations are printed to screen.
nma	an 'nma' object as obtained from function nma. Function mktrj is used internally to generate a trajectory based on the normal modes.
m.inds	the mode number(s) along which trajectory should be made (see function mktrj).
enma	an 'enma' object as obtained from function nma.pdbs. Function mktrj is used internally to generate a trajectory based on the normal modes.
pdbs	a 'pdbs' object as obtained from function pdbaln or read.fasta.pdb.
pdb	a 'pdb' object as obtained from function read.pdb.

inds	a 'select' object as obtained from function atom.select giving the atomic indices at which the calculation should be based. By default the function will attempt to locate C-alpha atoms using function atom.select.
x	a 'geostas' object as obtained from function geostas.

Details

This function attempts to identify rigid domains in a protein (or nucleic acid) structure based on an structural ensemble, e.g. obtained from NMR experiments, molecular dynamics simulations, or normal mode analysis.

The algorithm is based on a geometric approach for comparing pairwise traces of atomic motion and the search for their best superposition using a quaternion representation of rotation. The result is stored in a NxN atomic movement similarity matrix (AMSM) describing the correspondence between all pairs of atom motion. Rigid domains are obtained by clustering the elements of the AMS matrix (pairwise=TRUE), or alternatively, the columns similarity (pairwise=FALSE), using either K-means (kmeans) or hierarchical (hclust) clustering.

Compared to the conventional cross-correlation matrix (see function dccm) the "geostas" approach provide functionality to also detect domains involved in rotational motions (i.e. two atoms located on opposite sides of a rotating domain will appear as anti-correlated in the cross-correlation matrix, but should obtain a high similarity coefficient in the AMS matrix).

See examples for more details.

Value

Returns a list object of type 'geostas' with the following components:

amsm	a numeric matrix of atomic movement similarity (AMSM).
fit.inds	a numeric vector of xyz indices used for fitting.
grps	a numeric vector containing the domain assignment per residue.
atomgrps	a numeric vector containing the domain assignment per atom (only provided for geostas.pdb).
inds	a list of atom 'select' objects with indices to corresponding to the identified domains.

Note

The current implementation in Bio3D uses a different fitting and clustering approach than the original Java implementation. The results will therefore differ.

Author(s)

Julia Romanowska and Lars Skjaerven

References

Romanowska, J. et al. (2012) *JCTC* **8**, 2588–2599. Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.geostas, read.pdb, mktrj, read.ncdf, read.dcd, nma, dccm.

Examples

```
# PDB server connection required - testing excluded
try({

#### NMR-ensemble example
## Read a multi-model PDB file
pdb <- read.pdb("1d1d", multi=TRUE)

## Find domains and write PDB
gs  <- geostas(pdb, fit=TRUE)

## Plot a atomic movement similarity matrix
plot.geostas(gs, contour=FALSE)

## Fit all frames to the 'first' domain
domain.inds <- gs$inds[[1]]

xyz <- pdbfit(pdb, inds=domain.inds)

#write.pdb(pdb, xyz=xyz, chain=gs$atomgrps)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}


## Not run:
#### NMA example
## Fetch stucture
pdb <- read.pdb("1crn")

## Calculate (vibrational) normal modes
modes <- nma(pdb)

## Find domains
gs <- geostas(modes, k=2)

## Write NMA trajectory with domain assignment
mktrj(modes, mode=7, chain=gs$grps)

## Redo geostas domain clustering
gs <- geostas(modes, amsm=gs$amsm, k=5)



#### Trajectory example
```

```
## Read inn DCD trajectory file, fit coordinates
dcdfile <- system.file("examples/hivp.dcd", package = "bio3d")
trj <- read.dcd(dcdfile)
xyz <- fit.xyz(trj[1,], trj)

## Find domains
gs <- geostas(xyz, k=3, fit=FALSE)

## Principal component analysis
pc.md <- pca.xyz(xyz)

## Visualize PCs with colored domains (chain ID)
mktrj(pc.md, pc=1, chain=gs$grps)




#### X-ray ensemble GroEL subunits
# Define the ensemble PDB-ids
ids <- c("1sx4_[A,B,H,I]", "1xck_[A-B]", "1sx3_[A-B]", "4ab3_[A-B]")

# Download and split PDBs by chain ID
raw.files <- get.pdb(ids, path = "raw_pdbs", gzip = TRUE)
files <- pdbsplit(raw.files, ids, path = "raw_pdbs/split_chain/")

# Align structures
pdbs <- pdbaln(files)

# Find domains
gs <- geostas(pdbs, k=4, fit=TRUE)

# Superimpose to core region
pdbs$xyz <- pdbfit(pdbs, inds=gs$fit.inds)

# Principal component analysis
pc.xray <- pca(pdbs)

# Visualize PCs with colored domains (chain ID)
mktrj(pc.xray, pc=1, chain=gs$grps)


##- Same, but more manual approach
gaps.pos <- gap.inspect(pdbs$xyz)

# Find core region
core <- core.find(pdbs)

# Fit to core region
xyz <- fit.xyz(pdbs$xyz[1, gaps.pos$f.inds],
               pdbs$xyz[, gaps.pos$f.inds],
               fixed.inds=core$xyz,
               mobile.inds=core$xyz)
```

```
# Find domains
gs <- geostas(xyz, k=4, fit=FALSE)

# Perform PCA
pc.xray <- pca.xyz(xyz)

# Make trajectory
mktrj(pc.xray, pc=1, chain=gs$grps)


## End(Not run)
```

---

get.pdb *Download PDB Coordinate Files*

Description

Downloads PDB coordinate files from the RCSB Protein Data Bank.

Usage

```
get.pdb(ids, path = ".", URLonly=FALSE, overwrite = FALSE, gzip = FALSE,
     split = FALSE, format = "pdb", verbose = TRUE, ncore = 1, ...)
```

Arguments

ids	A character vector of one or more 4-letter PDB codes/identifiers or 6-letter PDB-ID_Chain-ID of the files to be downloaded, or a 'blast' object containing 'pdb.id'.
path	The destination path/directory where files are to be written.
URLonly	logical, if TRUE a character vector containing the URL path to the online file is returned and files are not downloaded. If FALSE the files are downloaded.
overwrite	logical, if FALSE the file will not be downloaded if it alread exist.
gzip	logical, if TRUE the gzipped PDB will be downloaded and extracted locally.
split	logical, if TRUE pdbsplit funciton will be called to split pdb files into separated chains.
format	format of the data file: 'pdb' or 'cif' for PDB and mmCIF file formats, respectively.
verbose	print details of the reading process.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
...	extra arguments passed to pdbsplit function.

Details

This is a basic function to automate file download from the PDB.

Value

Returns a list of successfully downloaded files. Or optionally if URLonly is TRUE a list of URLs for said files.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

read.pdb, write.pdb, atom.select, read.fasta.pdb, read.fasta, pdbsplit

Examples

```
# PDB server connection required - testing excluded
try({

## PDB file paths
get.pdb( c("1poo", "1moo"), URLonly=TRUE )

## These URLs can be used by 'read.pdb'
pdb <- read.pdb( get.pdb("5p21", URL=TRUE) )
summary(pdb)

## Download PDB file
## get.pdb("5p21")

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

get.seq *Download FASTA Sequence Files*

Description

Downloads FASTA sequence files from the NCBI nr, SWISSPROT/UNIPROT, OR RCSB PDB databases.

Usage

```
get.seq(ids, outfile = "seqs.fasta", db = "nr", verbose = FALSE)
```

Arguments

ids	A character vector of one or more appropriate database codes/identifiers of the files to be downloaded.
outfile	A single element character vector specifying the name of the local file to which sequences will be written.
db	A single element character vector specifying the database from which sequences are to be obtained.
verbose	logical, if TRUE URL details of the download process are printed.

Details

This is a basic function to automate sequence file download from the databases including NCBI nr, SWISSPROT/UNIPROT, and RCSB PDB.

Value

If all files are successfully downloaded a list object with two components is returned:

ali	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
ids	sequence names as identifiers.

This is similar to that returned by read.fasta. However, if some files were not successfully downloaded then a vector detailing which ids were not found is returned.

Note

For a description of FASTA format see: https://www.ncbi.nlm.nih.gov/BLAST/blastcgihelp.shtml. When reading alignment files, the dash '-' is interpreted as the gap character.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

blast.pdb, read.fasta, read.fasta.pdb, get.pdb

Examples

```
## Not run:
## Sequence identifiers (GI or PDB codes e.g. from blast.pdb etc.)
get.seq( c("P01112", "Q61411", "P20171") )

#aa <-get.seq( c("4q21", "5p21") )
#aa$id
#aa$ali

## End(Not run)
```

---

gnm *Gaussian Network Model*

Description

Perform Gaussian network model (GNM) based normal mode analysis (NMA) for a protein structure.

Usage

```
gnm(x, ...)

## S3 method for class 'pdb'
gnm(x, inds = NULL, temp = 300, keep = NULL,
  outmodes = NULL, gamma = 1, cutoff = 8, check.connect = TRUE, ...)

## S3 method for class 'pdbs'
gnm(x, fit = TRUE, full = FALSE, subspace = NULL,
  rm.gaps = TRUE, gc.first = TRUE, ncore = NULL, ...)
```

Arguments

x	an object of class pdb as obtained from function read.pdb.
...	(in gnm.pdbs) additional arguments passed to gnm.pdb.
inds	atom and xyz coordinate indices obtained from atom.select that selects the elements of pdb upon which the calculation should be based. If not provided the function will attempt to select all calpha atoms automatically.
temp	numerical, temperature for which the amplitudes for scaling the atomic displacement vectors are calculated. Set 'temp=NULL' to avoid scaling.
keep	numerical, final number of modes to be stored. Note that all subsequent analyses are limited to this subset of modes. This option is useful for very large structures and cases where memory may be limited.
outmodes	atom indices as obtained from atom.select specifying the atoms to include in the resulting mode object.
gamma	numerical, global scale of the force constant.

cutoff	numerical, distance cutoff for pair-wise interactions.
check.connect	logical, if TRUE check chain connectivity.
fit	logical, if TRUE C-alpha coordinate based superposition is performed prior to normal mode calculations.
full	logical, if TRUE return the complete, full structure, 'nma' objects.
subspace	number of eigenvectors to store for further analysis.
rm.gaps	logical, if TRUE obtain the hessian matrices for only atoms in the aligned positions (non-gap positions in all aligned structures). Thus, gap positions are removed from output.
gc.first	logical, if TRUE will call gc() first before mode calculation for each structure. This is to avoid memory overload when ncore > 1.
ncore	number of CPU cores used to do the calculation.

Details

This function builds a Gaussian network model (an isotropic elastic network model) for C-alpha atoms and performs subsequent normal mode analysis (NMA). The model employs a distance cutoff for the network construction: Atom pairs with distance falling within the cutoff have a harmonic interaction with a uniform force constant; Otherwise atoms have no interaction. Output contains N-1 (N, the number of residues) non-trivial modes (i.e. the degree of freedom is N-1), which can then be used to calculate atomic fluctuations and covariance.

Value

Returns an object of class 'gnm' with the following components:

force.constants	numeric vector containing the force constants corresponding to each mode.
fluctuations	numeric vector of atomic fluctuations.
U	numeric matrix with columns containing the raw eigenvectors.
L	numeric vector containing the raw eigenvalues.
xyz	numeric matrix of class xyz containing the Cartesian coordinates in which the calculation was performed.
temp	numerical, temperature for which the amplitudes for scaling the atomic displacement vectors are calculated.
triv.modes	number of trivial modes.
natoms	number of C-alpha atoms.
call	the matched call.

Author(s)

Xin-Qiu Yao & Lars Skjaerven

References

Bahar, I. et al. (1997) *Folding Des.* **2**, 173.

See Also

gnm.pdbs

Examples

```
## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate normal modes
modes <- gnm(pdb)

## Print modes
print(modes)

## Plot modes
plot(modes)
```

---

hclustplot *Dendrogram with Clustering Annotation*

Description

Draw a standard dendrogram with clustering annotation in the marginal regions and colored labels.

Usage

```
hclustplot(hc, k = NULL, h = NULL, colors = NULL, labels = NULL,
             fillbox = FALSE, heights = c(1, .3), mar = c(1, 1, 0, 1), ...)
```

Arguments

hc	an object of the type produced by hclust.
k	an integer scalar or vector with the desired number of groups. Redirected to function cutree.
h	numeric scalar or vector with heights where the tree should be cut. Redirected to function cutree. At least one of 'k' or 'h' must be specified.
colors	a numerical or character vector with the same length as 'hc' specifying the colors of the labels.
labels	a character vector with the same length as 'hc' containing the labels to be written.
fillbox	logical, if TRUE clustering annotation will be drawn as filled boxes below the dendrogram.
heights	numeric vector of length two specifying the values for the heights of rows on the device. See function layout.

mar	a numerical vector of the form 'c(bottom, left, top, right)' which gives the number of lines of margin to be specified on the four sides of the plot. If left at default the margins will be adjusted upon adding arguments 'main', 'ylab', etc.
...	other graphical parameters passed to functions plot.dendrogram, mtext, and par. Note that certain arguments will be ignored.

Details

This function adds extended visualization of cluster membership to a standard dendrogram. If 'k' or 'h' is provided a call to cutree will provide cluster membership information. Alternatively a vector of colors or cluster membership information can be provided through argument 'colors'.

See examples for further details on usage.

Value

Called for its effect.

Note

Argument 'horiz=TRUE' currently not supported.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.hclust, plot.dendrogram, hclust, cutree.

Examples

```
# Redundant testing excluded

attach(transducin)

##- perform RMSD clustering
rd <- rmsd(pdbs, fit=TRUE)
hc <- hclust(as.dist(rd))

##- draw dendrogram
hclustplot(hc, k=3)

##- draw dendrogram with manual clustering annotation
#hclustplot(hc, colors=annotation[, "color"], labels=pdbs$id)

detach(transducin)
```

hmmer *HMMER Sequence Search*

Description

Perform a HMMER search against the PDB, NR, swissprot or other sequence and structure databases.

Usage

```
hmmer(seq, type="phmmer", db = NULL, verbose = TRUE, timeout = 90)
```

Arguments

seq	a multi-element character vector containing the query sequence. Alternatively a 'fasta' object as obtained from functions get.seq or read.fasta can be provided.
type	character string specifying the 'HMMER' job type. Current options are 'phmmer', 'hmmscan', 'hmmsearch', and 'jackhmmer'.
db	character string specifying the database to search. Current options are 'pdb', 'nr', 'swissprot', 'pfam', etc. See 'details' for a complete list.
verbose	logical, if TRUE details of the download process is printed.
timeout	integer specifying the number of seconds to wait for the blast reply before a time out occurs.

Details

This function employs direct HTTP-encoded requests to the HMMER web server. HMMER can be used to search sequence databases for homologous protein sequences. The HMMER server implements methods using probabilistic models called profile hidden Markov models (profile HMMs).

There are currently four types of HMMER search to perform:

- 'phmmer': protein sequence vs protein sequence database.
(input argument seq must be a sequence).

Allowed options for type includes: 'env_nr', 'nr', 'refseq', 'pdb', 'rp15', 'rp35', 'rp55', 'rp75', 'swissprot', 'unimes', 'uniprotkb', 'uniprotrefprot', 'pfamseq'.

- 'hmmscan': protein sequence vs profile-HMM database.
(input argument seq must be a sequence).

Allowed options for type includes: 'pfam', 'gene3d', 'superfamily', 'tigrfam'.

- 'hmmsearch': protein alignment/profile-HMM vs protein sequence database.
(input argument seq must be an alignment).

Allowed options for type includes: 'pdb', 'swissprot'.

- 'jackhmmer': iterative search vs protein sequence database.
(input argument seq must be an alignment). 'jackhmmer' functionality incomplete!!

Allowed options for type includes: 'env_nr', 'nr', 'refseq', 'pdb', 'rp15', 'rp35', 'rp55', 'rp75', 'swissprot', 'unimes', 'uniprotkb', 'uniprotrefprot', 'pfamseq'.

More information can be found at the HMMER website:
http://hmmer.org

Value

A list object with components 'hit.tbl' and 'url'. 'hit.tbl' is a data frame with multiple components depending on the selected job 'type'. Frequently reported fields include:

name	a character vector containing the name of the target.
acc	a character vector containing the accession identifier of the target.
acc2	a character vector containing secondary accession of the target.
pdb.id	same as 'acc'.
id	a character vector containing Identifier of the target
desc	a character vector containing entry description.
score	a numeric vector containing bit score of the sequence (all domains, without correction).
bitscore	same as 'score'.
pvalue	a numeric vector containing the P-value of the score.
evalue	a numeric vector containing the E-value of the score.
mlog.evalue	a numeric vector containing minus the natural log of the E-value.
nregions	a numeric vector containing Number of regions evaluated.
nenvelopes	a numeric vector containing the number of envelopes handed over for domain definition, null2, alignment, and scoring.
ndom	a numeric vector containing the total number of domains identified in this sequence.
nreported	a numeric vector containing the number of domains satisfying reporting thresholding.
nincluded	a numeric vector containing the number of domains satisfying inclusion thresholding.
taxid	a character vector containing The NCBI taxonomy identifier of the target (if applicable).
species	a character vector containing the species name.
kg	a character vector containing the kingdom of life that the target belongs to - based on placing in the NCBI taxonomy tree.

More details can be found at the HMMER website:
https://www.ebi.ac.uk/Tools/hmmer/help/api

Note

Note that the chained 'pdbs' HMMER field (used for redundant PDBs) is included directly into the result list (applies only when `db='pdb'`). In this case, the 'name' component of the target contains the parent (non redundant) entry, and the 'acc' component the chained PDB identifiers. The search results will therefore provide duplicated PDB identifiers for component `$name`, while `$acc` should be unique.

Note

Online access is required to query HMMER services.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Finn, R.D. et al. (2011) *Nucl. Acids Res.* **39**, 29–37. Eddy, S.R. (2011) *PLoS Comput Biol* **7**(10): e1002195.

See also the 'HMMER' website:
http://hmmer.org

See Also

blast.pdb, plot.blast, seqaln, get.seq, pfam, uniprot

Examples

```
## Not run:
# HMMER server connection required - testing excluded

##- PHMMER
seq <- get.seq("2abl_A", outfile=tempfile())
res <- hmmer(seq, db="pdb")

##- HMMSCAN
fam <- hmmer(seq, type="hmmscan", db="pfam")
pfam.aln <- pfam(fam$hit.tbl$acc[1])

##- HMMSEARCH
hmm <- hmmer(pfam.aln, type="hmmsearch", db="pdb")
unique(hmm$hit.tbl$species)
hmm$hit.tbl$acc


## End(Not run)
```

identify.cna *Identify Points in a CNA Protein Structure Network Plot*

Description

'identify.cna' reads the position of the graphics pointer when the (first) mouse button is pressed. It then searches the coordinates given in 'x' for the point closest to the pointer. If this point is close enough to the pointer, its index and community members will be returned as part of the value of the call and the community members will be added as labels to the plot.

Usage

```
  ## S3 method for class 'cna'
identify(x, labels=NULL, cna=NULL, ...)
```

Arguments

x	A numeric matrix with Nx2 dimensions, where N is equal to the number of objects in a 2D CNA plot such as obtained from the 'plot.cna' and various 'layout' functions.
labels	An optional character vector giving labels for the points. Will be coerced using 'as.character', and recycled if necessary to the length of 'x'. Excess labels will be discarded, with a warning.
cna	A network object as returned from the 'cna' function.
...	Extra options passed to 'identify' function.

Details

This function calls the 'identify' and 'summary.cna' functions to query and label 2D CNA protein structure network plots produced by the 'plot.cna' function. Clicking with the mouse on plot points will add the corresponding labels and them to the plot and returned list object. A click with the right mouse button will stop the function.

Value

If 'labels' or 'cna' inputs are provided then a membership vector will be returned with the selected community ids and their members. Otherwise a vector with the ids of the selected communities will be returned.

Author(s)

Guido Scarabelli and Barry Grant

See Also

plot.cna, identify, plot.igraph, plot.communities, igraph.plotting

Examples

```
## Not run:

if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

attach(hivp)

# Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

# Plot the network
xy <- plot.cna(net)

# Use identify.cna on the communities
d <- identify.cna(xy, cna=net)

# Right click to end the function...
## d <- identify(xy, summary(net)$members)

detach(hivp)

}

## End(Not run)
```

---

inner.prod *Mass-weighted Inner Product*

Description

Inner product of vectors (mass-weighted if requested).

Usage

```
inner.prod(x, y, mass=NULL)
```

Arguments

x	a numeric vector or matrix.
y	a numeric vector or matrix.
mass	a numeric vector containing the atomic masses for weighting.

Details

This function calculates the inner product between two vectors, or alternatively, the column-wise vector elements of matrices. If atomic masses are provided, the dot products will be mass-weighted.

See examples for more details.

Value

Returns the inner product(s).

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma , normalize.vector

Examples

```
## Matrix operations
x <- 1:3
y <- diag(x)
z <- matrix(1:9, ncol = 3, nrow = 3)

inner.prod(x,y)
inner.prod(y,z)


## Application to normal modes
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate (vibrational) normal modes
modes <- nma(pdb)

## Check for orthogonality
inner.prod(modes$U[,7], modes$U[,8])
```

---

inspect.connectivity *Check the Connectivity of Protein Structures*

Description

Investigate protein coordinates to determine if the structure has missing residues.

Usage

```
inspect.connectivity(pdbs, cut=4.)
```

Arguments

pdbs	an object of class 3daling as obtained from function pdbaln or read.fasta.pdb; a xyz matrix containing the cartesian coordinates of C-alpha atoms; or a 'pdb' object as obtained from function read.pdb.
cut	cutoff value to determine residue connectvitiy.

Details

Utility function for checking if the PDB structures in a 'pdbs' object contains missing residues inside the structure.

Value

Returns a vector.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

dm, gap.inspect

Examples

```
## Not run:
## Fetch PDB files and split to chain A only PDB files
ids <- c("1a70_A", "1czp_A", "1frd_A", "1fxi_A", "1iue_A", "1pfd_A")
raw.files <- get.pdb(ids, path = "raw_pdbs")
files <- pdbsplit(raw.files, ids, path = "raw_pdbs/split_chain")

## Sequence Alignement, and connectivity check
pdbs <- pdbaln(files)

cons <- inspect.connectivity(pdbs)

## omit files with missing residues
files = files[cons]

## End(Not run)
```

`is.gap` *Gap Characters*

Description

Test for the presence of gap characters.

Usage

```
is.gap(x, gap.char = c("-", "."))
```

Arguments

`x`	an R object to be tested. Typically a sequence vector or sequence/structure alignment object as returned from `seqaln`, `pdbaln` etc.
`gap.char`	a character vector containing the gap character types to test for.

Value

Returns a logical vector with the same length as the input vector, or the same length as the number of columns present in an alignment input object 'x'. In the later case TRUE elements corresponding to 'gap.char' matches in any alignment column (i.e. gap containing columns).

Note

During alignment, gaps are introduced into sequences that are believed to have undergone deletions or insertions with respect to other sequences in the alignment. These gaps, often referred to as indels, can be represented with 'NA', '-' or '.' characters.

This function provides a simple test for the presence of such characters, or indeed any set of user defined characters set by the 'gap.char' argument.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`gap.inspect`, `read.fasta`, `read.fasta.pdb`, `seqaln`, `pdbaln`

Examples

```
is.gap( c("G",".","X","-","G","K","S","T") )

## Not run:
aln <- read.fasta( system.file("examples/kif1a.fa",
                   package = "bio3d") )

##- Print only non-gap positions (i.e. no gaps in any sequence)
aln$ali[, !is.gap(aln) ]

##- Mask any existing gaps with an "X"
xaln <- aln
xaln$ali[ is.gap(xaln$ali) ]="X"

##- Read a new PDB and align its sequence to the existing masked alignment
pdb <- read.pdb( "1mkj" )
seq2aln(pdbseq(pdb), xaln, id = "1mkj")

## End(Not run)
```

---

is.mol2 *Is an Object of Class 'mol2'?*

Description

Checks whether its argument is an object of class 'mol2'.

Usage

```
is.mol2(x)
```

Arguments

x	an R object.

Details

Tests if the object 'x' is of class 'mol2' (`is.mol2`), i.e. if 'x' has a "class" attribute equal to `mol2`.

Value

TRUE if x is an object of class 'mol2' and FALSE otherwise

See Also

`read.mol2`

Examples

```
# Read a PDB file
mol <- read.mol2( system.file("examples/aspirin.mol2", package="bio3d") )
is.mol2(mol)
```

`is.pdb` *Is an Object of Class 'pdb(s)'?*

Description

Checks whether its argument is an object of class 'pdb' or 'pdbs'.

Usage

```
is.pdb(x)
is.pdbs(x)
```

Arguments

x	an R object.

Details

Tests if the object 'x' is of class 'pdb' (`is.pdb`) or 'pdbs' (`is.pdbs`), i.e. if 'x' has a "class" attribute equal to pdb or pdbs.

Value

TRUE if x is an object of class 'pdb(s)' and FALSE otherwise

See Also

`read.pdb`, `read.fasta.pdb`, `pdbaln`

Examples

```
# Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
is.pdb(pdb)
```

`is.select` *Is an Object of Class 'select'?*

Description

Checks whether its argument is an object of class 'select'.

Usage

```
is.select(x)
```

Arguments

`x`	an R object to be tested.

Details

Tests if x is an object of class 'select', i.e. if x has a "class" attribute equal to `select`.

Value

TRUE if x is an object of class 'select' and FALSE otherwise

Author(s)

Julien Ide

See Also

`atom.select`

Examples

```
# Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

# Print structure summary
atom.select(pdb)

# Select all C-alpha atoms with residues numbers between 43 and 54
ca.inds <- atom.select(pdb, "calpha", resno=43:54)
is.select(ca.inds)
```

is.xyz *Is an Object of Class 'xyz'?*

Description

Checks whether its argument is an object of class 'xyz'.

Usage

```
is.xyz(x)
as.xyz(x)
```

Arguments

x	an R object to be tested

Details

Tests if x is an object of class 'xyz', i.e. if x has a "class" attribute equal to xyz.

Value

TRUE if x is an object of class 'xyz' and FALSE otherwise

See Also

read.pdb, read.ncdf, read.dcd, fit.xyz

Examples

```
# Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
is.xyz(pdb$xyz)
```

layout.cna *Protein Structure Network Layout*

Description

Determine protein structure network layout in 2D and 3D from the geometric center of each community.

Usage

```
layout.cna(x, pdb, renumber=TRUE, k=2, full=FALSE)
```

Arguments

x	A protein structure network object as obtained from the 'cna' function.
pdb	A pdb class object as obtained from the 'read.pdb' function.
renumber	Logical, if TRUE the input 'pdb' will be re-numbered starting at residue number one before community coordinate averages are calculated.
k	A single element numeric vector between 1 and 3 specifying the returned coordinate dimensions.
full	Logical, if TRUE the full all-Calpha atom network coordinates will be returned rather than the default clustered network community coordinates.

Details

This function calculates the geometric center for each community from the atomic position of it's Calpha atoms taken from a corresponding PDB file. Care needs to be taken to ensure the PDB residue numbers and the community vector names/length match.

The community residue membership are typically taken from the input network object but can be supplied as a list object with 'x$communities$membership'.

Value

A numeric matrix of Nxk, where N is the number of communities and k the number of dimensions requested.

Author(s)

Guido Scarabelli and Barry Grant

See Also

plot.cna, plot.communities, igraph.plotting, plot.igraph

Examples

```
if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

# Load the correlation network
attach(hivp)

# Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

# Plot will be slow
#xy <- plot.cna(net)
#plot3d.cna(net, pdb)

layout.cna(net, pdb, k=3)
```

```
layout.cna(net, pdb)

# can be used as input to plot.cna and plot3d.cna....
# plot.cna( net, layout=layout.cna(net, pdb) )
# plot3d.cna(net, pdb, layout=layout.cna(net, pdb, k=3))

detach(hivp)

}
```

---

lbio3d *List all Functions in the bio3d Package*

Description

A simple shortcut for ls("package:bio3d").

Usage

```
lbio3d()
```

Value

A character vector of function names from the bio3d package.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

---

load.enmff *ENM Force Field Loader*

Description

Load force field for elastic network normal mode calculation.

Usage

```
load.enmff(ff = 'calpha')
ff.calpha(r, rmin=2.9, ...)
ff.anm(r, cutoff=15, gamma=1, ...)
ff.pfanm(r, cutoff=NULL, ...)
ff.sdenm(r, atom.id, pdb, ...)
ff.reach(r, atom.id, ...)
ff.aaenm(r, ...)
ff.aaenm2(r, atom.id, pdb, ...)
```

Arguments

ff	a character string specifying the force field to use: 'calpha', 'anm', 'pfanm', 'reach', or 'sdenm'.
r	a numeric vector of c-alpha distances.
rmin	lowest allowed atom-atom distance for the force constant calculation. The default of 2.9A is based on an evaluation of 24 high-resolution X-ray structures (< 1A).
cutoff	numerical, cutoff for pair-wise interactions.
gamma	numerical, global scaling factor.
atom.id	atomic index.
pdb	a pdb object as obtained from function read.pdb.
...	additional arguments passed to and from functions.

Details

This function provides a collection of elastic network model (ENM) force fields for normal modes analysis (NMA) of protein structures. It returns a function for calculating the residue-residue spring force constants.

The 'calpha' force field - originally developed by Konrad Hinsen - is the recommended one for most applications. It employs a spring force constant differentiating between nearest-neighbour pairs along the backbone and all other pairs. The force constant function was parameterized by fitting to a local minimum of a crambin model using the AMBER94 force field.

The implementation of the 'ANM' (Anisotropic Network Model) force field originates from the lab of Ivet Bahar. It uses a simplified (step function) spring force constant based on the pair-wise distance. A variant of this from the Jernigan lab is the so-called 'pfANM' (parameter free ANM) with interactions that fall off with the square of the distance.

The 'sdENM' (by Dehouck and Mikhailov) employs residue specific spring force constants. It has been parameterized through a statistical analysis of a total of 1500 NMR ensembles.

The 'REACH' force field (by Moritsugu and Smith) is parameterized based on variance-covariance matrices obtained from MD simulations. It employs force constants that fall off exponentially with distance for non-bonded pairs.

The all-atom ENM force fields ('aaenm' and 'aaenm2') was obtained by fitting to a local energy minimum of a crambin model derived from the AMBER99SB force field (same approach as in Hinsen et al 2000). It employs a pair force constant function which falls as r^-6. 'aanma2' employs additonally specific force constants for covalent and intra-residue atom pairs. See also aanma for more details.

See references for more details on the individual force fields.

Value

'load.enmff' returns a function for calculating the spring force constants. The 'ff' functions returns a numeric vector of residue-residue spring force constants.

Note

The arguments 'atom.id' and 'pdb' are used from within function 'build.hessian' for functions that are not simply a function of the pair-wise distance. e.g. the force constants in the 'sdENM' model computes the force constants based on a function of the residue types and calpha distance.

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Hinsen, K. et al. (2000) *Chemical Physics* **261**, 25–37. Atilgan, A.R. et al. (2001) *Biophysical Journal* **80**, 505–515. Dehouck Y. & Mikhailov A.S. (2013) *PLoS Comput Biol* **9**:e1003209. Moritsugu K. & Smith J.C. (2008) *Biophysical Journal* **95**, 1639–1648. Yang, L. et al. (2009) *PNAS* **104**, 12347-52. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma, build.hessian

Examples

```
## Load the c-alpha force field
pfc.fun <- load.enmff('calpha')

## Calculate the pair force constant for a set of C-alpha distances
force.constants <- pfc.fun( seq(4,8, by=0.5) )

## Calculate the complete spring force constant matrix
## Fetch PDB
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Fetch only c-alpha coordinates
ca.inds <- atom.select(pdb, 'calpha')
xyz <- pdb$xyz[ca.inds$xyz]

## Calculate distance matrix
dists <- dm.xyz(xyz, mask.lower=FALSE)

## all pair-wise spring force constants
fc.matrix <- apply(dists, 1, pfc.fun)
```

---

mask *Mask a Subset of Atoms in a DCCM Object.*

Description

Produce a new DCCM object with selected atoms masked.

Usage

```
mask(...)

## S3 method for class 'dccm'
mask(dccm, pdb = NULL, a.inds = NULL, b.inds = NULL, ...)
```

Arguments

dccm	a DCCM structure object obtained from function dccm.
pdb	a PDB structure object obtained from read.pdb. Must match the dimensions of dccm.
a.inds	a numeric vector containing the indices of the elements of the DCCM matrix in which should not be masked. Alternatively, if pdb is provided a selection object (as obtained from atom.select) can be provided.
b.inds	a numeric vector containing the indices of the elements of the DCCM matrix in which should not be masked.
...	arguments not passed anywhere.

Details

This is a basic utility function for masking a DCCM object matrix to highlight user-selected regions in the correlation network.

When both a.inds and b.inds are provided only their intersection is retained. When only a.inds is provided then the corresponding region to everything else is retained.

Note: The current version assumes that the input PDB corresponds to the input DCCM. In many cases this will correspond to a PDB object containing only CA atoms.

Value

Returns a matrix list of class "dccm" with the indices/atoms not corresponding to the selection masked.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

dccm, atom.select

Examples

```
if(!requireNamespace("lattice", quietly=TRUE)) {
   message("Need lattice installed to run this example")
} else {

## Calculate DCCM
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
cij <- dccm(nma(pdb))

## Mask DCCM matrix according to matrix indices
cijm <- mask(cij, a.inds=40:50, b.inds=80:90)
plot(cijm)

## Retain only 40:50 to everything else
cijm <- mask(cij, a.inds=40:50)
plot(cijm)


## Mask DCCM matrix according PDB selection
pdb.ca <- trim(pdb, "calpha")
a.inds <- atom.select(pdb.ca, resno=40:50)
b.inds <- atom.select(pdb.ca, resno=80:90)

# Provide pdb object correspoding to input dccm
cijm <- mask(cij, pdb.ca, a.inds, b.inds)
plot(cijm)
}
```

---

mktrj *PCA / NMA Atomic Displacement Trajectory*

Description

Make a trajectory of atomic displacments along a given principal component / normal mode.

Usage

```
mktrj(...)

## S3 method for class 'pca'
mktrj(pca = NULL, pc = 1, mag = 1, step = 0.125, file =
NULL, pdb = NULL, rock=TRUE, ...)

## S3 method for class 'nma'
mktrj(nma = NULL, mode = 7, mag = 10, step = 1.25, file = NULL,
      pdb = NULL, rock=TRUE,  ...)

## S3 method for class 'enma'
mktrj(enma = NULL, pdbs = NULL, s.inds = NULL, m.inds = NULL,
      mag = 10, step = 1.25, file = NULL, rock = TRUE, ncore = NULL, ...)
```

Arguments

pca	an object of class "pca" as obtained with function pca.xyz or pca.
nma	an object of class "nma" as obtained with function nma.pdb.
enma	an object of class "enma" as obtained with function nma.pdbs.
pc	the PC number along which displacements should be made.
mag	a magnification factor for scaling the displacements.
step	the step size by which to increment along the pc/mode.
file	a character vector giving the output PDB file name.
pdb	an object of class "pdb" as obtained from read.pdb or class "pdbs" as obtained from read.fasta.pdb. If not NULL, used as reference to write the PDB file.
rock	logical, if TRUE the trajectory rocks.
mode	the mode number along which displacements should be made.
pdbs	a list object of class "pdbs" (obtained with pdbaln or read.fasta.pdb) which corresponds to the "enma" object.
s.inds	index or indices pointing to the structure(s) in the enma object for which the trajectory shall be generated.
m.inds	the mode number(s) along which displacements should be made.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
...	additional arguments passed to and from functions (e.g. to function write.pdb).

Details

Trajectory frames are built from reconstructed Cartesian coordinates produced by interpolating from the mean structure along a given pc or mode, in increments of step.

An optional magnification factor can be used to amplify displacements. This involves scaling by mag-times the standard deviation of the conformer distribution along the given pc (i.e. the square root of the associated eigenvalue).

Note

Molecular graphics software such as VMD or PyMOL is useful for viewing trajectories see e.g: http://www.ks.uiuc.edu/Research/vmd/.

Author(s)

Barry Grant, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca, nma, nma.pdbs, pymol.modes.

Examples

```
## Not run:

##- PCA example
attach(transducin)

# Calculate principal components
pc.xray <- pca(pdbs, fit=TRUE)

# Write PC trajectory of pc=1
outfile = tempfile()
a <- mktrj(pc.xray, file = outfile)
outfile

detach(transducin)


##- NMA example
## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate (vibrational) normal modes
modes <- nma(pdb)

## Visualize modes
outfile = file.path(tempdir(), "mode_7.pdb")
mktrj(modes, mode=7, pdb=pdb, file = outfile)
outfile


## End(Not run)
```

`motif.find` *Find Sequence Motifs.*

Description

Return Position Indices of a Short Sequence Motif Within a Larger Sequence.

Usage

```
motif.find(motif, sequence)
```

Arguments

`motif`	a character vector of the short sequence motif.
`sequence`	a character vector of the larger sequence.

Details

The sequence and the motif can be given as a either a multiple or single element character vector. The dot character and other valid `regexpr` characters are allowed in the motif, see examples.

Value

Returns a vector of position indices within the sequence where the motif was found, see examples.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`regexpr`, `read.fasta`, `pdbseq`

Examples

```
# PDB server connection required - testing excluded
try({

aa.seq <- pdbseq( read.pdb( get.pdb("4q21", URLonly=TRUE) ) )
motif = c("G....GKS")
motif.find(motif, aa.seq)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

mustang *Structure-based Sequence Alignment with MUSTANG*

Description

Create a multiple sequence alignment from a bunch of PDB files.

Usage

```
mustang(files, exefile="mustang", outfile="aln.mustang.fa",
        cleanpdb=FALSE, cleandir="mustangpdbs", verbose=TRUE)
```

Arguments

files	a character vector of PDB file names.
exefile	file path to the 'MUSTANG' program on your system (i.e. how is 'MUSTANG' invoked).
outfile	name of 'FASTA' output file to which alignment should be written.
cleanpdb	logical, if TRUE iterate over the PDB files and map non-standard residues to standard residues (e.g. SEP->SER..) to produce 'clean' PDB files.
cleandir	character string specifying the directory in which the 'clean' PDB files should be written.
verbose	logical, if TRUE 'MUSTANG' warning and error messages are printed.

Details

Structure-based sequence alignment with 'MUSTANG' attempts to arrange and align the sequences of proteins based on their 3D structure.

This function calls the 'MUSTANG' program, to perform a multiple structure alignment, which MUST BE INSTALLED on your system and in the search path for executables.

Note that non-standard residues are mapped to "Z" in MUSTANG. As a workaround the bio3d 'mustang' function will attempt to map any non-standard residues to standard residues (e.g. SEP->SER, etc). To avoid this behaviour use 'cleanpdb=FALSE'.

Value

A list with two components:

ali	an alignment character matrix with a row per sequence and a column per equivalent aminoacid.
ids	sequence names as identifers.

Note

A system call is made to the 'MUSTANG' program, which must be installed on your system and in the search path for executables.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'MUSTANG' is the work of Konagurthu et al: Konagurthu, A.S. et al. (2006) *Proteins* **64**(3):559–74.

More details of the 'MUSTANG' algorithm, along with download and installation instructions can be obtained from:
https://lcb.infotech.monash.edu/mustang/.

See Also

read.fasta, read.fasta.pdb, pdbaln, plot.fasta, seqaln

Examples

```
## Not run:

if(!check.utility('mustang')) {
   message('Need MUSTANG installed to run this example')
} else {

## Fetch PDB files and split to chain A only PDB files
ids <- c("1a70_A", "1czp_A", "1frd_A")
files <- get.pdb(ids, split = TRUE, path = tempdir())

##-- Or, read a folder/directory of existing PDB files
#pdb.path <- "my_dir_of_pdbs"
#files  <- list.files(path=pdb.path ,
#                     pattern=".pdb",
#                     full.names=TRUE)

##-- Align these PDB sequences
aln <- mustang(files)

##-- Read Aligned PDBs storing coordinate data
pdbs <- read.fasta.pdb(aln)

}

## End(Not run)
```

---

network.amendment *Amendment of a CNA Network According To A Input Community Membership Vector.*

Description

This function changes the 'communities' attribute of a 'cna' class object to match a given membership vector.

Usage

```
network.amendment(x, membership, minus.log=TRUE)
```

Arguments

x	A protein network graph object as obtained from the 'cna' function.
membership	A numeric vector containing the new community membership.
minus.log	Logical. Whether to use the minus.log on the cij values.

Details

This function is useful, in combination with 'community.tree', for inspecting different community partitioning options of a input 'cna' object. See examples.

Value

Returns a 'cna' class object with the attributes changed according to the membership vector provided.

Author(s)

Guido Scarabelli

See Also

cna, community.tree, summary.cna

Examples

```
# PDB server connection required - testing excluded

if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

try({

##-- Build a CNA object
pdb <- read.pdb("4Q21")
modes <- nma(pdb)
cij <- dccm(modes)
net <- cna(cij, cutoff.cij=0.2)

##-- Community membership vector for each clustering step
tree <- community.tree(net, rescale=TRUE)

## Produce a new k=7 membership vector and CNA network
memb.k7 <- tree$tree[ tree$num.of.comms == 7, ]
net.7 <- network.amendment(net, memb.k7)

plot(net.7, pdb)

print(net)
print(net.7)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
}
```

nma *Normal Mode Analysis*

Description

Perform normal mode analysis (NMA) on either a single or an ensemble of protein structures.

Usage

```
nma(...)
```

Arguments

...	arguments passed to the methods nma.pdb, or nma.pdbs. For function nma.pdb this will include an object of class pdb as obtained from function read.pdb. For function nma.pdbs an object of class pdbs as obtained from function pdbaln or read.fasta.pdb.

Details

Normal mode analysis (NMA) is a computational approach for studying and characterizing protein flexibility. Current functionality entails normal modes calculation on either a single protein structure or an ensemble of aligned protein structures.

This generic nma function calls the corresponding methods for the actual calculation, which is determined by the class of the input argument:

Function nma.pdb will be used when the input argument is of class pdb. The function calculates the normal modes of a C-alpha model of a protein structure.

Function nma.pdbs will be used when the input argument is of class pdbs. The function will perform normal mode analysis of each PDB structure stored in the pdbs object ('ensemble NMA').

See documentation and examples for each corresponding function for more details.

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma.pdb, nma.pdbs, pca.

Examples

```
##- Singe structure NMA
## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate normal modes
modes <- nma(pdb)

## Print modes
print(modes)

## Plot modes
plot(modes)

## Visualize modes
#m7 <- mktrj.nma(modes, mode=7, file="mode_7.pdb")


## Needs MUSCLE installed - testing excluded

##- Ensemble NMA
if(check.utility("muscle")) {

try({

## Fetch PDB files and split to chain A only PDB files
ids <- c("1a70_A", "1czp_A", "1frd_A", "1fxi_A", "1iue_A", "1pfd_A")
files <- get.pdb(ids, split = TRUE, path = tempdir())

## Sequence Alignement
pdbs <- pdbaln(files, outfile = tempfile())

## Normal mode analysis on aligned data
modes <- nma(pdbs, rm.gaps=FALSE)

## Plot fluctuation data
plot(modes, pdbs=pdbs)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
}
```

---

nma.pdb *Normal Mode Analysis*

Description

Perform elastic network model (ENM) C-alpha normal modes calculation of a protein structure.

Usage

```
## S3 method for class 'pdb'
nma(pdb, inds = NULL, ff = 'calpha', pfc.fun = NULL,
                  mass = TRUE, temp = 300.0, keep = NULL, hessian = NULL,
                  outmodes = NULL, ... )

build.hessian(xyz, pfc.fun, fc.weights = NULL, pdb = NULL, ...)

## S3 method for class 'nma'
print(x, nmodes=6, ...)
```

Arguments

pdb	an object of class pdb as obtained from function read.pdb.
inds	atom and xyz coordinate indices obtained from atom.select that selects the elements of pdb upon which the calculation should be based. If not provided the function will attempt to select the calpha atoms automatically (based on function atom.select).
ff	character string specifying the force field to use: 'calpha', 'anm', 'pfanm', 'reach', or 'sdenm'.
pfc.fun	customized pair force constant ('pfc') function. The provided function should take a vector of distances as an argument to return a vector of force constants. If provided, 'pfc.fun' will override argument ff. See examples below.
mass	logical, if TRUE the Hessian will be mass-weighted.
temp	numerical, temperature for which the amplitudes for scaling the atomic displacement vectors are calculated. Set 'temp=NULL' to avoid scaling.
keep	numerical, final number of modes to be stored. Note that all subsequent analyses are limited to this subset of modes. This option is useful for very large structures and cases where memory may be limiting.
hessian	hessian matrix as obtained from build.hessian. For internal purposes and generally not intended for public use.
outmodes	atom indices as obtained from atom.select) specifying the atoms to include in the resulting mode object.
xyz	a numeric vector of Cartesian coordinates.
fc.weights	a numeric matrix of size NxN (where N is the number of calpha atoms) containg scaling factors for the pariwise force constants. See examples below.
x	an nma object obtained from nma.pdb.
nmodes	numeric, number of modes to be printed.
...	additional arguments to build.hessian, aa2mass, pfc.fun, and print. One useful option here for dealing with unconventional residues is 'mass.custom', see the aa2mass function for details.

Details

This function calculates the normal modes of a C-alpha model of a protein structure. A number of force fields are implemented all of whhich employ the elastic network model (ENM).

The 'calpha' force field - originally developed by Konrad Hinsen - is the recommended one for most applications. It employs a spring force constant differentiating between nearest-neighbour pairs along the backbone and all other pairs. The force constant function was parameterized by fitting to a local minimum of a crambin model using the AMBER94 force field.

See `load.enmff` for details of the different force fields.

By default `nma.pdb` will diagonalize the mass-weighted Hessian matrix. The resulting mode vectors are moreover scaled by the thermal fluctuation amplitudes.

The implementation under default arguments reproduces the calculation of normal modes (VibrationalModes) in the Molecular Modeling Toolkit (MMTK) package. To reproduce ANM modes set `ff='anm'`, `mass=FALSE`, and `temp=NULL`.

Value

Returns an object of class 'nma' with the following components:

`modes`	numeric matrix with columns containing the normal mode vectors. Mode vectors are converted to unweighted Cartesian coordinates when `mass=TRUE`. Note that the 6 first trivial eigenvectos appear in columns one to six.
`frequencies`	numeric vector containing the vibrational frequencies corresponding to each mode (for `mass=TRUE`).
`force.constants`	numeric vector containing the force constants corresponding to each mode (for `mass=FALSE`)).
`fluctuations`	numeric vector of atomic fluctuations.
`U`	numeric matrix with columns containing the raw eigenvectors. Equals to the `modes` component when `mass=FALSE` and `temp=NULL`.
`L`	numeric vector containing the raw eigenvalues.
`xyz`	numeric matrix of class `xyz` containing the Cartesian coordinates in which the calculation was performed.
`mass`	numeric vector containing the residue masses used for the mass-weighting.
`temp`	numerical, temperature for which the amplitudes for scaling the atomic displacement vectors are calculated.
`triv.modes`	number of trivial modes.
`natoms`	number of C-alpha atoms.
`call`	the matched call.

Note

The current version provides an efficent implementation of NMA with execution time comparable to similar software (when the entire Hessian is diagonalized).

The main (speed related) bottleneck is currently the diagonalization of the Hessian matrix which is performed with the core R function eigen. For computing a few (5-20) approximate modes the user can consult package 'irlba'.

NMA is memory extensive and users should be cautions when running larger proteins (>3000 residues). Use 'keep' to reduce the amount of memory needed to store the final 'nma' object (the full 3Nx3N Hessian matrix still needs to be allocated).

We thank Edvin Fuglebakk for valuable discussions on the implementation as well as for contributing with testing.

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Hinsen, K. et al. (2000) *Chemical Physics* **261**, 25–37.

See Also

fluct.nma, mktrj.nma, dccm.nma, overlap, rmsip, load.enmff.

Examples

```
## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate normal modes
modes <- nma(pdb)

## Print modes
print(modes)

## Plot modes
plot(modes)

## Visualize modes
#m7 <- mktrj.nma(modes, mode=7, file="mode_7.pdb")

## Not run:
## Use Anisotropic Network Model
modes <- nma(pdb, ff="anm", mass=FALSE, temp=NULL, cutoff=15)

## Use SSE information and SS-bonds
sse      <- dssp(pdb, resno=FALSE, full=TRUE)
ss.bonds <- matrix(c(76,94, 64,80, 30,115, 6,127),
                   ncol=2, byrow=TRUE)


## User defined energy function
## Note: Must take a vector of distances
```

```
"my.ff" <- function(r) {
   ifelse( r>15, 0, 1 )
}

## Modes with a user defined energy function
modes <- nma(pdb, pfc.fun=my.ff)


## A more manual approach
sele <- atom.select(pdb, chain='A', elety='CA')
xyz <- pdb$xyz[sele$xyz]

hessian <- build.hessian(xyz, my.ff)
modes <- eigen(hessian)

## Dealing with unconventional residues
pdb <- read.pdb("1xj0")

## nma(pdb)
#modes <- nma(pdb, mass.custom=list(CSX=121.166))

## End(Not run)
```

---

nma.pdbs *Ensemble Normal Mode Analysis*

Description

Perform normal mode analysis (NMA) on an ensemble of aligned protein structures.

Usage

```
## S3 method for class 'pdbs'
nma(pdbs, fit = TRUE, full = FALSE, subspace = NULL,
         rm.gaps = TRUE, varweight=FALSE,
         outpath = NULL, ncore = 1, progress = NULL, ...)

## S3 method for class 'enma'
print(x, ...)
```

Arguments

pdbs	a numeric matrix of aligned C-alpha xyz Cartesian coordinates. For example an alignment data structure obtained with read.fasta.pdb or pdbaln.
fit	logical, if TRUE coordinate superposition is performed prior to normal mode calculations.
full	logical, if TRUE return the complete, full structure, 'nma' objects.
subspace	number of eigenvectors to store for further analysis.

rm.gaps	logical, if TRUE obtain the hessian matrices for only atoms in the aligned positions (non-gap positions in all aligned structures). Thus, gap positions are removed from output.
varweight	logical, if TRUE perform weighing of the pair force constants. Alternatively, provide a NxN matrix containing the weights. See function var.xyz.
outpath	character string specifing the output directory to which the PDB structures should be written.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
x	an enma object obtained from nma.pdbs.
progress	progress bar for use with shiny web app.
...	additional arguments to nma, aa2mass, and print.

Details

This function performs normal mode analysis (NMA) on a set of aligned protein structures obtained with function read.fasta.pdb or pdbaln. The main purpose is to provide aligned atomic fluctuations and mode vectors in an automated fashion.

The normal modes are calculated on the full structures as provided by object 'pdbs'. With the input argument 'full=TRUE' the full 'nma' objects are returned together with output 'U.subs' providing the aligned mode vectors. When 'rm.gaps=TRUE' the unaligned atoms are ommited from output. With default arguments 'rmsip' provides RMSIP values for all pairwise structures.

See examples for more details.

Value

Returns an 'enma' object with the following components:

fluctuations	a numeric matrix containing aligned atomic fluctuations with one row per input structure.
rmsip	a numeric matrix of pair wise RMSIP values (only the ten lowest frequency modes are included in the calculation).
U.subspace	a three-dimensional array with aligned eigenvectors (corresponding to the subspace defined by the first N non-trivial eigenvectors ('U') of the 'nma' object).
L	numeric matrix containing the raw eigenvalues with one row per input structure.
xyz	an object of class 'xyz' containing the Cartesian coordinates in which the calculation was performed. Coordinates are superimposed to the first structure of the pdbs object when 'fit=TRUE'.
full.nma	a list with a nma object for each input structure.

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

For normal mode analysis on single structure PDB: nma.pdb

For the analysis of the resulting 'eNMA' object: mktrj.enma, dccm.enma, plot.enma, cov.enma.

Similarity measures: sip, covsoverlap, bhattacharyya, rmsip.

Related functionality: pdbaln, read.fasta.pdb.

Examples

```
# Needs MUSCLE installed - testing excluded

if(check.utility("muscle")) {

try({

## Fetch PDB files and split to chain A only PDB files
ids <- c("1a70_A", "1czp_A", "1frd_A", "1fxi_A", "1iue_A", "1pfd_A")
files <- get.pdb(ids, split = TRUE, path = tempdir())

## Sequence Alignement
pdbs <- pdbaln(files, outfile = tempfile())

## Normal mode analysis on aligned data
modes <- nma(pdbs, rm.gaps=FALSE)

## Plot fluctuation data
plot(modes, pdbs=pdbs)

## Cluster on Fluctuation similariy
sip <- sip(modes)
hc <- hclust(dist(sip))
col <- cutree(hc, k=3)

## Plot fluctuation data
plot(modes, pdbs=pdbs, col=col)

## Remove gaps from output
modes <- nma(pdbs, rm.gaps=TRUE)

## RMSIP is pre-calculated
heatmap(1-modes$rmsip)

## Bhattacharyya coefficient
bc <- bhattacharyya(modes)
heatmap(1-bc)

}, silent=TRUE)
```

```
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
}
```

`normalize.vector` *Mass-Weighted Normalized Vector*

Description

Normalizes a vector (mass-weighted if requested).

Usage

```
normalize.vector(x, mass=NULL)
```

Arguments

`x`	a numeric vector or matrix to be normalized.
`mass`	a numeric vector containing the atomic masses for weighting.

Details

This function normalizes a vector, or alternatively, the column-wise vector elements of a matrix. If atomic masses are provided the vector is mass-weigthed.

See examples for more details.

Value

Returns the normalized vector(s).

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`nma` , `inner.prod`

Examples

```
x <- 1:3
y <- matrix(1:9, ncol = 3, nrow = 3)

normalize.vector(x)
normalize.vector(y)

## Application to normal modes
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate (vibrational) normal modes
modes <- nma(pdb)

## Returns a vector
nv <- normalize.vector(modes$modes[,7])

## Returns a matrix
nv <- normalize.vector(modes$modes[,7:10])

## Mass-weighted
nv <- normalize.vector(modes$modes[,7], mass=modes$mass)
```

`orient.pdb` *Orient a PDB Structure*

Description

Center, to the coordinate origin, and orient, by principal axes, the coordinates of a given PDB structure or xyz vector.

Usage

```
orient.pdb(pdb, atom.subset = NULL, verbose = TRUE)
```

Arguments

`pdb`	a pdb data structure obtained from `read.pdb` or a vector of 'xyz' coordinates.
`atom.subset`	a subset of atom positions to base orientation on.
`verbose`	print dimension details.

Value

Returns a numeric vector of re-oriented coordinates.

Note

Centering and orientation can be restricted to a `atom.subset` of atoms.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, write.pdb, fit.xyz, rot.lsq , atom.select

Examples

```
# PDB server connection required - testing excluded
try({

pdb <- read.pdb( "1bg2" )
xyz <- orient.pdb(pdb)
#write.pdb(pdb, xyz = xyz, file = "mov1.pdb")


# Based on C-alphas
inds <- atom.select(pdb, "calpha")
xyz  <- orient.pdb(pdb, atom.subset=inds$atom)
#write.pdb(pdb, xyz = xyz, file = "mov2.pdb")


# Based on a central Beta-strand
inds <- atom.select(pdb, resno=c(224:232), elety='CA')
xyz  <- orient.pdb(pdb, atom.subset=inds$atom)
#write.pdb(pdb, xyz = xyz, file = "mov3.pdb")

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

overlap *Overlap analysis*

Description

Calculate the squared overlap between sets of vectors.

Usage

```
overlap(modes, dv, nmodes=20)
```

Arguments

modes	an object of class "pca" or "nma" as obtained from function pca.xyz or nma. Alternatively a 3NxM matrix of eigenvectors can be provided.
dv	a displacement vector of length 3N.
nmodes	the number of modes in which the calculation should be based.

Details

Squared overlap (or dot product) is used to measure the similiarity between a displacement vector (e.g. a difference vector between two conformational states) and mode vectors obtained from principal component or normal modes analysis.

By definition the cumulative sum of the overlap values equals to one.

Structure modes$U (or alternatively, the 3NxM matrix of eigenvectors) should be of same length (3N) as dv.

Value

Returns a list with the following components:

overlap	a numeric vector of the squared dot products (overlap values) between the (normalized) vector (dv) and each mode in mode.
overlap.cum	a numeric vector of the cumulative squared overlap values.

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2011) *Proteins* **79**, 232–243. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

rmsip, pca.xyz, nma, difference.vector

Examples

```
attach(kinesin)

# Ignore gap containing positions
##gaps.res <- gap.inspect(pdbs$ali)
gaps.pos <- gap.inspect(pdbs$xyz)

#-- Do PCA
pc.xray <- pca.xyz(pdbs$xyz[, gaps.pos$f.inds])

# Define a difference vector between two structural states
diff.inds <- c(grep("d1v8ka", pdbs$id),
```

```
                grep("d1goja", pdbs$id))

dv <- difference.vector( pdbs$xyz[diff.inds,], gaps.pos$f.inds )

# Calculate the squared overlap between the PCs and the difference vector
o <- overlap(pc.xray, dv)
o <- overlap(pc.xray$U, dv)

# Plot results
plot(o$overlap, type='h', ylim=c(0,1))
points(o$overlap)
lines(o$overlap.cum, type='b', col='red')


detach(kinesin)

## Not run:
## Calculate overlap from NMA
pdb.a <- read.pdb("1cmk")
pdb.b <- read.pdb("3dnd")

## Fetch CA coordinates
sele.a <- atom.select(pdb.a, chain='E', resno=c(15:350), elety='CA')
sele.b <- atom.select(pdb.b, chain='A', resno=c(1:350), elety='CA')

xyz <- rbind(pdb.a$xyz[sele.a$xyz],
             pdb.b$xyz[sele.b$xyz])

## Superimpose
xyz[2,] <- fit.xyz(xyz[1,], xyz[2,], 1:ncol(xyz))

## The difference between the two conformations
dv <- difference.vector( xyz )

## Calculate normal modes
modes <- nma(pdb.a, inds=sele.a)

# Calculate the squared overlap between the normal modes
# and the difference vector
o <- overlap(modes, dv)

## End(Not run)
```

`pairwise` *Pair Indices*

Description

A utility function to determine indices for pairwise comparisons.

Usage

```
pairwise(N)
```

Arguments

N	a single numeric value representing the total number of things to undergo pairwise comparison.

Value

Returns a two column numeric matrix giving the indices for all pairs.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

seqidentity

Examples

```
pairwise(3)
pairwise(20)
```

---

pca *Principal Component Analysis*

Description

Performs principal components analysis (PCA) on biomolecular structure data.

Usage

```
pca(...)
```

Arguments

...	arguments passed to the methods pca.xyz, pca.pdbs, etc. Typically this includes either a numeric matrix of Cartesian coordinates with a row per structure/frame (function pca.xyz()), or an object of class pdbs as obtained from function pdbaln or read.fasta.pdb (function pca.pdbs()).

Details

Principal component analysis can be performed on any structure dataset of equal or unequal sequence composition to capture and characterize inter-conformer relationships.

This generic pca function calls the corresponding methods function for actual calculation, which is determined by the class of the input argument x. Use methods("pca") to list all the current methods for pca generic. These will include:

pca.xyz, which will be used when x is a numeric matrix containing Cartesian coordinates (e.g. trajectory data).

pca.pdbs, which will perform PCA on the Cartesian coordinates of a input pdbs object (as obtained from the 'read.fasta.pdb' or 'pdbaln' functions).

Currently, function pca.tor should be called explicitly as there are currently no defined 'tor' object classes.

See the documentation and examples for each individual function for more details and worked examples.

Author(s)

Barry Grant, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca.xyz, pca.pdbs, pdbaln.

---

pca.array *Principal Component Analysis of an array of matrices*

Description

Calculate the principal components of an array of correlation or covariance matrices.

Usage

```
## S3 method for class 'array'
pca(x, use.svd = TRUE, rm.gaps=TRUE, ...)
```

Arguments

x	an array of matrices, e.g. correlation or covariance matrices as obtained from functions dccm or enma2covs.
use.svd	logical, if TRUE singular value decomposition (SVD) is called instead of eigenvalue decomposition.
rm.gaps	logical, if TRUE gap cells (with missing coordinate data in any input matrix) are removed before calculation. This is equivalent to removing NA cells from x.
...	.

Details

This function performs PCA of symmetric matrices, such as distance matrices from an ensemble of crystallographic structures, residue-residue cross-correlations or covariance matrices derived from ensemble NMA or MD simulation replicates, and so on. The 'upper triangular' region of the matrix is regarded as a long vector of random variables. The function returns M eigenvalues and eigenvectors with each eigenvector having the dimension N(N-1)/2, where M is the number of matrices and N the number of rows/columns of matrices.

Value

Returns a list with components equivalent to the output from pca.xyz.

Author(s)

Xin-Qiu Yao, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca.xyz

---

pca.pdbs *Principal Component Analysis*

Description

Performs principal components analysis (PCA) on an ensemble of PDB structures.

Usage

```
## S3 method for class 'pdbs'
pca(pdbs, core.find = FALSE, fit = FALSE, ...)
```

Arguments

pdbs	an object of class pdbs as obtained from function pdbaln or read.fasta.pdb.
core.find	logical, if TRUE core.find() function will be called to find core positions and coordinates of PDB structures will be fitted based on cores.
fit	logical, if TRUE coordinates of PDB structures will be fitted based on all CA atoms.
...	additional arguments passed to the method pca.xyz.

Details

The function pca.pdbs is a wrapper for the function pca.xyz, wherein more details of the PCA procedure are documented.

Value

Returns a list with the following components:

L	eigenvalues.
U	eigenvectors (i.e. the variable loadings).
z.u	scores of the supplied data on the pcs.
sdev	the standard deviations of the pcs.
mean	the means that were subtracted.

Author(s)

Barry Grant, Lars Skjaerven and Xin-Qiu Yao

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca, pca.xyz, pdbaln, nma.

Examples

```
attach(transducin)

#-- Do PCA ignoring gap containing positions
pc.xray <- pca(pdbs)

# Plot results (conformer plots & scree plot)
plot(pc.xray, col=annotation[, "color"])

detach(transducin)
```

pca.tor *Principal Component Analysis*

Description

Performs principal components analysis (PCA) on torsion angle data.

Usage

```
## S3 method for class 'tor'
pca(data, ...)
```

Arguments

data	numeric matrix of torsion angles with a row per structure.
...	additional arguments passed to the method pca.xyz.

Value

Returns a list with the following components:

L	eigenvalues.
U	eigenvectors (i.e. the variable loadings).
z.u	scores of the supplied data on the pcs.
sdev	the standard deviations of the pcs.
mean	the means that were subtracted.

Author(s)

Barry Grant and Karim ElSawy

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

torsion.xyz, plot.pca, plot.pca.loadings, pca.xyz

Examples

```
##-- PCA on torsion data for multiple PDBs
attach(kinesin)

gaps.pos <- gap.inspect(pdbs$xyz)
tor <- t(apply( pdbs$xyz[, gaps.pos$f.inds], 1, torsion.xyz, atm.inc=1))
pc.tor <- pca.tor(tor[,-c(1,233,234,235)])
```

```
#plot(pc.tor)
plot.pca.loadings(pc.tor)

detach(kinesin)

## Not run:
##-- PCA on torsion data from an MD trajectory
trj <- read.dcd( system.file("examples/hivp.dcd", package="bio3d") )
tor <- t(apply(trj, 1, torsion.xyz, atm.inc=1))
gaps <- gap.inspect(tor)
pc.tor <- pca.tor(tor[,gaps$f.inds])
plot.pca.loadings(pc.tor)

## End(Not run)
```

`pca.xyz` *Principal Component Analysis*

Description

Performs principal components analysis (PCA) on a xyz numeric data matrix.

Usage

```
## S3 method for class 'xyz'
pca(xyz, subset = rep(TRUE, nrow(as.matrix(xyz))),
                 use.svd = FALSE, rm.gaps=FALSE, mass = NULL, ...)

## S3 method for class 'pca'
print(x, nmodes=6, ...)
```

Arguments

`xyz`	numeric matrix of Cartesian coordinates with a row per structure.
`subset`	an optional vector of numeric indices that selects a subset of rows (e.g. experimental structures vs molecular dynamics trajectory structures) from the full `xyz` matrix. Note: the full `xyz` is projected onto this subspace.
`use.svd`	logical, if TRUE singular value decomposition (SVD) is called instead of eigenvalue decomposition.
`rm.gaps`	logical, if TRUE gap positions (with missing coordinate data in any input structure) are removed before calculation. This is equivalent to removing NA cols from xyz.
`x`	an object of class `pca`, as obtained from function `pca.xyz`.
`nmodes`	numeric, number of modes to be printed.
`mass`	a 'pdb' object or numeric vector of residue/atom masses. By default (`mass=NULL`), mass is ignored. If provided with a 'pdb' object, masses of all amino acids obtained from `aa2mass` are used.
`...`	additional arguments to `fit.xyz` (for `pca.xyz`) or to `print` (for `print.pca`).

Value

Returns a list with the following components:

L	eigenvalues.
U	eigenvectors (i.e. the x, y, and z variable loadings).
z	scores of the supplied xyz on the pcs.
au	atom-wise loadings (i.e. xyz normalized eigenvectors).
sdev	the standard deviations of the pcs.
mean	the means that were subtracted.

Note

If mass is provided, mass weighted coordinates will be considered, and iteration of fitting onto the mean structure is performed internally. The extra fitting process is to remove external translation and rotation of the whole system. With this option, a direct comparison can be made between PCs from pca.xyz and vibrational modes from nma.pdb, with the fact that

$$A = k_B T F^{-1}$$

, where A is the variance-covariance matrix, F the Hessian matrix, k_B the Boltzmann's constant, and T the temperature.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca, pca.pdbs, plot.pca, mktrj.pca, pca.tor, project.pca

Examples

```
## Not run:
#-- Read transducin alignment and structures
aln <- read.fasta(system.file("examples/transducin.fa",package="bio3d"))
pdbs <- read.fasta.pdb(aln)

# Find core
core <- core.find(pdbs,
                  #write.pdbs = TRUE,
                  verbose=TRUE)

rm(list=c("pdbs", "core"))

## End(Not run)
```

```
#-- OR for demo purposes just read previously saved transducin data
attach(transducin)

# Previously fitted coordinates based on sub 1.0A^3 core. See core.find() function.
xyz <- pdbs$xyz

#-- Do PCA ignoring gap containing positions
pc.xray <- pca.xyz(xyz, rm.gaps=TRUE)

# Plot results (conformer plots & scree plot overview)
plot(pc.xray, col=annotation[, "color"])

# Plot a single conformer plot of PC1 v PC2
plot(pc.xray, pc.axes=1:2, col=annotation[, "color"])

## Plot atom wise loadings
plot.bio3d(pc.xray$au[,1], ylab="PC1 (A)")


# PDB server connection required - testing excluded
try({

## Plot loadings in relation to reference structure 1TAG
pdb <- read.pdb("1tag")
ind <- grep("1TAG", pdbs$id)             ## location in alignment

resno <- pdbs$resno[ind, !is.gap(pdbs)]  ## non-gap residues
tpdb <- trim.pdb(pdb, resno=resno)

op <- par(no.readonly=TRUE)
par(mfrow = c(3, 1), cex = 0.6, mar = c(3, 4, 1, 1))
plot.bio3d(pc.xray$au[,1], resno, ylab="PC1 (A)", sse=tpdb)
plot.bio3d(pc.xray$au[,2], resno, ylab="PC2 (A)", sse=tpdb)
plot.bio3d(pc.xray$au[,3], resno, ylab="PC3 (A)", sse=tpdb)
par(op)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}


## Not run:
# Write PC trajectory
resno = pdbs$resno[1, !is.gap(pdbs)]
resid = aa123(pdbs$ali[1, !is.gap(pdbs)])

a <- mktrj.pca(pc.xray, pc=1, file="pc1.pdb",
               resno=resno, resid=resid )

b <- mktrj.pca(pc.xray, pc=2, file="pc2.pdb",
               resno=resno, resid=resid )
```

```
c <- mktrj.pca(pc.xray, pc=3, file="pc3.pdb",
               resno=resno, resid=resid )

## End(Not run)

detach(transducin)
```

---

pdb.annotate *Get Customizable Annotations From PDB Or PFAM Databases*

Description

Get customizable annotations for query results from PDB or PFAM.

Usage

```
pdb.annotate(ids, anno.terms = NULL, unique = FALSE, verbose = FALSE,
             extra.terms = NULL)
pdb.pfam(ids, best.only = TRUE, compact = TRUE)
```

Arguments

ids	A charater vector of one or more 4-letter PDB codes/identifiers of the files for query, or a 'blast' object containing 'pdb.id'.
anno.terms	Terms can be used for query. The "anno.terms" can be "structureId", "chainId", "macromoleculeType", "chainLength", "experimentalTechnique", "resolution", "scopDomain", "pfam", "ligandId", "ligandName", "source", "structureTitle", "citation", "rObserved", "rFree", "rWork", and "spaceGroup". If anno.terms=NULL, all information would be returned.
unique	logical, if TRUE only unique PDB entries are returned. Alternatively data for each chain ID is provided.
verbose	logical, if TRUE more details are printed.
extra.terms	Additional annotation terms to retrieve from PDB. Currently not supported.
best.only	logical, if TRUE only the lowest eValue match for a given input id will be reported. Otherwise all significant matches will be returned.
compact	logical, if TRUE only a subset of annotation terms are returned. Otherwise full match details are reported (see examples).

Details

Given a list of PDB IDs (and query terms for the pdb.annotate function), these functions will download annotation information from the RCSB PDB and PFAM databases.

Value

Returns a data frame of query results with a row for each PDB record, and annotation terms column-wise.

Author(s)

Hongyang Li, Barry Grant, Lars Skjaerven, Xin-Qiu Yao

Examples

```
# PDB server connection required - testing excluded
try({

# Fetch all annotation terms
ids <- c("6Q21_B", "1NVW", "1P2U_A")
anno <- pdb.annotate(ids)

# Access terms, e.g. ligand names:
anno$ligandName

## only unique PDB IDs
anno <- pdb.annotate(ids, unique=TRUE)

# Fetch only specific terms
pdb.annotate(ids, anno.terms = c("pfam", "ligandId", "citation"))

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}


## Not run:
# PFAM server connection required - testing excluded

# Find PFAM annotations of PDB entries
pdb.pfam(c("6Q21_A", "1NVW", "1P2U_A"))

# More details and a not fond entry warning
pdb.pfam(c("1P2U_A", "6Q21_B"), compact=FALSE)

## End(Not run)
```

---

pdb2aln *Align a PDB structure to an existing alignment*

Description

Extract sequence from a PDB object and align it to an existing multiple sequence alignment that you wish keep intact.

Usage

```
pdb2aln(aln, pdb, id="seq.pdb", aln.id=NULL, file="pdb2aln.fa", ...)
```

Arguments

aln	an alignment list object with id and ali components, similar to that generated by read.fasta, read.fasta.pdb, and seqaln.
pdb	the PDB object to be added to aln.
id	name for the PDB sequence in the generated new alignment.
aln.id	id of the sequence in aln that is close to the sequence from pdb.
file	output file name for writing the generated new alignment.
...	additional arguments passed to seqaln.

Details

The basic effect of this function is to add a PDB sequence to an existing alignement. In this case, the function is simply a wrapper of seq2aln.

The more advanced (and also more useful) effect is giving complete mappings from the column indices of the original alignment (aln$ali) to atomic indices of equivalent C-alpha atoms in the pdb. These mappings are stored in the output list (see below 'Value' section). This feature is better illustrated in the function pdb2aln.ind, which calls pdb2aln and directly returns atom selections given a set of alignment positions. (See pdb2aln.ind for details.)

When aln.id is provided, the function will do pairwise alignment between the sequence from pdb and the sequence in aln with id matching aln.id. This is the best way to use the function if the protein has an identical or very similar sequence to one of the sequences in aln.

Value

Return a list object of the class 'fasta' containing three components:

id	sequence names as identifers.
ali	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
ref	an integer 2xN matrix, where N is the number of columns of the new alignment ali. The first row contains the column indices of the original alignment aln$ali. The second row contains atomic indices of equivalent C-alpha atoms in pdb. Gaps in the new alignement are indicated by NAs.

Author(s)

Xin-Qiu Yao & Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

seqaln, seq2aln, seqaln.pair, pdb2aln.ind

Examples

```
## Not run:
##--- Read aligned PDB coordinates (CA only)
aln  <- read.fasta(system.file("examples/kif1a.fa",package="bio3d"))
pdbs <- read.fasta.pdb(aln)

##--- Read PDB coordinate for a new structure (all atoms)
id <- get.pdb("2kin", URLonly=TRUE)
pdb <- read.pdb(id)

# add pdb to the alignment
naln <- pdb2aln(aln=pdbs, pdb=pdb, id=id)
naln


## End(Not run)
```

---

pdb2aln.ind *Mapping from alignment positions to PDB atomic indices*

Description

Find the best alignment between a PDB structure and an existing alignment. Then, given a set of column indices of the original alignment, returns atom selections of equivalent C-alpha atoms in the PDB structure.

Usage

```
pdb2aln.ind(aln, pdb, inds = NULL, ...)
```

Arguments

aln	an alignment list object with id and ali components, similar to that generated by read.fasta, read.fasta.pdb, pdbaln, and seqaln.
pdb	the PDB object to be aligned to aln.
inds	a numeric vector containing a subset of column indices of aln. If NULL, non-gap positions of aln$ali are used.
...	additional arguments passed to pdb2aln.

Details

Call pdb2aln to align the sequence of pdb to aln. Then, find the atomic indices of C-alpha atoms in pdb that are equivalent to inds, the subset of column indices of aln$ali.

The function is a rountine utility in a combined analysis of molecular dynamics (MD) simulation trajectories and crystallographic structures. For example, a typical post-analysis of MD simulation is to compare the principal components (PCs) derived from simulation trajectories with those derived from crystallographic structures. The C-alpha atoms used to fit trajectories and do PCA must be the same (or equivalent) to those used in the analysis of crystallographic structures, e.g. the 'non-gap' alignment positions. Call pdb2aln.ind with providing relevant alignment positions, one can easily get equivalent atom selections ('select' class objects) for the simulation topology (PDB) file and then do proper trajectory analysis.

Value

Returns a list containing two "select" objects:

a	atom and xyz indices for the alignment.
b	atom and xyz indices for the PDB.

Note that if any element of inds has no corresponding CA atom in the PDB, the output a$atom and b$atom will be shorter than inds, i.e. only indices having equivalent CA atoms are returned.

Author(s)

Xin-Qiu Yao, Lars Skjaerven & Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

seq2aln, seqaln.pair, pdb2aln

Examples

```
## Not run:
##--- Read aligned PDB coordinates (CA only)
aln  <- read.fasta(system.file("examples/kif1a.fa",package="bio3d"))
pdbs <- read.fasta.pdb(aln)

##--- Read the topology file of MD simulations
##--- For illustration, here we read another pdb file (all atoms)
pdb <- read.pdb("2kin")

#--- Map the non-gap positions to PDB C-alpha atoms
#pc.inds <- gap.inspect(pdbs$ali)
#npc.inds <- pdb2aln.ind(aln=pdbs, pdb=pdb, inds=pc.inds$f.inds)

#npc.inds$a
```

```
#npc.inds$b

#--- Or, map the non-gap positions with a known close sequence in the alignment
#npc.inds <- pdb2aln.ind(aln=pdbs, pdb=pdb, aln.id="1bg2", inds=pc.inds$f.inds)

#--- Map core positions
core <- core.find(pdbs)
core.inds <- pdb2aln.ind(aln=pdbs, pdb=pdb, inds = core$c1A.atom)

core.inds$a
core.inds$b

##--- Fit simulation trajectories to one of the X-ray structures based on
##--- core positions
#xyz <- fit.xyz(pdbs$xyz[1,], pdb$xyz, core.inds$a$xyz, core.inds$b$xyz)

##--- Do PCA of trajectories based on non-gap positions
#pc.traj <- pca(xyz[, npc.inds$b$xyz])


## End(Not run)
```

---

pdb2sse *Obtain An SSE Sequence Vector From A PDB Object*

Description

Results are similar to that returned by stride(pdb)$sse and dssp(pdb)$sse.

Usage

```
pdb2sse(pdb, verbose = TRUE)
```

Arguments

pdb	an object of class pdb as obtained from function read.pdb.
verbose	logical, if TRUE warnings and other messages will be printed.

Details

call for its effects.

Value

a character vector indicating SSE elements for each amino acide residue. The 'names' attribute of the vector contains 'resno', 'chain', 'insert', and 'SSE segment number', seperated by the character '_'.

Author(s)

Barry Grant & Xin-Qiu Yao

See Also

dssp, stride, bounds.sse

Examples

```
#PDB server connection required - testing excluded
try({

pdb <- read.pdb("1a7l")
sse <- pdb2sse(pdb)
sse

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

pdbaln *Sequence Alignment of PDB Files*

Description

Create multiple sequences alignments from a list of PDB files returning aligned sequence and structure records.

Usage

```
pdbaln(files, fit = FALSE, pqr = FALSE, ncore = 1,
       nseg.scale = 1, progress = NULL, ...)
```

Arguments

files	a character vector of PDB file names. Alternatively, a list of pdb objects can be provided.
fit	logical, if TRUE coordinate superposition is performed on the input structures.
pqr	logical, if TRUE the input structures are assumed to be in PQR format.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
nseg.scale	split input data into specified number of segments prior to running multiple core calculation. See fit.xyz.
progress	progress bar for use with shiny web app.
...	extra arguments passed to seqaln function.

Details

This wrapper function calls the underlying functions `read.pdb`, `pdbseq`, `seqaln` and `read.fasta.pdb` returning a list of class `"pdbs"` similar to that returned by `read.fasta.pdb`.

As these steps are often error prone it is recomended for most cases that the individual underlying functions are called in sequence with checks made on the valadity of their respective outputs to ensure sensible results.

Value

Returns a list of class `"pdbs"` with the following five components:

`xyz`	numeric matrix of aligned C-alpha coordinates.
`resno`	character matrix of aligned residue numbers.
`b`	numeric matrix of aligned B-factor values.
`chain`	character matrix of aligned chain identifiers.
`id`	character vector of PDB sequence/structure names.
`ali`	character matrix of aligned sequences.
`call`	the matched call.

Note

See recommendation in details section above.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`read.pdb`, `pdbseq`, `seqaln`, `read.fasta`,`read.fasta.pdb`, `core.find`, `fit.xyz`, `read.all`, `pymol.pdbs`

Examples

```
## Not run:
##- Align PDBs (from vector of filenames)
#files <- get.pdb(c("4q21","5p21"), URLonly=TRUE)
files <- get.pdb(c("4q21","5p21"), path=tempdir(), overwrite=TRUE)
pdbaln(files)


##- Align PDBs (from list of existing PDB objects)
pdblist <- list(read.pdb(files[1]), read.pdb(files[2]))
pdbaln(pdblist)


## End(Not run)
```

pdbfit *PDB File Coordinate Superposition*

Description

Protein Databank Bank file coordinate superposition with the Kabsch algorithm.

Usage

```
pdbfit(...)

## S3 method for class 'pdb'
pdbfit(pdb, inds = NULL, ...)

## S3 method for class 'pdbs'
pdbfit(pdbs, inds = NULL, outpath = NULL, ...)
```

Arguments

pdb	a multi-model pdb object of class "pdb", as obtained from read.pdb.
pdbs	a list of class "pdbs" containing PDB file data, as obtained from read.fasta.pdb or pdbaln.
inds	a list object with a 'xyz' component with indices that selects the coordinate positions (in terms of x, y and z elements) upon which fitting should be based. This defaults to all equivalent non-gap positions for function pdbfit.pdbs, and to all calpha atoms for function pdbfit.pdb.
outpath	character string specifing the output directory for optional coordinate file output. Note that full files (i.e. all atom files) are written, seebelow.
...	extra arguments passed to fit.xyz function.

Details

The function pdbfit is a wrapper for the function fit.xyz, wherein full details of the superposition procedure are documented.

Input to pdbfit.pdbs should be a list object obtained with the function read.fasta.pdb or pdbaln. See the examples below.

For function pdbfit.pdb the input should be a multi-model pdb object with multiple (>1) frames in the 'xyz' component.

The reference frame for supperposition (i.e. the fixed structure to which others are superposed) is the first entry in the input "pdbs" object. For finer control use fit.xyz.

Value

Returns moved coordinates.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Kabsch *Acta Cryst* (1978) **A34**, 827–828.

See Also

pdbaln, read.fasta.pdb, fit.xyz, rmsd, read.pdb

Examples

```
## Not run:
#files <- get.pdb(c("4q21","5p21"), URLonly=TRUE)
files <- get.pdb(c("4q21","5p21"), path=tempdir(), overwrite=TRUE)
pdbs <- pdbaln(files)
xyz <- pdbfit(pdbs)

# Superpose again this time outputing all-atom PDBs to disc
#xyz <- pdbfit( pdbs, outpath="fitted" )

## End(Not run)
```

---

pdbs2pdb *PDBs to PDB Converter*

Description

Convert a list of PDBs from an "pdbs" object to a list of pdb objects.

Usage

```
pdbs2pdb(pdbs, inds = NULL, rm.gaps = FALSE, all.atom=FALSE, ncore=NULL)
```

Arguments

pdbs	a list of class "pdbs" containing PDB file data, as obtained from read.fasta.pdb, pdbaln, or read.all.
inds	a vector of indices that selects the PDB structures to convert.
rm.gaps	logical, if TRUE atoms in gap containing columns are removed in the output pdb objects.
all.atom	logical, if TRUE all atom data are converted (the 'pdbs' object must be obtained from read.all or pdbs$id refers to existing PDB files).
ncore	number of CPU cores used to do the calculation.

Details

This function will generate a list of pdb objects from a "pdbs" class.

See examples for more details/

Value

Returns a list of pdb objects.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, pdbaln, read.fasta.pdb.

Examples

```
## Not run:
## Fetch PDBs
pdb.ids <- c("1YX5_B", "3NOB", "1P3Q_U")
#outdir <- paste(tempdir(), "/raw_pdbs", sep="")
outdir = "raw_pdbs"
raw.files <- get.pdb(pdb.ids, path = outdir)

## Split PDBs by chain ID and multi-model records
all.files <- pdbsplit(raw.files, pdb.ids,
                path =paste(outdir, "/split_chain", sep=""))

## Align and fit
pdbs     <- pdbaln(all.files, fit=TRUE)

## Convert back to PDB objects
all.pdbs <- pdbs2pdb(pdbs)

## Access the first PDB object
## all.pdbs[[1]]

## Return PDB objects consisting of only
## atoms in non-gap positions
all.pdbs <- pdbs2pdb(pdbs, rm.gaps=TRUE)


## End(Not run)
```

pdbs2sse *SSE annotation for a PDBs Object*

Description

Returns secondary structure element (SSE) annotation ("sse" object) for a structure in the provided "pdbs" object.

Usage

```
pdbs2sse(pdbs, ind = NULL, rm.gaps = TRUE, resno = TRUE, pdb = FALSE, ...)
```

Arguments

pdbs	a list of class "pdbs" containing PDB file data, as obtained from read.fasta.pdb or pdbaln.
ind	numeric index pointing to the PDB in which the SSE should be provided. If ind=NULL, then the consensus SSE is returned.
rm.gaps	logical, if TRUE SSEs spanning gap containing columns are omitted from the output in the resulting sse object.
resno	logical, if TRUE output is in terms of residue numbers rather than residue index (position in sequence).
pdb	logical, if TRUE function dssp will be called on the corresponding pdb object rather than to use pdbs$sse to obtain the SSE object.
...	arguments passed to function dssp.

Details

This function provides a "sse" list object containing secondary structure elements (SSE) annotation data for a particular structure in the provided "pdbs" object. Residue numbers are provided relative to the alignment in the "pdbs" object.

When ind=NULL the function will attemt to return the consensus SSE annotation, i.e. where there are SSEs across all structures. This will only work SSE data is found in the "pdbs" object.

See examples for more details.

Value

Returns a list object of class sse.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

dssp, pdbaln, read.fasta.pdb.

Examples

```
## Not run:
attach(transducin)

## calculate RMSF
rf <- rmsf(pdbs$xyz)

## Fetch SSE annotation, output in terms of alignment index
sse <- pdbs2sse(pdbs, ind=1, rm.gaps=FALSE, resno=FALSE)

## Add SSE annotation to plot
plotb3(rf, sse=sse)


## Calculate RMSF only for non-gap columns
gaps.pos <- gap.inspect(pdbs$xyz)
rf <- rmsf(pdbs$xyz[, gaps.pos$f.inds])

## With gap columns removed, output in terms of residue number
sse <- pdbs2sse(pdbs, ind=1, rm.gaps=TRUE, resno=TRUE)
gaps.res <- gap.inspect(pdbs$ali)
plotb3(rf, sse=sse, resno=pdbs$resno[1, gaps.res$f.inds])

detach(transducin)

## End(Not run)
```

---

pdbseq *Extract The Aminoacid Sequence From A PDB Object*

Description

Return a vector of the one-letter IUPAC or three-letter PDB style aminoacid codes from a given PDB object.

Usage

```
pdbseq(pdb, inds = NULL, aa1 = TRUE)
```

Arguments

pdb	a PDB structure object obtained from read.pdb.
inds	a list object of ATOM and XYZ indices as obtained from atom.select.
aa1	logical, if TRUE then the one-letter IUPAC sequence is returned. IF FALSE then the three-letter PDB style sequence is returned.

Details

See the examples below and the functions atom.select and aa321 for further details.

Value

A character vector of aminoacid codes.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of IUPAC one-letter codes see:
https://www.insdc.org/documents/feature_table.html#7.4.3

For more information on PDB residue codes see:
http://ligand-expo.rcsb.org/ld-search.html

See Also

read.pdb, atom.select, aa321, read.fasta

Examples

```
## Not run:
pdb <- read.pdb( "5p21" )
pdbseq(pdb)

#pdbseq(pdb, inds=atom.select(pdb, resno=5:15, elety="CA"), aa1=FALSE)

## End(Not run)
```

---

pdbsplit *Split a PDB File Into Separate Files, One For Each Chain.*

Description

Split a Protein Data Bank (PDB) coordinate file into new separate files with one file for each chain.

Usage

```
pdbsplit(pdb.files, ids = NULL, path = "split_chain", overwrite=TRUE,
         verbose = FALSE, mk4=FALSE, ncore = 1, progress = NULL, ...)
```

Arguments

pdb.files	a character vector of PDB file names.
ids	a character vector of PDB and chain identifiers (of the form: 'pdbId_chainId', e.g. '1bg2_A'). Used for filtering chain IDs for output (in the above example only chain A would be produced).
path	output path for chain-split files.
overwrite	logical, if FALSE the PDB structures will not be read and written if split files already exist.
verbose	logical, if TRUE details of the PDB header and chain selections are printed.
mk4	logical, if TRUE output filenames will use only the first four characters of the input filename (see basename.pdb for details).
ncore	number of CPU cores used for the calculation. ncore>1 requires package 'parallel' be installed.
progress	progress bar for use with shiny web app.
...	additional arguments to read.pdb. Useful e.g. for parsing multi model PDB files, including ALT records etc. in the output files.

Details

This function will produce single chain PDB files from multi-chain input files. By default all separate filenames are returned. To return only a subset of select chains the optional input 'ids' can be provided to filter the output (e.g. to fetch only chain C, of a PDB object with additional chains A+B ignored). See examples section for further details.

Note that multi model atom records will only split into individual PDB files if multi=TRUE, else they are omitted. See examples.

Value

Returns a character vector of chain-split file names.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

read.pdb, atom.select, write.pdb, get.pdb.

Examples

```
## Not run:
  ## Save separate PDB files for each chain of a local or on-line file
  pdbsplit( get.pdb("2KIN", URLonly=TRUE) )


  ## Split several PDBs by chain ID and multi-model records
  raw.files <- get.pdb( c("1YX5", "3NOB") , URLonly=TRUE)
  chain.files <- pdbsplit(raw.files,  path=tempdir(), multi=TRUE)
  basename(chain.files)


  ## Output only desired pdbID_chainID combinations
  ## for the last entry (1f9j), fetch all chains
  ids <- c("1YX5_A", "3NOB_B", "1F9J")
  raw.files <- get.pdb( ids , URLonly=TRUE)
  chain.files <- pdbsplit(raw.files, ids, path=tempdir())
  basename(chain.files)

## End(Not run)
```

`pfam` *Download Pfam FASTA Sequence Alignment*

Description

Downloads FASTA sequence alignment from the Pfam database.

Usage

```
pfam(id, alignment = "seed", verbose = FALSE)
```

Arguments

`id`	the Pfam familiy identifier (e.g 'Piwi') or accession (e.g. 'PF02171').
`alignment`	the alignment type. Allowed values are: 'seed', 'ncbi', 'full', 'metagenomics'.
`verbose`	logical, if TRUE details of the download process is printed.

Details

This is a basic function to download a multiple sequence alignment for a protein family from the Pfam database.

Value

A 'fasta' object with the following components:

`ali`	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
`ids`	sequence names as identifiers.
`call`	the matched call.

Note

Full more information on the Pfam database:
http://pfam.xfam.org

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, hmmer, get.seq, uniprot

Examples

```
## Not run:
# PFAM server connection required - testing excluded

aln <- pfam("piwi")
aln <- pfam("PF02171")

seq <- get.seq("1rx2_A", outfile = tempfile())
hmm <- hmmer(seq, type="hmmscan", db="pfam")
aln <- pfam(hmm$hit.tbl$acc[1])

# Or much more simply for RCSB PDB entries:
acc <- pdb.pfam("1rx2_A", compact=FALSE)$pfamAcc
aln <- pfam(acc)

## End(Not run)
```

plot.bio3d *Plots with marginal SSE annotation*

Description

Draw a standard scatter plot with optional secondary structure in the marginal regions.

Usage

```
  plotb3(x, resno = NULL, rm.gaps = FALSE, type = "h",
             main = "", sub = "",
             xlim = NULL, ylim = NULL, ylim2zero = TRUE,
             xlab = "Residue", ylab = NULL,
             axes = TRUE, ann = par("ann"), col = par("col"),
             sse = NULL, sse.type="classic", sse.min.length=5,
             top = TRUE, bot = TRUE,
             helix.col = "gray20", sheet.col = "gray80",
             sse.border = FALSE, ...)

             ## S3 method for class 'bio3d'
plot(...)
```

Arguments

x	a numeric vector of values to be plotted. Any reasonable way of defining these plot coordinates is acceptable. See the function 'xy.coords' for details.
resno	an optional vector with length equal to that of 'x' that will be used to annotate the xaxis. This is typically a vector of residue numbers. If NULL residue positions from 1 to the length of 'x' will be used. See examples below.
rm.gaps	logical, if TRUE gaps in x, indicated by NA values, will be removed from plot.
type	one-character string giving the type of plot desired. The following values are possible, (for details, see 'plot'): 'p' for points, 'l' for lines, 'o' for over-plotted points and lines, 'b', 'c') for points joined by lines, 's' and 'S' for stair steps and 'h' for histogram-like vertical lines. Finally, 'n' does not produce any points or lines.
main	a main title for the plot, see also 'title'.
sub	a sub-title for the plot.
xlim	the x limits (x1,x2) of the plot. Note that x1 > x2 is allowed and leads to a reversed axis.
ylim	the y limits of the plot.
ylim2zero	logical, if TRUE the y-limits are forced to start at zero.
xlab	a label for the x axis, defaults to a description of 'x'.

ylab	a label for the y axis, defaults to a description of 'y'.
axes	a logical value indicating whether both axes should be drawn on the plot. Use graphical parameter 'xaxt' or 'yaxt' to suppress just one of the axes.
ann	a logical value indicating whether the default annotation (title and x and y axis labels) should appear on the plot.
col	The colors for lines and points. Multiple colors can be specified so that each point is given its own color. If there are fewer colors than points they are recycled in the standard fashion. Lines are plotted in the first color specified.
sse	secondary structure object as returned from dssp, stride or in certain cases read.pdb.
sse.type	single element character vector that determines the type of secondary structure annotation drawn. The following values are possible, 'classic' and 'fancy'. See details and examples below.
sse.min.length	a single numeric value giving the length below which secondary structure elements will not be drawn. This is useful for the exclusion of short helix and strand regions that can often crowd these forms of plots.
top	logical, if TRUE rectangles for each sse are drawn towards the top of the plotting region.
bot	logical, if TRUE rectangles for each sse are drawn towards the bottom of the plotting region.
helix.col	The colors for rectangles representing alpha helices.
sheet.col	The colors for rectangles representing beta strands.
sse.border	The border color for all sse rectangles.
...	other graphical parameters.

Details

This function is useful for plotting per-residue numeric vectors for a given protein structure (e.g. results from RMSF, PCA, NMA etc.) along with a schematic representation of major secondary structure elements.

Two forms of secondary structure annotation are available: so called 'classic' and 'fancy'. The former draws marginal rectangles and has been available within Bio3D from version 0.1. The later draws more 'fancy' (and distracting) 3D like helices and arrowed strands.

See the functions 'plot.default', dssp and stride for further details.

Value

Called for its effect.

Note

Be sure to check the correspondence of your 'sse' object with the 'x' values being plotted as no internal checks are performed.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.default, dssp, stride

Examples

```
# PDB server connection required - testing excluded
try({

## Plot of B-factor values along with secondary structure from PDB
pdb <- read.pdb( "1bg2" )
bfac <- pdb$atom[pdb$calpha,"b"]
plot.bio3d(bfac, sse=pdb, ylab="B-factor", col="gray")
points(bfac, typ="l")

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}


## Not run:
## Use PDB residue numbers and include short secondary structure elements
plot.bio3d(pdb$atom[pdb$calpha,"b"], sse=pdb, resno=pdb, ylab="B-factor",
  typ="l", lwd=1.5, col="blue", sse.min.length=0)


## Calculate secondary structure using stride() or dssp()
#sse <- stride(pdb)
sse <- dssp(pdb)

## Plot of B-factor values along with calculated secondary structure
plot.bio3d(pdb$atom[pdb$calpha,"b"], sse=sse, ylab="B-factor", typ="l",
col="blue", lwd=2)

## End(Not run)


# PDB server connection required - testing excluded
try({

## Plot 'aligned' data respecting gap positions
attach(transducin)

pdb = read.pdb("1tnd") ## Reference PDB see: pdbs$id[1]
```

```
pdb = trim.pdb(pdb, inds=atom.select(pdb, chain="A"))

## Plot of B-factor values with gaps
plot.bio3d(pdbs$b, resno=pdb, sse=pdb, ylab="B-factor")

## Plot of B-factor values after removing all gaps
plot.bio3d(pdbs$b, rm.gaps=TRUE, resno = pdb, sse=pdb, ylab="B-factor")

detach(transducin)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}


## Fancy secondary structure elements
##plot.bio3d(pdb$atom[pdb$calpha,"b"], sse=pdb, ssetype="fancy")
## Currently not implemented
```

---

plot.cmap *Plot Contact Matrix*

Description

Plot a contact matrix with optional secondary structure in the marginal regions.

Usage

```
## S3 method for class 'cmap'
plot(x, col=2, pch=16, main="Contact map", sub="",
           xlim=NULL, ylim=NULL, xlab = "Residue index", ylab = xlab,
           axes=TRUE, ann=par("ann"), sse=NULL, sse.type="classic",
           sse.min.length=5, bot=TRUE, left=TRUE,
           helix.col="gray20", sheet.col="gray80", sse.border=FALSE,
           add=FALSE, ...)
```

Arguments

x	a numeric matrix of residue contacts as obtained from function cmap.
col	color code or name, see par.
pch	plotting 'character', i.e., symbol to use. This can either be a single character or an integer code for one of a set of graphics symbols. See points.
main	a main title for the plot, see also 'title'.
sub	a sub-title for the plot.
xlim	the x limits (x1,x2) of the plot. Note that x1 > x2 is allowed and leads to a reversed axis.

ylim	the y limits of the plot.
xlab	a label for the x axis, defaults to a description of 'x'.
ylab	a label for the y axis, defaults to a description of 'y'.
axes	a logical value indicating whether both axes should be drawn on the plot. Use graphical parameter 'xaxt' or 'yaxt' to suppress just one of the axes.
ann	a logical value indicating whether the default annotation (title and x and y axis labels) should appear on the plot.
sse	secondary structure object as returned from dssp, stride or in certain cases read.pdb.
sse.type	single element character vector that determines the type of secondary structure annotation drawn. The following values are possible, 'classic' and 'fancy'. See details and examples below.
sse.min.length	a single numeric value giving the length below which secondary structure elements will not be drawn. This is useful for the exclusion of short helix and strand regions that can often crowd these forms of plots.
left	logical, if TRUE rectangles for each sse are drawn towards the left of the plotting region.
bot	logical, if TRUE rectangles for each sse are drawn towards the bottom of the plotting region.
helix.col	The colors for rectangles representing alpha helices.
sheet.col	The colors for rectangles representing beta strands.
sse.border	The border color for all sse rectangles.
add	logical, specifying if the contact map should be added to an already existing plot. Note that when 'TRUE' only points are plotted (no annotation).
...	other graphical parameters.

Details

This function is useful for plotting a residue-residue contact data for a given protein structure along with a schematic representation of major secondary structure elements.

Two forms of secondary structure annotation are available: so called 'classic' and 'fancy'. The former draws marginal rectangles and has been available within Bio3D from version 0.1. The later draws more 'fancy' (and distracting) 3D like helices and arrowed strands.

Value

Called for its effect.

Note

Be sure to check the correspondence of your 'sse' object with the 'x' values being plotted as no internal checks are performed.

Author(s)

Lars Skjaerven, Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

cmap, dm, plot.dmat, plot.default, plot.bio3d, dssp, stride

Examples

```
##- Read PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

##- Calcualte contact map
cm <- cmap(pdb)

##- Plot contact map
plot.cmap(cm, sse=pdb)

##- Add to plot
plot.cmap(t(cm), col=3, pch=17, add=TRUE)
```

---

plot.cna *Protein Structure Network Plots in 2D and 3D.*

Description

Plot a protein dynamic network as obtained from the *cna* function.

Usage

```
  ## S3 method for class 'cna'
plot(x, pdb = NULL, weights=NULL, vertex.size=NULL,
            layout=NULL, col=NULL, full=FALSE, scale=TRUE, color.edge = FALSE,
            interactive=FALSE, ...)
  ## S3 method for class 'ecna'
plot(x, ...)
```

Arguments

x	A protein network graph object (or a list of such objects) as obtained from the 'cna' function.
pdb	A PDB structure object obtained from 'read.pdb'. If supplied this will be used to guide the network plot 'layout', see 'layout.cna' for details.
weights	A numeric vector containing the edge weights for the network.

vertex.size	A numeric vector of node/community sizes. If NULL the size will be taken from the input network graph object 'x'. Typically for 'full=TRUE' nodes will be of an equal size and for 'full=FALSE' community node size will be proportional to the residue membership of each community.
layout	Either a function or a numeric matrix. It specifies how the vertices will be placed on the plot. See 'layout.cna'.
col	A vector of colors used for node/vertex rendering. If NULL these values are taken from the input network 'V(x$community.network)$color'.
full	Logical, if TRUE the full all-atom network rather than the clustered community network will be plotted.
scale	Logical, if TRUE weights are scaled with respect to the network.
color.edge	Logical, if TRUE edges are colored with respect to their weights.
interactive	Logical, if TRUE interactive graph will be drawn where users can manually adjust the network (positions of vertices, colors of edges, etc.). Needs Tcl/Tk support in the installed R build.
...	Additional graphical parameters for 'plot.igraph'.

Details

This function calls 'plot.igraph' from the igraph package to plot cna networks the way we like them.

The plot layout is user settable, we like the options of: 'layout.cna', 'layout.fruchterman.reingold', 'layout.mds' or 'layout.svd'. Note that first of these uses PDB structure information to produce a more meaningful layout.

Extensive plot modifications are possible by setting additional graphical parameters (...). These options are detailed in 'igraph.plotting'. Common parameters to alter include:

vertex.label: Node labels, `V(x$network)$name`. Use NA to omit.

vertex.label.color: Node label colors, see also `vertex.label.cex` etc.

edge.color: Edge colors, `E(x$network)$color`.

mark.groups: Community highlighting, a community list object, see also `mark.col` etc.

Value

Produces a network plot on the active graphics device. Also returns the plot layout coordinates silently, which can be passed to the 'identify.cna' function.

Note

Be sure to check the correspondence of your 'pdb' object with your network object 'x', as few internal checks are currently performed by the 'layout.cna' function.

Author(s)

Barry Grant and Guido Scarabelli

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.igraph, plot.communities, igraph.plotting

Examples

```
# PDB server connection required - testing excluded

if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

try({

##-- Build a CNA object
pdb <- read.pdb("4Q21")
modes <- nma(pdb)
cij <- dccm(modes)
net <- cna(cij, cutoff.cij=0.2)

# Plot coarse grain network based on dynamically coupled communities
xy <- plot.cna(net)
#plot.dccm(cij, margin.segments=net$communities$membership)

# Chose a different PDB informed layout for plot
plot.cna(net, pdb)

# Play with plot layout and colors...
plot.cna(net, layout=igraph::layout.mds(net$community.network), col=c("blue","green") )

# Plot full residue network colored by communities - will be slow due to number of edges!!
plot.cna(net, pdb, full=TRUE)

# Alter plot settings
plot.cna(net, pdb, full=TRUE, vertex.size=3, weights=1, vertex.label=NA)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
}
```

---

plot.core *Plot Core Fitting Progress*

Description

Plots the total ellipsoid volume of core positions versus core size at each iteration of the core finding process.

Usage

```
## S3 method for class 'core'
plot(x, y = NULL, type = "h", main = "", sub = "",
   xlim = NULL, ylim = NULL, xlab = "Core Size (Number of Residues)",
   ylab = "Total Ellipsoid Volume (Angstrom^3)", axes = TRUE,
   ann = par("ann"), col = par("col"), ...)
```

Arguments

x	a list object obtained with the function core.find from which the 'volume' component is taken as the x coordinates for the plot.
y	the y coordinates for the plot.
type	one-character string giving the type of plot desired.
main	a main title for the plot, see also 'title'.
sub	a sub-title for the plot.
xlim	the x limits of the plot.
ylim	the y limits of the plot.
xlab	a label for the x axis.
ylab	a label for the y axis.
axes	a logical value indicating whether both axes should be drawn.
ann	a logical value indicating whether the default annotation (title and x and y axis labels) should appear on the plot.
col	The colors for lines and points. Multiple colours can be specified so that each point is given its own color. If there are fewer colors than points they are recycled in the standard fashion.
...	extra plotting arguments.

Value

Called for its effect.

Note

The produced plot can be useful for deciding on the core/non-core boundary.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

core.find, print.core

Examples

```
## Not run:

##-- Generate a small kinesin alignment and read corresponding structures
pdbfiles <- get.pdb(c("1bg2","2ncd","1i6i","1i5s"), URLonly=TRUE)
pdbs <- pdbaln(pdbfiles)

##-- Find 'core' positions
core <- core.find(pdbs)
plot(core)

##-- Fit on these relatively invarient subset of positions
core.inds <- print(core)
xyz <- pdbfit(pdbs, core.inds, outpath="corefit_structures")

##-- Compare to fitting on all equivalent positions
xyz2 <- pdbfit(pdbs)

## Note that overall RMSD will be higher but RMSF will
##  be lower in core regions, which may equate to a
##  'better fit' for certain applications
gaps <- gap.inspect(pdbs$xyz)
rmsd(xyz[,gaps$f.inds])
rmsd(xyz2[,gaps$f.inds])

plot(rmsf(xyz[,gaps$f.inds]), typ="l", col="blue", ylim=c(0,9))
points(rmsf(xyz2[,gaps$f.inds]), typ="l", col="red")


## End(Not run)
```

---

plot.dccm *DCCM Plot*

Description

Plot a dynamical cross-correlation matrix.

Usage

```
## S3 method for class 'dccm'
plot(x, resno=NULL, sse=NULL, colorkey=TRUE,
                    at=c(-1, -0.75, -0.5,  -0.25, 0.25, 0.5, 0.75, 1),
                    main="Residue Cross Correlation",
                    helix.col = "gray20", sheet.col = "gray80",
                    inner.box=TRUE, outer.box=FALSE,
                    xlab="Residue No.", ylab="Residue No.",
              margin.segments=NULL, segment.col=vmd_colors(), segment.min=1, ...)
```

Arguments

x	a numeric matrix of atom-wise cross-correlations as output by the 'dccm' function.
resno	an optional vector with length equal to that of x that will be used to annotate the x- and y-axis. This is typically a vector of residue numbers. Can be also provided with a 'pdb' object, in which 'resno' of all C-alpha atoms will be used. If NULL residue positions from 1 to the length of x will be used. See examples below.
sse	secondary structure object as returned from dssp, stride or read.pdb.
colorkey	logical, if TRUE a key is plotted.
at	numeric vector specifying the levels to be colored.
main	a main title for the plot.
helix.col	The colors for rectangles representing alpha helices.
sheet.col	The colors for rectangles representing beta strands.
inner.box	logical, if TRUE an outer box is drawn.
outer.box	logical, if TRUE an outer box is drawn.
xlab	a label for the x axis.
ylab	a label for the y axis.
margin.segments	a numeric vector of cluster membership as obtained from cutree() or other community detection method. This will be used for bottom and left margin annotation.
segment.col	a vector of colors used for each cluster group in margin.segments.
segment.min	a single element numeric vector that will cause margin.segments with a length below this value to be excluded from the plot.
...	additional graphical parameters for contourplot.

Details

See the 'contourplot' function from the lattice package for plot customization options, and the functions dssp and stride for further details.

Value

Called for its effect.

Note

Be sure to check the correspondence of your 'sse' object with the 'cij' values being plotted as no internal checks are currently performed.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.bio3d, plot.dmat, filled.contour, contour, image plot.default, dssp, stride

Examples

```
## Not run:
  ##-- Read example trajectory file
  trtfile <- system.file("examples/hivp.dcd", package="bio3d")
  trj <- read.dcd(trtfile)

  ## Read reference PDB and trim it to match the trajectory
  pdb <- trim(read.pdb("1W5Y"), 'calpha')

  ## select residues 24 to 27 and 85 to 90 in both chains
  inds <- atom.select(pdb, resno=c(24:27,85:90))

  ## lsq fit of trj on pdb
  xyz <- fit.xyz(pdb$xyz, trj, fixed.inds=inds$xyz, mobile.inds=inds$xyz)

  ## Dynamic cross-correlations of atomic displacements
  cij <- dccm(xyz)

  ## Default plot
  plot.dccm(cij)

  ## Change the color scheme and the range of colored data levels
  plot.dccm(cij, contour=FALSE, col.regions=bwr.colors(200), at=seq(-1,1,by=0.01) )

  ## Add secondary structure annotation to plot margins
  plot.dccm(cij, sse=pdb)

  ## Add additional margin annotation for chains
  ## Also label x- and y-axis with PDB residue numbers
  ch <- ifelse(pdb$atom$chain=="A", 1,2)
```

```
  plot.dccm(cij, resno=pdb, sse=pdb, margin.segments=ch)

  ## Plot with cluster annotation from dynamic network analysis
  #net <- cna(cij)
  #plot.dccm(cij, margin.segments=net$raw.communities$membership)

  ## Focus on major communities (i.e. exclude those below a certain total length)
  #plot.dccm(cij, margin.segments=net$raw.communities$membership, segment.min=25)


## End(Not run)
```

`plot.dmat` *Plot Distance Matrix*

Description

Plot a distance matrix (DM) or a difference distance matrix (DDM).

Usage

```
## S3 method for class 'dmat'
plot(x, key = TRUE, resnum.1 = c(1:ncol(x)), resnum.2 = resnum.1,
          axis.tick.space = 20, zlim = range(x, finite = TRUE),
          nlevels = 20, levels = pretty(zlim, nlevels),
          color.palette = bwr.colors,
          col = color.palette(length(levels) - 1),
          axes = TRUE, key.axes, xaxs = "i", yaxs = "i", las = 1,
          grid = TRUE, grid.col = "yellow", grid.nx = floor(ncol(x)/30),
          grid.ny = grid.nx, center.zero = TRUE, flip=TRUE, ...)
```

Arguments

`x`	a numeric distance matrix generated by the function `dm`.
`key`	logical, if TRUE a color key is plotted.
`resnum.1`	a vector of residue numbers for annotating the x axis.
`resnum.2`	a vector of residue numbers for annotating the y axis.
`axis.tick.space`	the separation between each axis tick mark.
`zlim`	z limits for the distances to be plotted.
`nlevels`	if `levels` is not specified, the range of 'z' values is divided into approximately this many levels.
`levels`	a set of levels used to partition the range of 'z'. Must be *strictly* increasing (and finite). Areas with 'z' values between consecutive levels are painted with the same color.

color.palette	a color palette function, used to assign colors in the plot.
col	an explicit set of colors to be used in the plot. This argument overrides any palette function specification.
axes	logical, if TRUE plot axes are drawn.
key.axes	statements which draw axes on the plot key. It overrides the default axis.
xaxs	the x axis style. The default is to use internal labeling.
yaxs	the y axis style. The default is to use internal labeling.
las	the style of labeling to be used. The default is to use horizontal labeling.
grid	logical, if TRUE overlaid grid is drawn.
grid.col	color of the overlaid grid.
grid.nx	number of grid cells in the x direction.
grid.ny	number of grid cells in the y direction.
center.zero	logical, if TRUE levels are forced to be equidistant around zero, assuming that zlim ranges from less than to more than zero.
flip	logical, indicating whether the second axis should be fliped.
...	additional graphical parameters for image.

Value

Called for its effect.

Note

This function is based on the layout and legend key code in the function filled.contour by Ross Ihaka. As with filled.contour the output is a combination of two plots: the legend and (in this case) image (rather than a contour plot).

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.T

Much of this function is based on the filled.contour function by Ross Ihaka.

See Also

dm, filled.contour, contour, image

Examples

```
# Read PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

# DM
d <- dm(pdb,"calpha")

# Plot DM
##filled.contour(d, nlevels = 4)
##plot(d)
plot(d,
     resnum.1 = pdb$atom[pdb$calpha,"resno"],
     color.palette = mono.colors,
     xlab="Residue Number", ylab="Residue Number")

## Not run:
# Download and align two PDB files
pdbs <- pdbaln( get.pdb( c( "4q21", "521p"), path=tempdir(), overwrite=TRUE))

# Get distance matrix
a <- dm.xyz(pdbs$xyz[1,])
b <- dm.xyz(pdbs$xyz[2,])

# Calculate DDM
c <- a - b

# Plot DDM
plot(c,key=FALSE, grid=FALSE)

plot(c, axis.tick.space=10,
     resnum.1=pdbs$resno[1,],
     resnum.2=pdbs$resno[2,],
     grid.col="black",
     xlab="Residue No. (4q21)", ylab="Residue No. (521p)")


## End(Not run)
```

`plot.enma` *Plot eNMA Results*

Description

Produces a plot of atomic fluctuations of aligned normal modes.

Usage

```
## S3 method for class 'enma'
plot(x,
```

```
          pdbs = NULL,
          xlab = NULL,
          ylab="Fluctuations", ...)
```

Arguments

x	the results of ensemble NMA obtained with nma.pdbs. Alternatively, a matrix in the similar format as enma$fluctuations can be provided.
pdbs	an object of class 'pdbs' in which the 'enma' object x was obtained from. If provided SSE data of the first structure of pdbs will drawn.
xlab	a label for the x axis.
ylab	labels for the y axes.
...	extra plotting arguments passed to plot.fluct that effect the atomic fluctuations plot only.

Details

plot.enma produces a fluctuation plot of aligned nma objects. If corresponding pdbs object is provided the plot contains SSE annotation and appropriate resiude index numbering.

Value

Called for its effect.

Author(s)

Lars Skjaerven, Barry Grant

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma, plotb3, plot.fluct

Examples

```
## Not run:
ids <- c("1a70_A", "1czp_A", "1frd_A", "1fxi_A", "1iue_A", "1pfd_A")
raw.files <- get.pdb(ids, path = "raw_pdbs")
files <- pdbsplit(raw.files, ids, path = "raw_pdbs/split_chain")

## Sequence/structure alignement
pdbs <- pdbaln(files)

## Normal mode analysis on aligned data
modes <- nma(pdbs)
```

```
## Plot fluctuations
plot(modes, pdbs=pdbs)

## Group and spread fluctuation profiles
hc <- hclust(as.dist(1-modes$rmsip))
col <- cutree(hc, k=2)
plot(modes, pdbs=pdbs, col=col, spread=TRUE)

## End(Not run)
```

`plot.fasta` *Plot a Multiple Sequence Alignment*

Description

Produces a schematic representation of a multiple sequence alignment.

Usage

```
## S3 method for class 'fasta'
plot(x, hc = TRUE, labels = x$id, cex.lab = 0.7,
                          xlab = "Alignment index",
                          main = "Sequence Alignment Overview",
                          mar4 = 4, ...)
```

Arguments

`x`	multiple sequence alignement of class 'fasta' as obtained from `seqaln`.
`hc`	logical, if TRUE plot a dendrogram on the left side. Alternatively, an object obtained from `hclust` can be provided.
`labels`	labels corresponding to each row in the alignment.
`cex.lab`	scaling factor for the labels.
`xlab`	label for x-axis.
`main`	a main title for the plot.
`mar4`	margin size for the labels.
`...`	additional arguments passed to function `hclust`.

Details

`plot.fasta` is a utility function for producting a schematic representation of a multiple sequence alignment.

Value

Called for its effect.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

seqaln, read.fasta, entropy, aln2html.

Examples

```
# Read alignment
aln <- read.fasta(system.file("examples/kif1a.fa",package="bio3d"))

## alignment plot
plot(aln, labels=basename.pdb(aln$id))

## Works also for a 'pdbs' object
attach(transducin)
plot(pdbs)

detach(transducin)

## Not run:
infile <- "http://pfam.xfam.org/family/PF00071/alignment/seed/format?format=fasta"
aln <- read.fasta( infile )
plot(aln)

## End(Not run)
```

---

plot.fluct *Plot Fluctuations*

Description

Produces a plot of atomic fluctuations obtained from ensemble normal mode analysis or molecular dynamics simulations.

Usage

```
## S3 method for class 'fluct'
plot(x,
        col = NULL, label = rownames(x), signif = FALSE,
        p.cutoff = 0.005, q.cutoff = 0.04,
        s.cutoff = 5, n.cutoff = 2, mean = FALSE, polygon = FALSE,
        spread = FALSE, offset = 1,
        ncore = NULL, ...)
```

Arguments

x	a numeric vector or matrix containing atomic fluctuation data obtained from e.g. nma.pdbs or rmsf.
col	a character vector of plotting colors. Used also to group fluctuation profiles. NA values in col will omit the corresponding fluctuation profile in the plot.
label	a character vector of plotting labels with length matching nrow(x). If mean=TRUE, the length of label can be equal to the number of categories indicated by col.
signif	logical, if TRUE significance of fluctuation difference is calculated and annotated for each atomic position.
p.cutoff	Cutoff of p-value to define significance.
q.cutoff	Cutoff of the mean fluctuation difference to define significance.
s.cutoff	Cutoff of sample size in each group to calculate the significance.
n.cutoff	Cutoff of consecutive residue positions with significant fluctuation difference. If the actual number is less than the cutoff, correponding postions will not be annotated.
mean	logical, if TRUE plot mean fluctuations of each group. Significance is still calculated with the original data.
polygon	logical, if TRUE a nicer plot with area under the line for the first row of x are filled with polygons.
ncore	number of CPU cores used to do the calculation. By default (ncore=NULL), use all available CPU cores. The argument is only used when signif=TRUE.
spread	logical, if TRUE the fluctuation profiles are spread - i.e. not on top of each other.
offset	numerical offset value in use when 'spread=TRUE'.
...	extra plotting arguments passed to plot.bio3d.

Details

The significance calculation is performed when signif=TRUE and there are at least two groups with sample size larger than or equal to s.cutoff. A "two-sided" student's t-test is performed for each atomic position (each column of x). If x contains gaps, indicated by NAs, only non-gapped positions are considered. The position is considered significant if both p-value <= p.cutoff and the mean value difference of the two groups, q, satisfies q >= q.cutoff. If more than two groups are available, every pair of groups are subjected to the t-test calculation and the minimal p-value along with the q-value for the corresponding pair are used for the significance evaluation.

Value

If significance is calculated, return a vector indicating significant positions.

Author(s)

Xin-Qiu Yao, Lars Skjaerven, Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.bio3d, rmsf, nma.pdbs, t.test, polygon.

Examples

```
## Not run:
## load transducin example data
attach(transducin)

## subset of pdbs to analyze
inds = c(1:5, 16:20)
pdbs <- trim(pdbs, row.inds=inds)
gaps.res = gap.inspect(pdbs$ali)

## reference RESNO and SSE for axis annotations
resno <- pdbs$resno[1, gaps.res$f.inds]
sse <- pdbs$sse[1, gaps.res$f.inds]

## eNMA calculation and obtain modes of motion including atomic fluctuations
modes <- nma(pdbs, ncore=NULL)
x = modes$fluctuation

## simple line plot with SSE annotation
plot.fluct(x, sse=sse, resno=resno)

## group data by specifying colors of each fluctuation line; same color indicates
## same group. Also do significance calculation and annotation
col = c(rep('red', 5), rep('blue', 5))
plot.fluct(x, col=col, signif=TRUE, sse=sse, resno=resno)

## spread lines
plot.fluct(x, col=col, signif=TRUE, sse=sse, resno=resno, typ='l', spread=TRUE)

## show only line of mean values for each group.
## Nicer plot with area shaded for the first group.
plot.fluct(x, col=col, signif=TRUE, sse=sse, resno=resno, mean=TRUE,
           polygon=TRUE, label=c('GTP', 'GDI'))

detach(transducin)

## End(Not run)
```

---

plot.geostas *Plot Geostas Results*

Description

Plot an atomic movement similarity matrix with domain annotation

Usage

```
## S3 method for class 'geostas'
plot(x, at=seq(0, 1, 0.1), main="AMSM with Domain Assignment",
                          col.regions=rev(heat.colors(200)),
                          margin.segments=x$grps, ...)
```

Arguments

x	an object of type geostas as obtained by the 'geostas' function.
at	numeric vector specifying the levels to be colored.
main	a main title for the plot.
col.regions	color vector. See contourplot for more information.
margin.segments	a numeric vector of cluster membership as obtained from cutree() or other community detection method. This will be used for bottom and left margin annotation.
...	additional graphical parameters for plot.dccm and contourplot.

Details

This is a wrapper function for plot.dccm with appropriate adjustments for plotting atomic movement similarity matrix obtained from function geostas.

See the plot.dccm for more details.

Value

Called for its effect.

Author(s)

Barry Grant, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.dccm, geostas

plot.hmmer *Plot a Summary of HMMER Hit Statistics.*

Description

Produces a number of basic plots that should facilitate hit selection from the match statistics of a HMMER result.

Usage

```
 ## S3 method for class 'hmmer'
plot(x, ...)
```

Arguments

x	HMMER results as obtained from the function hmmer.
...	arguments passed to plot.blast.

Details

See plot.blast for details.

Value

Produces a plot on the active graphics device and returns a three component list object:

hits	an ordered matrix detailing the subset of hits with a normalized score above the chosen cutoff. Database identifiers are listed along with their cluster group number.
acc	a character vector containing the database accession identifier of each hit above the chosen threshold.
pdb.id	a character vector containing the database accession identifier of each hit above the chosen threshold.
inds	a numeric vector containing the indices of the hits relative to the input hmmer object.

Author(s)

Barry Grant, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

hmmer, blast.pdb

Examples

```
## Not run:
# HMMER server connection required - testing excluded

##- PHMMER
seq <- get.seq("2abl_A", outfile = tempfile())
res <- hmmer(seq, db="pdb")
plot.hmmer(res)


## End(Not run)
```

`plot.matrix.loadings` *Plot Residue-Residue Matrix Loadings*

Description

Plot residue-residue matrix loadings of a particular PC that is obtained from a principal component analysis (PCA) of cross-correlation or distance matrices.

Usage

```
## S3 method for class 'matrix.loadings'
plot(x, pc = 1, resno = NULL, sse = NULL,
  mask.n = 0, plot = TRUE, ...)
```

Arguments

`x`	the results of PCA as obtained from `pca.array`.
`pc`	the principal component along which the loadings will be shown.
`resno`	numerical vector or 'pdb' object as obtained from `read.pdb` to show residue number on the x- and y-axis.
`sse`	a 'sse' object as obtained from `dssp` or `stride`, or a 'pdb' object as obtained from `read.pdb` to show secondary structural elements along x- and y-axis.
`mask.n`	the number of elements from the diagonal to be masked from output.
`plot`	logical, if FALSE no plot will be shown.
`...`	additional arguments passed to `plot.dccm`.

Details

The function plots loadings (the eigenvectors) of PCA performed on a set of matrices such as distance matrices from an ensemble of crystallographic structures and residue-residue cross-correlations or covariance matrices derived from ensemble NMA or MD simulation replicates (See `pca.array` for detail). Loadings are displayed as a matrix with dimension the same as the input matrices of the PCA. Each element of loadings represents the proportion that the corresponding residue pair contributes to the variance in a particular PC. The plot can be used to identify key regions that best explain the variance of underlying matrices.

Value

Plot and also returns a numeric matrix containing the loadings.

Author(s)

Xin-Qiu Yao

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

plot.dccm, pca.array

Examples

```
## Not run:
   attach(transducin)
   gaps.res <- gap.inspect(pdbs$ali)
   sse <- pdbs$sse[1, gaps.res$f.inds]

   # calculate modes
   modes <- nma(pdbs, ncore=NULL)

   # calculate cross-correlation matrices from the modes
   cijs <- dccm(modes, ncore=NULL)$all.dccm

   # do PCA on cross-correlation matrices
   pc <- pca.array(cijs)

   # plot loadings
   l <- plot.matrix.loadings(pc, sse=sse)
   l[1:10, 1:10]

   # plot loadings with elements 10-residue separated from diagonal masked
   plot.matrix.loadings(pc, sse=sse, mask.n=10)


## End(Not run)
```

---

plot.nma *Plot NMA Results*

Description

Produces eigenvalue/frequency spectrum plots and an atomic fluctuations plot.

Usage

```
## S3 method for class 'nma'
plot(x, pch = 16, col = par("col"), cex=0.8, mar=c(6, 4, 2, 2),...)
```

Arguments

x	the results of normal modes analysis obtained with nma.
pch	a vector of plotting characters or symbols: see points.
col	a character vector of plotting colors.
cex	a numerical single element vector giving the amount by which plotting text and symbols should be magnified relative to the default.
mar	A numerical vector of the form c(bottom, left, top, right) which gives the number of lines of margin to be specified on the four sides of the plot.
...	extra plotting arguments passed to plot.bio3d that effect the atomic fluctuations plot only.

Details

plot.nma produces an eigenvalue (or frequency) spectrum plot together with a plot of the atomic fluctuations.

Value

Called for its effect.

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

nma, plot.bio3d

Examples

```
## Fetch structure
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate modes
modes <- nma(pdb)

plot(modes, sse=pdb)
```

plot.pca *Plot PCA Results*

Description

Produces a z-score plot (conformer plot) and an eigen spectrum plot (scree plot).

Usage

```
## S3 method for class 'pca'
plot(x, pc.axes=NULL, pch=16, col=par("col"), cex=0.8, mar=c(4, 4, 1, 1),...)

## S3 method for class 'pca.scree'
plot(x, y = NULL, type = "o", pch = 18,
         main = "", sub = "", xlim = c(0, 20), ylim = NULL,
         ylab = "Proportion of Variance (%)",
         xlab = "Eigenvalue Rank", axes = TRUE, ann = par("ann"),
         col = par("col"), lab = TRUE, ...)
## S3 method for class 'pca.score'
plot(x, inds=NULL, col=rainbow(nrow(x)), lab = "", ...)
```

Arguments

x	the results of principal component analysis obtained with pca.xyz.
pc.axes	an optional numeric vector of length two specifying the principal components to be plotted. A NULL value will result in an overview plot of the first three PCs and a scree plot. See examples.
pch	a vector of plotting characters or symbols: see 'points'.
col	a character vector of plotting colors.
cex	a numerical single element vector giving the amount by which plotting text and symbols should be magnified relative to the default.
mar	A numerical vector of the form c(bottom, left, top, right) which gives the number of lines of margin to be specified on the four sides of the plot.
inds	row indices of the conformers to label.
lab	a character vector of plot labels.
y	the y coordinates for the scree plot.
type	one-character string giving the type of plot desired.
main	a main title for the plot, see also 'title'.
sub	a sub-title for the plot.
xlim	the x limits of the plot.
ylim	the y limits of the plot.
ylab	a label for the y axis.

xlab	a label for the x axis.
axes	a logical value indicating whether both axes should be drawn.
ann	a logical value indicating whether the default annotation (title and x and y axis labels) should appear on the plot.
...	extra plotting arguments.

Details

plot.pca is a wrapper calling both plot.pca.score and plot.pca.scree resulting in a 2x2 plot with three score plots and one scree plot.

Value

Produces a plot of PCA results in the active graphics device and invisibly returns the plotted 'z' coordinates along the requested 'pc.axes'. See examples section where these coordinates are used to identify plotted points.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca.xyz, plot.bio3d

Examples

```
attach(transducin)

pc.xray <- pca(pdbs$xyz, rm.gaps=TRUE)
plot(pc.xray)

## Color plot by nucleotide state
vcolors <- annotation[, "color"]
plot(pc.xray, col=vcolors)

## Focus on a single plot of PC1 vs PC2
x <- plot(pc.xray, pc.axes=1:2, col=vcolors)

## Identify points interactively with mouse clicks
#identify(x, labels=basename.pdb(pdbs$id))

## Add labels to select points
inds <- c(1,10,37)
text(x[inds,], labels=basename.pdb(pdbs$id[inds]), col="blue")

## Alternative labeling method
```

```
#labs <- rownames(annotation)
#inds <- c(2,7)
#plot.pca.score(pc.xray, inds=inds, col=vcolors, lab=labs)

## color by seq identity groupings
#ide <- seqidentity(pdbs$ali)
#hc <- hclust(as.dist(1-ide))
#grps <- cutree(hc, h=0.2)
#vcolors <- rainbow(max(grps))[grps]
#plot.pca.score(pc.xray, inds=inds, col=vcolors, lab=labs)

detach(transducin)
```

`plot.pca.loadings` *Plot Residue Loadings along PC1 to PC3*

Description

Plot residue loadings along PC1 to PC3 from a given xyz C-alpha matrix of `loadings`.

Usage

```
## S3 method for class 'pca.loadings'
plot(x, resnums = seq(1, (length(x[, 1])/3), 25), ...)
```

Arguments

`x`	the results of principal component analysis obtained from `pca.xyz`, or just the loadings returned from `pca.xyz`.
`resnums`	a numeric vector of residue numbers.
`...`	extra plotting arguments.

Value

Called for its effect.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`pca.xyz`, `plot.pca`

Examples

```
attach(transducin)

pc.xray <- pca.xyz(pdbs$xyz[, gap.inspect(pdbs$xyz)$f.inds])
plot.pca.loadings(pc.xray$U)

detach(transducin)
```

`plot.rmsip` *Plot RMSIP Results*

Description

Produces a heat plot of RMSIP (Root mean square inner product) for the visualization of modes similarity.

Usage

```
## S3 method for class 'rmsip'
plot(x, xlab = NULL, ylab = NULL, col = gray(50:0/50),
      zlim=c(0,1), ...)
```

Arguments

`x`	an object of class `rmsip`.
`xlab`	a label for the x axis, defaults to 'a'.
`ylab`	a label for the y axis, defaults to 'b'.
`col`	a vector of colors for the RMSIP map (or overlap values).
`zlim`	the minimum and maximum 'z' values for which colors should be plotted.
`...`	additional arguments to function `image`.

Details

`plot.rmsip` produces a color image with the function `image`.

Value

Called for its effect.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

rmsip, overlap, nma, image.

Examples

```
## Read PDB structure
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Perform NMA
modes.a <- nma(pdb, ff="calpha")
modes.b <- nma(pdb, ff="anm")

## Calculate and plot RMSIP
r <- rmsip(modes.a, modes.b)
plot(r)
```

---

print.cna *Summarize and Print Features of a cna Network Graph*

Description

These functions attempt to summarize and print a cna network graph to the terminal in a human readable form.

Usage

```
  ## S3 method for class 'cna'
print(x, ...)
  ## S3 method for class 'cna'
summary(object, verbose=TRUE, ...)
```

Arguments

x	A cna network and community object as obtained from the function 'cna'.
object	A cna network and community object as obtained from the function 'cna'.
verbose	Logical, if TRUE a community summary table is prited to screen.
...	Extra arguments passed to the 'write.table' function.

Details

Simple summary and print methods for protein dynamic networks.

Value

The function summary.cna returns a list with the following components:

`id`	A community number/identifier vector with an element for each community.
`size`	A numeric community size vector, with elements giving the number of nodes within each community.
`members`	A lst detailing the nodes within each community.

Author(s)

Guido Scarabelli and Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

cna, print.igraph, str.igraph, igraph.plotting

Examples

```
if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

## Load the correlation network
attach(hivp)

## Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

## Examine network composition
print(net)
x<- summary(net)
x$members[[2]]

detach(hivp)

}
```

print.core *Printing Core Positions and Returning Indices*

Description

Print method for core.find objects.

Usage

```
## S3 method for class 'core'
print(x, vol = NULL, ...)
```

Arguments

x	a list object obtained with the function core.find.
vol	the maximal cumulative volume value at which core positions are detailed.
...	additional arguments to 'print'.

Value

Returns a three component list of indices:

atom	atom indices of core positions
xyz	xyz indices of core positions
resno	residue numbers of core positions

Note

The produced plot.core function can be useful for deciding on the core/non-core boundary.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

core.find, plot.core

Examples

```
## Not run:
##-- Generate a small kinesin alignment and read corresponding structures
pdbfiles <- get.pdb(c("1bg2","2ncd","1i6i","1i5s"), URLonly=TRUE)
pdbs <- pdbaln(pdbfiles)

##-- Find 'core' positions
core <- core.find(pdbs)
plot(core)

##-- Fit on these relatively invarient subset of positions
core.inds <- print(core, vol=0.5)

print(core, vol=0.7)
print(core, vol=1.0)


## End(Not run)
```

`print.fasta` *Printing Sequence Alignments*

Description

Print method for fasta and pdbs sequence alignment objects.

Usage

```
## S3 method for class 'fasta'
print(x, alignment=TRUE, ...)
.print.fasta.ali(x, width = NULL, col.inds = NULL, numbers = TRUE,
         conservation=TRUE, ...)
```

Arguments

`x`	a sequence alignment object as obtained from the functions `read.fasta`, `read.fasta.pdb`, `pdbaln`, `seqaln`, etc.
`alignment`	logical, if TRUE the sequence alignment will be printed to screen.
`width`	a single numeric value giving the number of residues per printed sequence block. By default this is determined from considering alignment identifier widths given a standard 85 column terminal window.
`col.inds`	an optional numeric vector that can be used to select subsets of alignment positions/columns for printing.
`numbers`	logical, if TRUE position numbers and a tick-mark every 10 positions are printed above and below sequence blocks.
`conservation`	logical, if TRUE conserved and semi-conserved columns in the alignment are marked with an '*' and '^', respectively.
`...`	additional arguments to '.print.fasta.ali'.

Value

Called mostly for its effect but also silently returns block divided concatenated sequence strings as a matrix.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, read.fasta.pdb, pdbaln, seqaln

Examples

```
file <- system.file("examples/kif1a.fa",package="bio3d")
aln  <- read.fasta(file)
print(aln)

# print(aln, col.inds=30:100, numbers=FALSE)
```

---

print.xyz *Printing XYZ coordinates*

Description

Print method for objects of class 'xyz'.

Usage

```
## S3 method for class 'xyz'
print(x, ...)
```

Arguments

x	a 'xyz' object indicating 3-D coordinates of biological molecules.
...	additional arguments passed to 'print'.

Value

Called for its effect.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`is.xyz`, `read.ncdf`, `read.pdb`, `read.dcd`, `fit.xyz`

Examples

```
# Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
print(pdb$xyz)
```

`project.pca` *Project Data onto Principal Components*

Description

Projects data onto principal components.

Usage

```
project.pca(data, pca, angular = FALSE, fit = FALSE, ...)
z2xyz.pca(z.coord, pca)
xyz2z.pca(xyz.coord, pca)
```

Arguments

`data`	a numeric vector or row-wise matrix of data to be projected.
`pca`	an object of class `"pca"` as obtained from functions `pca.xyz` or `pca.tor`.
`angular`	logical, if TRUE the data to be projected is treated as torsion angle data.
`fit`	logical, if TRUE the data is first fitted to `pca$mean`.
`...`	other parameters for `fit.xyz`.
`xyz.coord`	a numeric vector or row-wise matrix of data to be projected.
`z.coord`	a numeric vector or row-wise matrix of PC scores (i.e. the z-scores which are centered and rotated versions of the origional data projected onto the PCs) for conversion to xyz coordinates.

Value

A numeric vector or matrix of projected PC scores.

Author(s)

Karim ElSawy and Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

pca.xyz, pca.tor, fit.xyz

Examples

```
## Not run:
attach(transducin)

gaps.pos <- gap.inspect(pdbs$xyz)

#-- Do PCA without structures 2 and 7
pc.xray <- pca.xyz(pdbs$xyz[-c(2,7), gaps.pos$f.inds])

#-- Project structures 2 and 7 onto the PC space
d <- project.pca(pdbs$xyz[c(2,7), gaps.pos$f.inds], pc.xray)

plot(pc.xray$z[,1], pc.xray$z[,2],col="gray")
points(d[,1],d[,2], col="red")

detach(transducin)

## End(Not run)
```

---

prune.cna *Prune A cna Network Object*

Description

Remove nodes and their associated edges from a cna network graph.

Usage

```
prune.cna(x, edges.min = 1, size.min = 1)
```

Arguments

x	A protein network graph object as obtained from the 'cna' function.
edges.min	A single element numeric vector specifying the minimum number of edges that retained nodes should have. Nodes with less than 'edges.min' will be pruned.
size.min	A single element numeric vector specifying the minimum node size that retained nodes should have. Nodes with less composite residues than 'size.min' will be pruned.

Details

This function is useful for cleaning up cna network plots by removing, for example, small isolated nodes. The output is a new cna object minus the pruned nodes and their associated edges. Node naming is preserved.

Value

A cna class object, see function cna for details.

Note

Some improvements to this function are required, including a better effort to preserve the original community structure rather than calculating a new one. Also may consider removing nodes form the raw.network object that is returned also.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

cna, summary.cna, vmd.cna, plot.cna

Examples

```
if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

# Load the correlation network
attach(hivp)

# Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

# Plot coarse grain network based on dynamically coupled communities
par(mfcol=c(1,2), mar=c(0,0,0,0))
plot.cna(net)

# Prune network
dnet <- prune.cna(net, edges.min = 1)
plot(dnet)

detach(hivp)

}
```

pymol *Biomolecular Visualization with PyMOL*

Description

Visualize Bio3D structure objects in PyMOL

Usage

```
pymol(...)

## S3 method for class 'pdbs'
pymol(pdbs, col=NULL, as="ribbon", file=NULL, type="script",
                    exefile="pymol", user.vec=NULL, ...)

## S3 method for class 'nma'
pymol(...)

## S3 method for class 'pca'
pymol(...)

## S3 method for class 'modes'
pymol(modes, mode=NULL, file=NULL, scale=5, dual=FALSE,
                    type="script", exefile="pymol", ...)

## S3 method for class 'dccm'
pymol(dccm, pdb, file=NULL,
                    step=0.2, omit=0.2, radius = 0.15,
                    type="script", exefile="pymol", ...)
```

Arguments

pdbs	aligned C-alpha Cartesian coordinates as obtained with read.fasta.pdb or pdbaln.
col	a single element character vector specifying the coloring of the structures. Options are: 'index', 'index2', 'gaps', 'rmsf', 'user'. Special cases: Provide a 'core' object as obtained by core.find to color on the invariant core. Alternatively, provide a vector containing the color code for each structure in the 'pdbs' object.
user.vec	User defined vector for coloring. Only used if col="user".
as	show as 'ribbon', 'cartoon', 'lines', 'putty'.
file	a single element character vector specifying the file name of the PyMOL session/script file.

type	a single element character vector specifying the output type: 'script' generates a .pml script; 'session' generates a .pse session file; 'launch' launches pymol.
exefile	file path to the 'PYMOL' program on your system (i.e. how is 'PYMOL' invoked). If NULL, use OS-dependent default path to the program.
modes	an object of class nma or pca as obtained from functions nma or pca.xyz.
mode	the mode number for which the vector field should be made.
scale	global scaling factor.
dual	logical, if TRUE mode vectors are also drawn in both direction.
dccm	an object of class dccm as obtained from function dccm.
pdb	an object of class pdb as obtained from function read.pdb or a numerical vector of Cartesian coordinates.
step	binning interval of cross-correlation coefficents.
omit	correlation coefficents with values (0-omit, 0+omit) will be omitted from visualization.
radius	numeric, radius of visualized correlation cylinders in PyMol. Alternatively, a matrix with the same dimesions as dccm can be provided, e.g. to draw cylinders with radii associated to the pairwise correlation value.
...	arguments passed to function pymol.modes for 'nma' and 'pca' objects.

Details

These functions provides a convenient approach for the visualization of Bio3D objects in PyMOL. See examples for more details.

DCCM PyMOL visualization: This function generates a PyMOL (python) script that will draw colored lines between (anti)correlated residues. The PyMOL script file is stored in the working directory with filename "R.py". PyMOL will only be launched (and opened) when using argument 'type='launch". Alternatively a PDB file with CONECT records will be generated (when argument type='pdb').

For the PyMOL version, PyMOL CGO objects are generated - each object representing a range of correlation values (corresponding to the actual correlation values as found in the correlation matrix). E.g. the PyMOL object with name "cor_-1_-08" would display all pairs of correlations with values between -1 and -0.8.

NMA / PCA PyMOL vector field visualization: This function generates a PyMOL (python) script for drawing mode vectors on a PDB structure. The PyMOL script file is stored in the working directory with filename "R.py".

Value

Called for its action

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

view

Examples

```
## Not run:

##- pymol with a 'pdbs' object
attach(transducin)

# build a pymol session containing all structures in the PDBs object
pymol(pdbs)

# color by invariant core (
# core <- core.find(pdbs)
pymol(pdbs, col=core)

# color by RMSF
pymol(pdbs, col="rmsf")

# color by a user defined vector
# For example, colored by averaged contact density around each residue
cm <- cmap(pdbs, binary=FALSE)
vec <- rowSums(cm, na.rm=TRUE)
pymol(pdbs, col="user", user.vec=vec)

# color by clustering
rd <- rmsd(pdbs$xyz)
hc <- hclust(as.dist(rd))
grps <- cutree(hc, k=3)
pymol(pdbs, col=grps)



##- pymol with a 'dccm' object
## Fetch stucture
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Calculate normal modes
modes <- nma(pdb)

## Calculate correlation matrix
cm <- dccm.nma(modes)

pymol(cm, modes$xyz)
```

```
##- pymol with a 'nma' or 'pca' object
pymol(modes, mode=7)

detach(transducin)

## End(Not run)
```

`read.all` *Read Aligned Structure Data*

Description

Read aligned PDB structures and store their equalvalent atom data, including xyz coordinates, residue numbers, residue type and B-factors.

Usage

```
read.all(aln, prefix = "", pdbext = "", sel = NULL, rm.wat=TRUE, rm.ligand=FALSE,
         compact = TRUE, ncore = NULL, ...)
```

Arguments

`aln`	an alignment data structure obtained with `read.fasta`.
`prefix`	prefix to aln$id to locate PDB files.
`pdbext`	the file name extention of the PDB files.
`sel`	a selection string detailing the atom type data to store (see function store.atom)
`rm.wat`	logical, if TRUE water atoms are removed.
`rm.ligand`	logical, if TRUE ligand atoms are removed.
`compact`	logical, if TRUE the number of atoms stored for each aligned residue varies according to the amino acid type. If FALSE, the constant maximum possible number of atoms are stored for all aligned residues.
`ncore`	number of CPU cores used to do the calculation. By default (`ncore=NULL`) use all detected CPU cores.
`...`	other parameters for `read.pdb`.

Details

The input `aln`, produced with `read.fasta`, must have identifers (i.e. sequence names) that match the PDB file names. For example the sequence corresponding to the structure file "mypdbdir/1bg2.pdb" should have the identifer 'mypdbdir/1bg2.pdb' or '1bg2' if input 'prefix' and 'pdbext' equal 'mypdbdir/' and 'pdb'. See the examples below.

Sequence miss-matches will generate errors. Thus, care should be taken to ensure that the sequences in the alignment match the sequences in their associated PDB files.

Value

Returns a list of class "pdbs" with the following five components:

xyz	numeric matrix of aligned C-alpha coordinates.
resno	character matrix of aligned residue numbers.
b	numeric matrix of aligned B-factor values.
chain	character matrix of aligned chain identifiers.
id	character vector of PDB sequence/structure names.
ali	character matrix of aligned sequences.
resid	character matrix of aligned 3-letter residue names.
all	numeric matrix of aligned equalvelent atom coordinates.
all.elety	numeric matrix of aligned atom element types.
all.resid	numeric matrix of aligned three-letter residue codes.
all.resno	numeric matrix of aligned residue numbers.
all.grpby	numeric vector indicating the group of atoms belonging to the same aligned residue.
all.hetatm	a list of 'pdb' objects for non-protein atoms.

Note

This function is still in development and is NOT part of the offical bio3d package.

The sequence character 'X' is useful for masking unusual or unknown residues, as it can match any other residue type.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, read.pdb, core.find, fit.xyz

Examples

```
# still working on speeding this guy up
## Not run:
## Read sequence alignment
file <- system.file("examples/kif1a.fa",package="bio3d")
aln  <- read.fasta(file)

## Read aligned PDBs storing all data for 'sel'
sel <- c("N", "CA", "C", "O", "CB", "*G", "*D",  "*E", "*Z")
```

```
pdbs <- read.all(aln, sel=sel)

atm <- colnames(pdbs$all)
ca.ind  <- which(atm == "CA")
core <- core.find(pdbs)
core.ind <- c( matrix(ca.ind, nrow=3)[,core$c0.5A.atom] )

## Fit structures
nxyz <- fit.xyz(pdbs$all[1,], pdbs$all,
               fixed.inds  = core.ind,
               mobile.inds = core.ind)

ngap.col <- gap.inspect(nxyz)

#npc.xray <- pca.xyz(nxyz[ ,ngap.col$f.inds])

#a <- mktrj.pca(npc.xray, pc=1, file="pc1-all.pdb",
#               elety=pdbs$all.elety[1,unique( ceiling(ngap.col$f.inds/3) )],
#               resid=pdbs$all.resid[1,unique( ceiling(ngap.col$f.inds/3) )],
#               resno=pdbs$all.resno[1,unique( ceiling(ngap.col$f.inds/3) )] )


## End(Not run)
```

`read.cif` *Read mmCIF File*

Description

Read a Protein Data Bank (mmCIF) coordinate file.

Usage

```
read.cif(file, maxlines = -1, multi = FALSE,
         rm.insert = FALSE, rm.alt = TRUE, verbose = TRUE)
```

Arguments

`file`	a single element character vector containing the name of the mmCIF file to be read, or the four letter PDB identifier for online file access.
`maxlines`	the maximum number of lines to read before giving up with large files. By default if will read up to the end of input on the connection.
`multi`	logical, if TRUE multiple ATOM records are read for all models in multi-model files and their coordinates returned.
`rm.insert`	logical, if TRUE PDB insert records are ignored.
`rm.alt`	logical, if TRUE PDB alternate records are ignored.
`verbose`	print details of the reading process.

Details

The current version of `read.cif` reads only ATOM/HETATM records and creates a pdb object of the data.

See `read.pdb` for more info.

Value

Returns a list of class `"pdb"` with the following components:

`atom`	a data.frame containing all atomic coordinate ATOM and HETATM data, with a row per ATOM/HETATM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
`xyz`	a numeric matrix of class `"xyz"` containing the ATOM and HETATM coordinate data.
`calpha`	logical vector with length equal to `nrow(atom)` with TRUE values indicating a C-alpha "elety".
`call`	the matched call.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`read.pdb` `atom.select`, `write.pdb`, `trim.pdb`, `cat.pdb`, `read.prmtop`, `as.pdb`, `read.dcd`, `read.ncdf`,

Examples

```
## Read a mmCIF file from the RCSB online database
# cif <- read.cif("1hel")
```

---

read.crd *Read Coordinate Data from Amber or Charmm*

Description

Read a CHARMM CARD (CRD) or AMBER coordinate file.

Usage

```
read.crd(file, ...)
```

Arguments

file	the name of the coordinate file to be read.
...	additional arguments passed to the methods read.crd.charmm or read.crd.amber.

Details

read.crd is a generic function calling the corresponding function determined by the class of the input argument x. Use methods("read.crd") to get all the methods for read.crd generic:

read.crd.charmm will be used for file extension '.crd'.

read.crd.amber will be used for file extension '.rst' or '.inpcrd'.

See examples for each corresponding function for more details.

Value

See the 'value' section for the corresponding functions for more details.

Author(s)

Barry Grant and Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.crd.amber, read.crd.charmm, write.crd, read.prmtop, read.pdb, write.pdb, atom.select, read.dcd, read.ncdf

Examples

```
## Not run:
## Read a PRMTOP file
prmtop <- read.prmtop(system.file("examples/crambin.prmtop", package="bio3d"))
print(prmtop)

## Read a Amber CRD file
crds <- read.crd(system.file("examples/crambin.inpcrd", package="bio3d"))

## Atom selection
ca.inds <- atom.select(prmtop, "calpha")

## Convert to PDB format
pdb <- as.pdb(prmtop, crds, inds=ca.inds)

## End(Not run)
```

`read.crd.amber` *Read AMBER Coordinate files*

Description

Read coordinate data from an AMBER coordinate / restart file.

Usage

```
## S3 method for class 'amber'
read.crd(file, ...)
```

Arguments

`file`	name of crd file to read.
`...`	arguments passed to and from functions.

Details

Read a AMBER Coordinate format file.

Value

A list object of type 'amber' and 'crd' with the following components:

`xyz`	a numeric matrix of class 'xyz' containing the Cartesian coordinates.
`velocities`	a numeric vector containg the atom velocities.
`time`	numeric, length of the simulation (applies to Amber restart coordinate files).
`natoms`	total number of atoms in the coordinate file.
`box`	dimensions of the box.

Note

See AMBER documentation for Coordinate format description.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. https://ambermd.org/FileFormats.php

See Also

`read.prmtop`, `read.ncdf`, `as.pdb`, `atom.select`, `read.pdb`, `read.crd.charmm`

Examples

```
## Not run:
## Read Amber PRMTOP and CRD files
prm <- read.prmtop(system.file("examples/crambin.prmtop", package="bio3d"))
crd <- read.crd(system.file("examples/crambin.inpcrd", package="bio3d"))

## Convert to PDB format
pdb <- as.pdb(prm, crd)

## Atom selection
ca.inds <- atom.select(prm, "calpha")

## End(Not run)
```

---

read.crd.charmm *Read CRD File*

Description

Read a CHARMM CARD (CRD) coordinate file.

Usage

```
## S3 method for class 'charmm'
read.crd(file, ext = TRUE, verbose = TRUE, ...)
```

Arguments

file	the name of the CRD file to be read.
ext	logical, if TRUE assume expanded CRD format.
verbose	print details of the reading process.
...	arguments going nowhere.

Details

See the function read.pdb for more details.

Value

Returns a list with the following components:

atom	a character matrix containing all atomic coordinate data, with a row per atom and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
xyz	a numeric vector of coordinate data.
calpha	logical vector with length equal to nrow(atom) with TRUE values indicating a C-alpha "elety".

Note

Similar to the output of read.pdb, the column names of atom can be used as a convenient means of data access, namely: Atom serial number "eleno", Atom type "elety", Alternate location indicator "alt", Residue name "resid", Residue sequence number "resno", Code for insertion of residues "insert", Orthogonal coordinates "x", Orthogonal coordinates "y", Orthogonal coordinates "z", Weighting factor "b". See examples for further details.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of CHARMM CARD (CRD) format see:
https://academiccharmm.org/documentation/version/c49b1/io#Coordinate.

See Also

write.crd, read.pdb, atom.select, write.pdb, read.dcd, read.fasta.pdb, read.fasta

Examples

```
## Not run:
 pdb <- read.pdb("1bg2")
 crdfile <- paste(tempfile(), '.crd', sep='')
 write.crd(pdb, file=crdfile)
 crd <- read.crd(crdfile, ext=FALSE)
 ca.inds <- which(crd$calpha)
 crd$atom[ca.inds[1:20],c("x","y","z")]
# write.pdb(crd, file=tempfile())

## End(Not run)
```

---

read.dcd *Read CHARMM/X-PLOR/NAMD Binary DCD files*

Description

Read coordinate data from a binary DCD trajectory file.

Usage

```
read.dcd(trjfile, big=FALSE, verbose = TRUE, cell = FALSE)
```

Arguments

`trjfile`	name of trajectory file to read. A vector if treat a batch of files
`big`	logical, if TRUE attempt to read large files into a big.matrix object
`verbose`	logical, if TRUE print details of the reading process.
`cell`	logical, if TRUE return cell information only. Otherwise, return coordinates.

Details

Reads a CHARMM or X-PLOR/NAMD binary trajectory file with either big- or little-endian storage formats.

Reading is accomplished with two different sub-functions: `dcd.header`, which reads header info, and `dcd.frame`, which takes header information and reads atoms frame by frame producing an nframes/natom*3 matrix of cartesian coordinates or an nframes/6 matrix of cell parameters.

Value

A numeric matrix of xyz coordinates with a frame/structure per row and a Cartesian coordinate per column or a numeric matrix of cell information with a frame/structure per row and lengths and angles per column.

Note

See CHARMM documentation for DCD format description.

If you experience problems reading your trajectory file with read.dcd() consider first reading your file into VMD and from there exporting a new DCD trajectory file with the 'save coordinates' option. This new file should be easily read with read.dcd().

Error messages beginning 'cannot allocate vector of size' indicate a failure to obtain memory, either because the size exceeded the address-space limit for a process or, more likely, because the system was unable to provide the memory. Note that on a 32-bit OS there may well be enough free memory available, but not a large enough contiguous block of address space into which to map it. In such cases try setting the input option 'big' to TRUE. This is an experimental option that results in a 'big.matrix' object.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`read.pdb`, `write.pdb`, `atom.select`

Examples

```
# Redundant testing excluded

##-- Read cell parameters from example trajectory file
trtfile <- system.file("examples/hivp.dcd", package="bio3d")
trj <- read.dcd(trtfile, cell = TRUE)
##-- Read coordinates from example trajectory file
trj <- read.dcd(trtfile)

## Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

## select residues 24 to 27 and 85 to 90 in both chains
inds <- atom.select(pdb, resno=c(24:27,85:90), elety='CA')

## lsq fit of trj on pdb
xyz <- fit.xyz(pdb$xyz, trj, fixed.inds=inds$xyz, mobile.inds=inds$xyz)

##-- RMSD of trj frames from PDB
r1 <- rmsd(a=pdb, b=xyz)


## Not run:
# Pairwise RMSD of trj frames for positions 47 to 54
flap.inds <- atom.select(pdb, resno=c(47:54), elety='CA')
p <- rmsd(xyz[,flap.inds$xyz])
# plot highlighting flap opening?
plot.dmat(p, color.palette = mono.colors)

## End(Not run)
```

`read.fasta` *Read FASTA formated Sequences*

Description

Read aligned or un-aligned sequences from a FASTA format file.

Usage

```
read.fasta(file, rm.dup = TRUE, to.upper = FALSE, to.dash=TRUE)
```

Arguments

`file`	input sequence file.
`rm.dup`	logical, if TRUE duplicate sequences (with the same names/ids) will be removed.

to.upper	logical, if TRUE residues are forced to uppercase.
to.dash	logical, if TRUE '.' gap characters are converted to '-' gap characters.

Value

A list with two components:

ali	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
ids	sequence names as identifers.
call	the matched call.

Note

For a description of FASTA format see: https://www.ncbi.nlm.nih.gov/BLAST/blastcgihelp.shtml. When reading alignment files, the dash '-' is interpreted as the gap character.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta.pdb

Examples

```
# Read alignment
aln <- read.fasta(system.file("examples/hivp_xray.fa",package="bio3d"))

# Print alignment overview
aln

# Sequence names/ids
head( aln$id )

# Alignment positions 335 to 339
head( aln$ali[,33:39] )

# Sequence d2a4f_b
aa123( aln$ali["d2a4f_b",] )

# Write out positions 33 to 45 only
#aln$ali=aln$ali[,30:45]
#write.fasta(aln, file="eg2.fa")
```

`read.fasta.pdb` *Read Aligned Structure Data*

Description

Read aligned PDB structures and store their C-alpha atom data, including xyz coordinates, residue numbers, residue type and B-factors.

Usage

```
read.fasta.pdb(aln, prefix = "", pdbext = "", fix.ali = FALSE,
            pdblist=NULL, ncore = 1, nseg.scale = 1, progress = NULL, ...)
```

Arguments

`aln`	an alignment data structure obtained with `read.fasta`.
`prefix`	prefix to aln$id to locate PDB files.
`pdbext`	the file name extention of the PDB files.
`fix.ali`	logical, if TRUE check consistence between `$ali` and `$resno`, and correct `$ali` if they don't match.
`pdblist`	an optional list of pdb objects with sequence corresponding to the alignments in `aln`. Primarily used through function `pdbaln` when the PDB objects already exists (avoids reading PDBs from file).
`ncore`	number of CPU cores used to do the calculation. `ncore>1` requires package 'parallel' installed.
`nseg.scale`	split input data into specified number of segments prior to running multiple core calculation. See `fit.xyz`.
`progress`	progress bar for use with shiny web app.
`...`	other parameters for `read.pdb`.

Details

The input `aln`, produced with `read.fasta`, must have identifers (i.e. sequence names) that match the PDB file names. For example the sequence corresponding to the structure "1bg2.pdb" should have the identifer '1bg2'. See examples below.

Sequence miss-matches will generate errors. Thus, care should be taken to ensure that the sequences in the alignment match the sequences in their associated PDB files.

Value

Returns a list of class `"pdbs"` with the following five components:

`xyz`	numeric matrix of aligned C-alpha coordinates.
`resno`	character matrix of aligned residue numbers.

b	numeric matrix of aligned B-factor values.
chain	character matrix of aligned chain identifiers.
id	character vector of PDB sequence/structure names.
ali	character matrix of aligned sequences.
resid	character matrix of aligned 3-letter residue names.
sse	character matrix of aligned helix and strand secondary structure elements as defined in each PDB file.
call	the matched call.

Note

The sequence character 'X' is useful for masking unusual or unknown residues, as it can match any other residue type.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, read.pdb, core.find, fit.xyz, read.all, pymol.pdbs

Examples

```
# Redundant testing excluded
try({

# Read sequence alignment
file <- system.file("examples/kif1a.fa",package="bio3d")
aln  <- read.fasta(file)

# Read aligned PDBs
pdbs <- read.fasta.pdb(aln)

# Structure/sequence names/ids
basename( pdbs$id )

# Alignment positions 335 to 339
pdbs$ali[,335:339]
pdbs$resid[,335:339]
pdbs$resno[,335:339]
pdbs$b[,335:339]

# Alignment C-alpha coordinates for these positions
pdbs$xyz[, atom2xyz(335:339)]
```

```
# See 'fit.xyz()' function for actual coordinate superposition
#  e.g. fit to first structure
# xyz <- fit.xyz(pdbs$xyz[1,], pdbs)
# xyz[, atom2xyz(335:339)]

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

`read.mol2` *Read MOL2 File*

Description

Read a Tripos MOL2 file

Usage

```
read.mol2(file, maxlines = -1L)

## S3 method for class 'mol2'
print(x, ...)
```

Arguments

`file`	a single element character vector containing the name of the MOL2 file to be read.
`maxlines`	the maximum number of lines to read before giving up with large files. Default is all lines.
`x`	an object as obtained from `read.mol2`.
`...`	additional arguments to 'print'.

Details

Basic functionality to parse a MOL2 file. The current version reads and stores '@<TRIPOS>MOLECULE', '@<TRIPOS>ATOM', '@<TRIPOS>BOND' and '@<TRIPOS>SUBSTRUCTURE' records.

In the case of a multi-molecule MOL2 file, each molecule will be stored as an individual 'mol2' object in a list. Conversely, if the multi-molecule MOL2 file contains identical molecules in different conformations (typically from a docking run), then the output will be one object with an `atom` and `xyz` component (xyz in matrix representation; row-wise coordinates).

See examples for further details.

Value

Returns a list of molecules containing the following components:

`atom`	a data frame containing all atomic coordinate ATOM data, with a row per ATOM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
`bond`	a data frame containing all atomic bond information.
`substructure`	a data frame containing all substructure information.
`xyz`	a numeric matrix of ATOM coordinate data.
`info`	a numeric vector of MOL2 info data.
`name`	a single element character vector containing the molecule name.

Note

For `atom` list components the column names can be used as a convenient means of data access, namely: Atom serial number "eleno", Atom name "elena", Orthogonal coordinates "x", Orthogonal coordinates "y", Orthogonal coordinates "z", Reisude number "resno", Atom type "elety", Residue name "resid", Atom charge "charge", Status bit "statbit",

For `bond` list components the column names are: Bond identifier "id", number of the atom at one end of the bond"origin", number of the atom at the other end of the bond "target", the SYBYL bond type "type".

For `substructure` list components the column names are: substructure identifier "id", substructure name "name", the ID number of the substructure's root atom "root_atom", the substructure type "subst_type", the type of dictionary associated with the substructure "dict_type", the chain to which the substructre belongs "chain", the subtype of the chain "sub_type", the number of inter bonds "inter_bonds", status bit "status".

See examples for further details.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`write.mol2`, `atom.select.mol2`, `trim.mol2`, `as.pdb.mol2` `read.pdb`

Examples

```
cat("\n")
## Not run:
## Read a single entry MOL2 file
## (returns a single object)
mol <- read.mol2( system.file("examples/aspirin.mol2", package="bio3d") )
```

```
## Short summary of the molecule
print(mol)

## ATOM records
mol$atom

## BOND records
mol$bond

## Print some coordinate data
head(mol$atom[, c("x","y","z")])

## Or coordinates as a numeric vector
#head(mol$xyz)

## Print atom charges
head(mol$atom[, "charge"])

## Convert to PDB
pdb <- as.pdb(mol)


## Read a multi-molecule MOL2 file
## (returns a list of objects)
#multi.mol <- read.mol2("zinc.mol2")

## Number of molecules described in file
#length(multi.mol)

## Access ATOM records for the first molecule
#multi.mol[[1]]$atom

## Or coordinates for the second molecule
#multi.mol[[2]]$xyz



## Process output from docking (e.g. DOCK)
## (typically one molecule with many conformations)
## (returns one object, but xyz in matrix format)
#dock <- read.mol2("dock.mol2")

## Reference PDB file (e.g. X-ray structure)
#pdb <- read.pdb("dock_ref.pdb")

## Calculate RMSD of docking modes
#sele <- atom.select(dock, "noh")
#rmsd(pdb$xyz, dock$xyz, b.inds=sele$xyz)

## End(Not run)
```

read.ncdf *Read AMBER Binary netCDF files*

Description

Read coordinate data from a binary netCDF trajectory file.

Usage

```
read.ncdf(trjfile, headonly = FALSE, verbose = TRUE, time = FALSE,
          first = NULL, last = NULL, stride = 1, cell = FALSE,
          at.sel = NULL)
```

Arguments

trjfile	name of trajectory file to read. A vector if treat a batch of files
headonly	logical, if TRUE only trajectory header information is returned. If FALSE only trajectory coordinate data is returned.
verbose	logical, if TRUE print details of the reading process.
time	logical, if TRUE the first and last have the time unit ps; Otherwise the unit is the frame number.
first	starting time or frame number to read; If NULL, start from the begining of the file(s).
last	read data until last time or frame number; If NULL or equal to -1, read until the end of the file(s).
stride	take at every stride frame(s)
cell	logical, if TRUE and headonly is FALSE return cell information only. Otherwise, return header or coordinates.
at.sel	an object of class 'select' indicating a subset of atomic coordinates to be read.

Details

Reads a AMBER netCDF format trajectory file with the help of David W. Pierce's (UCSD) ncdf4 package available from CRAN.

Value

A list of trajectory header data, a numeric matrix of xyz coordinates with a frame/structure per row and a Cartesian coordinate per column, or a numeric matrix of cell information with a frame/structure per row and lengths and angles per column. If time=TRUE, row names of returned coordinates or cell are set to be the physical time of corresponding frames.

Note

See AMBER documentation for netCDF format description.

NetCDF binary trajectory files are supported by the AMBER modules sander, pmemd and ptraj. Compared to formatted trajectory files, the binary trajectory files are smaller, higher precision and significantly faster to read and write.

NetCDF provides for file portability across architectures, allows for backwards compatible extensibility of the format and enables the files to be self-describing. Support for this format is available in VMD.

If you experience problems reading your trajectory file with read.ncdf() consider first reading your file into VMD and from there exporting a new DCD trajectory file with the 'save coordinates' option. This new file should be easily read with read.dcd().

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. https://www.unidata.ucar.edu/software/netcdf/ https://cirrus.ucsd.edu/~pierce/ncdf/ https://ambermd.org/FileFormats.php#netcdf

See Also

read.dcd, write.ncdf, read.pdb, write.pdb, atom.select

Examples

```
## Not run:
##-- Read example trajectory file
trtfile <- system.file("examples/hivp.dcd", package="bio3d")
trj <- read.dcd(trtfile)

## Write to netCDF format
write.ncdf(trj, "newtrj.nc")

## Read trj
trj <- read.ncdf("newtrj.nc")

## End(Not run)
```

`read.pdb` *Read PDB File*

Description

Read a Protein Data Bank (PDB) coordinate file.

Usage

```
read.pdb(file, maxlines = -1, multi = FALSE, rm.insert = FALSE,
         rm.alt = TRUE, ATOM.only = FALSE, hex = FALSE, verbose = TRUE)

read.pdb2(file, maxlines = -1, multi = FALSE, rm.insert = FALSE,
         rm.alt = TRUE, ATOM.only = FALSE, verbose = TRUE)

## S3 method for class 'pdb'
print(x, printseq=TRUE, ...)

## S3 method for class 'pdb'
summary(object, printseq=FALSE, ...)
```

Arguments

`file`	a single element character vector containing the name of the PDB file to be read, or the four letter PDB identifier for online file access.
`maxlines`	the maximum number of lines to read before giving up with large files. By default if will read up to the end of input on the connection.
`multi`	logical, if TRUE multiple ATOM records are read for all models in multi-model files and their coordinates returned.
`rm.insert`	logical, if TRUE PDB insert records are ignored.
`rm.alt`	logical, if TRUE PDB alternate records are ignored.
`ATOM.only`	logical, if TRUE only ATOM/HETATM records are stored. Useful for speed enhancements with large files where secondary structure, biological unit and other remark records are not required.
`hex`	logical, if TRUE enable parsing of hexadecimal atom numbers (> 99.999) and residue numbers (> 9.999) (e.g. from VMD). Note that numbering is assumed to be consecutive (with no missing numbers) and the hexadecimals should start at atom number 100.000 and residue number 10.000 and proceed to the end of file.
`verbose`	print details of the reading process.
`x`	a PDB structure object obtained from `read.pdb`.
`object`	a PDB structure object obtained from `read.pdb`.
`printseq`	logical, if TRUE the PDB ATOM sequence will be printed to the screen. See also `pdbseq`.
`...`	additional arguments to 'print'.

Details

read.pdb is a re-implementation (using Rcpp) of the slower but more tested R implementation of the same function (called read.pdb2 since bio3d-v2.3).

maxlines may be set so as to restrict the reading to a portion of input files. Note that the preferred means of reading large multi-model files is via binary DCD or NetCDF format trajectory files (see the read.dcd and read.ncdf functions).

Value

Returns a list of class "pdb" with the following components:

atom	a data.frame containing all atomic coordinate ATOM and HETATM data, with a row per ATOM/HETATM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
helix	'start', 'end' and 'length' of H type sse, where start and end are residue numbers "resno".
sheet	'start', 'end' and 'length' of E type sse, where start and end are residue numbers "resno".
seqres	sequence from SEQRES field.
xyz	a numeric matrix of class "xyz" containing the ATOM and HETATM coordinate data.
calpha	logical vector with length equal to nrow(atom) with TRUE values indicating a C-alpha "elety".
remark	a list object containing information taken from 'REMARK' records of a "pdb". It can be used for building biological units (See biounit).
call	the matched call.

Note

For both atom and het list components the column names can be used as a convenient means of data access, namely: Atom serial number "eleno" , Atom type "elety", Alternate location indicator "alt", Residue name "resid", Chain identifier "chain", Residue sequence number "resno", Code for insertion of residues "insert", Orthogonal coordinates "x", Orthogonal coordinates "y", Orthogonal coordinates "z", Occupancy "o", and Temperature factor "b". See examples for further details.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

atom.select, write.pdb, trim.pdb, cat.pdb, read.prmtop, as.pdb, read.dcd, read.ncdf, read.fasta.pdb, read.fasta, biounit

Examples

```
## Read a PDB file from the RCSB online database
#pdb <- read.pdb("4q21")

## Read a PDB file from those included with the package
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )

## Print a brief composition summary
pdb

## Examine the storage format (or internal *str*ucture)
str(pdb)

## Print data for the first four atom
pdb$atom[1:4,]

## Print some coordinate data
head(pdb$atom[, c("x","y","z")])

## Or coordinates as a numeric vector
#head(pdb$xyz)

## Print C-alpha coordinates (can also use 'atom.select' function)
head(pdb$atom[pdb$calpha, c("resid","elety","x","y","z")])
inds <- atom.select(pdb, elety="CA")
head( pdb$atom[inds$atom, ] )

## The atom.select() function returns 'indices' (row numbers)
## that can be used for accessing subsets of PDB objects, e.g.
inds <- atom.select(pdb,"ligand")
pdb$atom[inds$atom,]
pdb$xyz[inds$xyz]

## See the help page for atom.select() function for more details.


## Not run:
## Print SSE data for helix and sheet,
##  see also dssp() and stride() functions
print.sse(pdb)
pdb$helix
pdb$sheet$start

## Print SEQRES data
pdb$seqres

## SEQRES as one letter code
```

```
aa321(pdb$seqres)

## Where is the P-loop motif in the ATOM sequence
inds.seq <- motif.find("G....GKT", pdbseq(pdb))
pdbseq(pdb)[inds.seq]

## Where is it in the structure
inds.pdb <- atom.select(pdb,resno=inds.seq, elety="CA")
pdb$atom[inds.pdb$atom,]
pdb$xyz[inds.pdb$xyz]

## View in interactive 3D mode
#view(pdb)

## End(Not run)
```

`read.pdcBD` *Read PQR output from pdcBD File*

Description

Read a pdcBD PQR coordinate file.

Usage

```
read.pdcBD(file, maxlines = 50000, multi = FALSE, rm.insert = FALSE,
         rm.alt = TRUE, verbose = TRUE)
```

Arguments

`file`	the name of the pdcBD PQR file to be read.
`maxlines`	the maximum number of lines to read before giving up with large files. Default is 50,000 lines.
`multi`	logical, if TRUE multiple ATOM records are read for all models in multi-model files.
`rm.insert`	logical, if TRUE PDB insert records are ignored.
`rm.alt`	logical, if TRUE PDB alternate records are ignored.
`verbose`	print details of the reading process.

Details

`maxlines` may require increasing for some large multi-model files. The preferred means of reading such data is via binary DCD format trajectory files (see the `read.dcd` function).

Value

Returns a list of class "pdb" with the following components:

atom	a character matrix containing all atomic coordinate ATOM data, with a row per ATOM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
het	a character matrix containing atomic coordinate records for atoms within "non-standard" HET groups (see atom).
helix	'start', 'end' and 'length' of H type sse, where start and end are residue numbers "resno".
sheet	'start', 'end' and 'length' of E type sse, where start and end are residue numbers "resno".
seqres	sequence from SEQRES field.
xyz	a numeric vector of ATOM coordinate data.
calpha	logical vector with length equal to nrow(atom) with TRUE values indicating a C-alpha "elety".

Note

For both atom and het list components the column names can be used as a convenient means of data access, namely: Atom serial number "eleno" , Atom type "elety", Alternate location indicator "alt", Residue name "resid", Chain identifier "chain", Residue sequence number "resno", Code for insertion of residues "insert", Orthogonal coordinates "x", Orthogonal coordinates "y", Orthogonal coordinates "z", Occupancy "o", and Temperature factor "b". See examples for further details.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

atom.select, write.pdb, read.dcd, read.fasta.pdb, read.fasta

Examples

```
# PDB server connection required - testing excluded
try({

# Read a PDB file
pdb <- read.pdb( "1bg2" )

# Print data for the first atom
```

```
pdb$atom[1,]
# Look at the first het atom
pdb$het[1,]
# Print some coordinate data
pdb$atom[1:20, c("x","y","z")]

# Print C-alpha coordinates (can also use 'atom.select')
##pdb$xyz[pdb$calpha, c("resid","x","y","z")]

# Print SSE data (for helix and sheet)
pdb$helix
pdb$sheet$start

# Print SEQRES data
pdb$seqres

# Renumber residues
nums <- as.numeric(pdb$atom[,"resno"])
pdb$atom[,"resno"] <- nums - (nums[1] - 1)

# Write out renumbered PDB file
#write.pdb(pdb=pdb,file="eg.pdb")

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

`read.pqr` *Read PQR File*

Description

Read a PQR coordinate file.

Usage

```
read.pqr(file, maxlines = -1, multi = FALSE, rm.insert = FALSE,
         rm.alt = TRUE, verbose = TRUE)
```

Arguments

`file`	the name of the PQR file to be read.
`maxlines`	the maximum number of lines to read before giving up with large files. By default if will read up to the end of input on the connection.
`multi`	logical, if TRUE multiple ATOM records are read for all models in multi-model files.
`rm.insert`	logical, if TRUE PDB insert records are ignored.

rm.alt	logical, if TRUE PDB alternate records are ignored.
verbose	print details of the reading process.

Details

PQR file format is basically the same as PDB format except for the fields of o and b. In PDB, these two fields are filled with 'Occupancy' and 'B-factor' values, respectively, with each field 6-column long. In PQR, they are atomic 'partial charge' and 'radii' values, respectively, with each field 8-column long.

maxlines may require increasing for some large multi-model files. The preferred means of reading such data is via binary DCD format trajectory files (see the read.dcd function).

Value

Returns a list of class "pdb" with the following components:

atom	a data.frame containing all atomic coordinate ATOM and HETATM data, with a row per ATOM/HETATM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
helix	'start', 'end' and 'length' of H type sse, where start and end are residue numbers "resno".
sheet	'start', 'end' and 'length' of E type sse, where start and end are residue numbers "resno".
seqres	sequence from SEQRES field.
xyz	a numeric matrix of class "xyz" containing the ATOM and HETATM coordinate data.
calpha	logical vector with length equal to nrow(atom) with TRUE values indicating a C-alpha "elety".
call	the matched call.

Note

For both atom and het list components the column names can be used as a convenient means of data access, namely: Atom serial number "eleno" , Atom type "elety", Alternate location indicator "alt", Residue name "resid", Chain identifier "chain", Residue sequence number "resno", Code for insertion of residues "insert", Orthogonal coordinates "x", Orthogonal coordinates "y", Orthogonal coordinates "z", Occupancy "o", and Temperature factor "b". See examples for further details.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

atom.select, write.pqr, read.pdb, write.pdb, read.dcd, read.fasta.pdb, read.fasta

Examples

```
# PDB server connection required - testing excluded
try({

# Read a PDB file and write it as a PQR file
pdb <- read.pdb( "4q21" )
outfile = file.path(tempdir(), "eg.pqr")
write.pqr(pdb=pdb, file = outfile)

# Read the PQR file
pqr <- read.pqr(outfile)

## Print a brief composition summary
pqr

## Examine the storage format (or internal *str*ucture)
str(pqr)

## Print data for the first four atom
pqr$atom[1:4,]

## Print some coordinate data
head(pqr$atom[, c("x","y","z")])

## Print C-alpha coordinates (can also use 'atom.select' function)
head(pqr$atom[pqr$calpha, c("resid","elety","x","y","z")])
inds <- atom.select(pqr, elety="CA")
head( pqr$atom[inds$atom, ] )

## The atom.select() function returns 'indices' (row numbers)
## that can be used for accessing subsets of PDB objects, e.g.
inds <- atom.select(pqr,"ligand")
pqr$atom[inds$atom,]
pqr$xyz[inds$xyz]

## See the help page for atom.select() function for more details.

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

---

read.prmtop *Read AMBER Parameter/Topology files*

Description

Read parameter and topology data from an AMBER PrmTop file.

Usage

```
read.prmtop(file)

## S3 method for class 'prmtop'
print(x, printseq=TRUE, ...)
```

Arguments

file	a single element character vector containing the name of the PRMTOP file to be read.
x	a PRMTOP structure object obtained from read.prmtop.
printseq	logical, if TRUE the residue sequence will be printed to the screen. See also pdbseq.
...	additional arguments to 'print'.

Details

This function provides basic functionality to read and parse a AMBER PrmTop file. The resulting 'prmtop' object contains a complete list object of the information stored in the PrmTop file.

See examples for further details.

Value

Returns a list of class 'prmtop' (inherits class 'amber') with components according to the flags present in the PrmTop file. See the AMBER documentation for a complete list of flags/components: https://ambermd.org/FileFormats.php.

Selected components:

ATOM_NAME	a character vector of atom names.
ATOMS_PER_MOLECULE	a numeric vector containing the number of atoms per molecule.
MASS	a numeric vector of atomic masses.
RESIDUE_LABEL	a character vector of residue labels.
RESIDUE_RESIDUE_POINTER	a numeric vector of pointers to the first atom in each residue.
call	the matched call.

Note

See AMBER documentation for PrmTop format description: https://ambermd.org/FileFormats.php.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. https://ambermd.org/FileFormats.php

See Also

read.crd, read.ncdf, as.pdb, atom.select, read.pdb

Examples

```
## Not run:
## Read a PRMTOP file
prmtop <- read.prmtop(system.file("examples/crambin.prmtop", package="bio3d"))
print(prmtop)

## Explore prmtop file
head(prmtop$MASS)
head(prmtop$ATOM_NAME)

## Read Amber coordinates
crds <- read.crd(system.file("examples/crambin.inpcrd", package="bio3d"))

## Atom selection
ca.inds <- atom.select(prmtop, "calpha")

## Convert to PDB format
pdb <- as.pdb(prmtop, crds)
pdb.ca <- as.pdb(prmtop, crds, inds=ca.inds)

## Trajectory processing
#trj <- read.ncdf("traj.nc", at.sel=ca.inds)

## Convert to multimodel PDB format
#pdb <- as.pdb(prmtop, trj[1:20,], inds=ca.inds, inds.crd=NULL)

## RMSD of trajectory
#rd <- rmsd(crds$xyz[ca.inds$xyz], traj, fit=TRUE)

## End(Not run)
```

---

rgyr *Radius of Gyration*

Description

Calculate the radius of gyration of coordinate sets.

Usage

```
rgyr(xyz, mass=NULL, ncore=1, nseg.scale=1)
```

Arguments

xyz	a numeric vector, matrix or list object with an xyz component, containing one or more coordinate sets.
mass	a numeric vector of atomic masses (unit a.m.u.), or a PDB object with masses stored in the "B-factor" column. If mass==NULL, all atoms are assumed carbon.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
nseg.scale	split input data into specified number of segments prior to running multiple core calculation. See fit.xyz.

Details

Radius of gyration is a standard measure of overall structural change of macromolecules.

Value

Returns a numeric vector of radius of gyration.

Author(s)

Xin-Qiu Yao & Pete Kekenes-Huskey

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

fit.xyz, rmsd, read.pdb, read.fasta.pdb

Examples

```
# PDB server connection required - testing excluded
try({

# -- Calculate Rog of single structure
pdb <- read.pdb("1bg2")
mass <- rep(12, length(pdb$xyz)/3)
mass[substr(pdb$atom[,"elety"], 1, 1) == "N"] <- 14
mass[substr(pdb$atom[,"elety"], 1, 1) == "H"] <- 1
mass[substr(pdb$atom[,"elety"], 1, 1) == "O"] <- 16
mass[substr(pdb$atom[,"elety"], 1, 1) == "S"] <- 32

rgyr(pdb, mass)

}, silent=TRUE)
```

```
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}


## Not run:
# -- Calculate Rog of a trajectory
xyz <- read.dcd(system.file("examples/hivp.dcd", package="bio3d"))
rg <- rgyr(xyz)
rg[1:10]


## End(Not run)
```

`rle2` *Run Length Encoding with Indices*

Description

Compute the lengths, values and indices of runs of equal values in a vector. This is a modifed version of base function `rle()`.

Usage

```
rle2(x)

## S3 method for class 'rle2'
print(x, digits = getOption("digits"), prefix = "", ...)
```

Arguments

`x`	an atomic vector for `rle()`; an object of class `"rle"` for `inverse.rle()`.
`...`	further arguments; ignored here.
`digits`	number of significant digits for printing, see `print.default`.
`prefix`	character string, prepended to each printed line.

Details

Missing values are regarded as unequal to the previous value, even if that is also missing.

`inverse.rle()` is the inverse function of `rle2()` and `rle()`, reconstructing `x` from the runs.

Value

`rle()` returns an object of class `"rle"` which is a list with components:

`lengths`	an integer vector containing the length of each run.
`values`	a vector of the same length as `lengths` with the corresponding values.

Examples

```
x <- rev(rep(6:10, 1:5))
rle(x)
## lengths [1:5]  5 4 3 2 1
## values  [1:5] 10 9 8 7 6
rle2(x)
## lengths: int [1:5] 5 4 3 2 1
## values : int [1:5] 10 9 8 7 6
## indices: int [1:5] 5 9 12 14 15
```

`rmsd` *Root Mean Square Deviation*

Description

Calculate the RMSD between coordinate sets.

Usage

```
rmsd(a, b=NULL, a.inds=NULL, b.inds=NULL, fit=FALSE, ncore=1, nseg.scale=1)
```

Arguments

`a`	a numeric vector containing the reference coordinate set for comparison with the coordinates in `b`. Alternatively, if `b=NULL` then `a` can be a matrix or list object containing multiple coordinates for pairwise comparison.
`b`	a numeric vector, matrix or list object with an `xyz` component, containing one or more coordinate sets to be compared with `a`.
`a.inds`	a vector of indices that selects the elements of `a` upon which the calculation should be based.
`b.inds`	a vector of indices that selects the elements of `b` upon which the calculation should be based.
`fit`	logical, if TRUE coordinate superposition is performed prior to RMSD calculation.
`ncore`	number of CPU cores used to do the calculation. `ncore>1` requires package 'parallel' installed.
`nseg.scale`	split input data into specified number of segments prior to running multiple core calculation. See `fit.xyz`.

Details

RMSD is a standard measure of structural distance between coordinate sets.

Structure `a[a.inds]` and `b[b.inds]` should have the same length.

A least-squares fit is performed prior to RMSD calculation by setting `fit=TRUE`. See the function `fit.xyz` for more details of the fitting process.

Value

Returns a numeric vector of RMSD value(s).

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

fit.xyz, rot.lsq, read.pdb, read.fasta.pdb

Examples

```
# Redundant testing excluded
try({

# -- Calculate RMSD between two or more structures
aln <- read.fasta(system.file("examples/kif1a.fa",package="bio3d"))
pdbs <- read.fasta.pdb(aln)

# Gap positions
inds <- gap.inspect(pdbs$xyz)

# Superposition before pairwise RMSD
rmsd(pdbs$xyz, fit=TRUE)

# RMSD between structure 1 and structures 2 and 3
rmsd(a=pdbs$xyz[1,], b=pdbs$xyz[2:3,], a.inds=inds$f.inds, b.inds=inds$f.inds, fit=TRUE)

# RMSD between structure 1 and all structures in alignment
rmsd(a=pdbs$xyz[1,], b=pdbs, a.inds=inds$f.inds, b.inds=inds$f.inds, fit=TRUE)

# RMSD without superposition
rmsd(pdbs$xyz)

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

rmsf *Atomic RMS Fluctuations*

Description

Calculate atomic root mean squared fluctuations.

Usage

```
rmsf(xyz, grpby=NULL, average=FALSE)
```

Arguments

xyz	numeric matrix of coordinates with each row corresponding to an individual conformer.
grpby	a vector counting connective duplicated elements that indicate the elements of 'xyz' that should be considered as a group (e.g. atoms from a particular residue). If provided a 'pdb' object, grouping is automatically set by amino acid residues.
average	logical, if TRUE averaged over atoms.

Details

RMSF is an often used measure of conformational variance. It is calculated by

$$f_i = \sqrt{\frac{1}{M-1}\sum_j \|r_i^j - r_i^0\|^2}$$

, where f_i is the RMSF value for the ith atom, M the total number of frames (total number of rows of xyz), r_i^j the positional vector of the ith atom in the jth frame, and r_i^0 the mean position of ith atom. ||r|| denotes the Euclidean norm of the vector r.

Value

Returns a numeric vector of RMSF values. If average=TRUE a single numeric value representing the averaged RMSF value over all atoms will be returned.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.dcd, fit.xyz, read.fasta.pdb

Examples

```
attach(transducin)

# Ignore Gaps
gaps <- gap.inspect(pdbs$ali)

r <- rmsf(pdbs$xyz)
plot(r[gaps$f.inds], typ="h", ylab="RMSF (A)")

detach(transducin)

## Not run:

pdb <- read.pdb("1d1d", multi=TRUE)
xyz <- pdb$xyz

# superimpose trajectory
xyz <- fit.xyz(xyz[1, ], xyz)

# select mainchain atoms
sele <- atom.select(pdb, elety=c("CA", "C", "N", "O"))

# residue numbers to group by
resno <- pdb$atom$resno[sele$atom]

# mean rmsf value of mainchain atoms of each residue
r <- rmsf(xyz[, sele$xyz], grpby=resno)
plot.bio3d(r, resno=pdb, sse=pdb, ylab="RMSF (A)")


## End(Not run)
```

---

rmsip *Root Mean Square Inner Product*

Description

Calculate the RMSIP between two mode subspaces.

Usage

```
rmsip(...)

## S3 method for class 'enma'
rmsip(enma, ncore=NULL, subset=10, ...)

## Default S3 method:
rmsip(modes.a, modes.b, subset=10,
                        row.name="a", col.name="b", ...)
```

Arguments

enma	an object of class "enma" obtained from function nma.pdbs.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
subset	the number of modes to consider.
modes.a	an object of class "pca" or "nma" as obtained from functions pca.xyz or nma.
modes.b	an object of class "pca" or "nma" as obtained from functions pca.xyz or nma.
row.name	prefix name for the rows.
col.name	prefix name for the columns.
...	arguments passed to associated functions.

Details

RMSIP is a measure for the similarity between two set of modes obtained from principal component or normal modes analysis.

Value

Returns an rmsip object with the following components:

overlap	a numeric matrix containing pairwise (squared) dot products between the modes.
rmsip	a numeric RMSIP value.

For function rmsip.enma a numeric matrix containing all pairwise RMSIP values of the modes stored in the enma object.

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Amadei, A. et al. (1999) *Proteins* **36**, 19–424.

See Also

pca, nma, overlap.

Other similarity measures: sip, covsoverlap, bhattacharyya.

Examples

```
## Not run:
# Load data for HIV example
trj <- read.dcd(system.file("examples/hivp.dcd", package="bio3d"))
pdb <- read.pdb(system.file("examples/hivp.pdb", package="bio3d"))

# Do PCA on simulation data
```

```
xyz.md <- fit.xyz(pdb$xyz, trj, fixed.inds=1:ncol(trj))
pc.sim <- pca.xyz(xyz.md)

# NMA
modes <- nma(pdb)

# Calculate the RMSIP between the MD-PCs and the NMA-MODEs
r <- rmsip(modes, pc.sim, subset=10, row.name="NMA", col.name="PCA")

# Plot pairwise overlap values
plot(r, xlab="NMA", ylab="PCA")

## End(Not run)
```

---

sdENM *Index for the sdENM ff*

Description

A dictonary of spring force constants for the sdENM force field.

Usage

```
data(sdENM)
```

Format

An array of 27 matrices containg the spring force constants for the 'sdENM' force field (see Dehouch et al for more information). Each matrix in the array holds the force constants for all amino acid pairs for a specific distance range.

See examples for more details.

Source

Dehouck Y. & Mikhailov A.S. (2013) *PLoS Comput Biol* **9**:e1003209.

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Dehouck Y. et al. (2013) *PLoS Comput Biol* **9**:e1003209.

Examples

```
## Load force constant data
data(sdENM)

## force constants for amino acids A, C, D, E, and F
## in distance range [4, 4.5)
sdENM[1:5, 1:5, 1]
```

```
## and distance range [4.5, 5)
sdENM[1:5, 1:5, 2]

## amino acid pair A-P, at distance 4.2
sdENM["A", "P", 1]

## Not run:
## for use in NMA
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
modes <- nma(pdb, ff="sdenm")

## End(Not run)
```

`seq2aln` *Add a Sequence to an Existing Alignmnet*

Description

Add one or more sequences to an existing multiple alignment that you wish to keep intact.

Usage

```
seq2aln(seq2add, aln, id = "seq", file = "aln.fa", ...)
```

Arguments

`seq2add`	an sequence character vector or an alignment list object with `id` and `ali` components, similar to that generated by `read.fasta` and `seqaln`.
`aln`	an alignment list object with `id` and `ali` components, similar to that generated by `read.fasta` and `seqaln`.
`id`	a vector of sequence names to serve as sequence identifers.
`file`	name of 'FASTA' output file to which alignment should be written.
`...`	additional arguments passed to `seqaln`.

Details

This function calls the 'MUSCLE' program, to perform a profile profile alignment, which MUST BE INSTALLED on your system and in the search path for executables.

Value

A list with two components:

`ali`	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
`id`	sequence names as identifers.

Note

A system call is made to the 'MUSCLE' program, which must be installed on your system and in the search path for executables.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'MUSCLE' is the work of Edgar: Edgar (2004) *Nuc. Acid. Res.* **32**, 1792–1797.

Full details of the 'MUSCLE' algorithm, along with download and installation instructions can be obtained from:
http://www.drive5.com/muscle/.

See Also

seqaln, read.fasta, read.fasta.pdb, seqbind

Examples

```
## Not run:
aa.1 <- pdbseq( read.pdb("1bg2") )
aa.2 <- pdbseq( read.pdb("3dc4") )
aa.3 <- pdbseq( read.pdb("1mkj") )

aln <- seqaln( seqbind(aa.1,aa.2) )

seq2aln(aa.3, aln)

## End(Not run)
```

---

seqaln *Sequence Alignment with MUSCLE*

Description

Create multiple alignments of amino acid or nucleotide sequences according to the method of Edgar.

Usage

```
seqaln(aln, id=NULL, profile=NULL, exefile="muscle", outfile="aln.fa",
       protein=TRUE, seqgroup=FALSE, refine=FALSE, extra.args="",
       verbose=FALSE, web.args = list(), ...)
```

Arguments

aln	a sequence character matrix, as obtained from seqbind, or an alignment list object as obtained from read.fasta.
id	a vector of sequence names to serve as sequence identifers.
profile	a profile alignment of class 'fasta' (e.g. obtained from read.fasta). The alignment aln will be added to the profile.
exefile	file path to the 'MUSCLE' program on your system (i.e. how is 'MUSCLE' invoked). Alternatively, 'CLUSTALO' can be used. Also supported is using the 'msa' package from Bioconductor (need to install packages using BiocManager::install()). To do so, simply set exefile="msa".
outfile	name of 'FASTA' output file to which alignment should be written.
protein	logical, if TRUE the input sequences are assumed to be protein not DNA or RNA.
seqgroup	logical, if TRUE similar sequences are grouped together in the output.
refine	logical, if TRUE the input sequences are assumed to already be aligned, and only tree dependent refinement is performed.
extra.args	a single character string containing extra command line arguments for the alignment program.
verbose	logical, if TRUE 'MUSCLE' warning and error messages are printed.
web.args	a 'list' object containing arguments to perform online sequence alignment using EMBL-EBI Web Services. See below for details.
...	additional arguments passed to the function msa::msaMuscle().

Details

Sequence alignment attempts to arrange the sequences of protein, DNA or RNA, to highlight regions of shared similarity that may reflect functional, structural, and/or evolutionary relationships between the sequences.

Aligned sequences are represented as rows within a matrix. Gaps ('-') are inserted between the aminoacids or nucleotides so that equivalent characters are positioned in the same column.

This function calls the 'MUSCLE' program to perform a multiple sequence alignment, which must be installed on your system and in the search path for executables. If local 'MUSCLE' can not be found, alignment can still be performed via online web services (see below) with limited features.

If you have a large number of input sequences (a few thousand), or they are very long, the default settings may be too slow for practical use. A good compromise between speed and accuracy is to run just the first two iterations of the 'MUSCLE' algorithm by setting the extra.args argument to "-maxiters 2".

You can set 'MUSCLE' to improve an existing alignment by setting refine to TRUE.

To inspect the sequence clustering used by 'MUSCLE' to produce alignments, include "-tree2 tree.out" in the extra.args argument. You can then load the "tree.out" file with the 'read.tree' function from the 'ape' package.

'CLUSTALO' can be used as an alternative to 'MUSCLE' by specifiying exefile='clustalo'. This might be useful e.g. when adding several sequences to a profile alignment.

If local 'MUSCLE' or 'CLUSTALO' program is unavailable, the alignment can be performed via the 'msa' package from the Bioconductor repository. To do so, set `exefile="msa"`. Note that both 'msa' and 'Biostrings' packages need to be installed properly using `BiocManager::install()`.

If the access to any method metioned above fails, the function will attempt to perform alignment via the EMBL-EBI Web Services (See https://www.ebi.ac.uk/). In this case, the argument `web.args` cannot be empty and must contain at least user's E-Mail address. Note that as stated by EBI, a fake email address may result in your jobs being killed and your IP, organisation or entire domain being black-listed (See FAQs on https://www.ebi.ac.uk/). Possible parameters to be passed via `web.args` include:

email a string containing a valid E-Mail address. Required.

title a string for the title of the job to be submitted to the remote server. Optional.

timeout integer specifying the number of seconds to wait for the response of the server before a time out occurs. Default: 90.

An example of usage is `web.args=list(email='user_id@email.provider')`.

Value

Returns a list of class `"fasta"` with the following components:

`ali`	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
`id`	sequence names as identifers.
`call`	the matched call.

Note

A system call is made to the 'MUSCLE' program, which must be installed on your system and in the search path for executables. See http://thegrantlab.org/bio3d/articles/online/install_vignette/Bio3D_install.html for instructions of how to install this program.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'MUSCLE' is the work of Edgar: Edgar (2004) *Nuc. Acid. Res.* **32**, 1792–1797.

Full details of the 'MUSCLE' algorithm, along with download and installation instructions can be obtained from:
http://www.drive5.com/muscle/.

See Also

`read.fasta`, `read.fasta.pdb`, `get.seq`, `seqbind`, `pdbaln`, `plot.fasta`, `blast.pdb`

Examples

```
## Not run:
##-- Basic sequence alignemnt
seqs <- get.seq(c("4q21_A", "1ftn_A"))
aln <- seqaln(seqs)

##-- add a sequence to the (profile) alignment
seq <- get.seq("1tnd_A")
aln <- seqaln(seq, profile=aln)


##-- Read a folder/directory of PDB files
#pdb.path <- "my_dir_of_pdbs"
#files  <- list.files(path=pdb.path ,
#                     pattern=".pdb",
#                     full.names=TRUE)

##-- Use online files
files <- get.pdb(c("4q21","1ftn"), URLonly=TRUE)

##-- Extract and store sequences
raw <- NULL
for(i in 1:length(files)) {
  pdb <- read.pdb(files[i])
  raw <- seqbind(raw, pdbseq(pdb) )
}

##-- Align these sequences
aln <- seqaln(raw, id=files, outfile="seqaln.fa")

##-- Read Aligned PDBs storing coordinate data
pdbs <- read.fasta.pdb(aln)

## Sequence identity
seqidentity(aln)

## Note that all the above can be done with the pdbaln() function:
#pdbs <- pdbaln(files)


##-- For identical sequences with masking use a custom matrix
aa <- seqbind(c("X","C","X","X","A","G","K"),
              c("C","-","A","X","G","X","X","K"))

aln <- seqaln(aln=aln, id=c("a","b"), outfile="temp.fas", protein=TRUE,
               extra.args= paste("-matrix",
                system.file("matrices/custom.mat", package="bio3d"),
                "-gapopen -3.0 ",
                "-gapextend -0.5",
                "-center 0.0") )

## End(Not run)
```

`seqaln.pair` *Sequence Alignment of Identical Protein Sequences*

Description

Create multiple alignments of amino acid sequences according to the method of Edgar.

Usage

```
seqaln.pair(aln, ...)
```

Arguments

`aln`	a sequence character matrix, as obtained from `seqbind`, or an alignment list object as obtained from `read.fasta`.
`...`	additional arguments for the function `seqaln`.

Details

This function is intended for the alignment of identical sequences only. For standard alignment see the related function `seqaln`.

This function is useful for determining the equivalences between sequences and structures. For example in aligning a PDB sequence to an existing multiple sequence alignment, where one would first mask the alignment sequences and then run the alignment to determine equivalences.

Value

A list with two components:

`ali`	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
`ids`	sequence names as identifers.

Note

A system call is made to the 'MUSCLE' program, which must be installed on your system and in the search path for executables.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

'MUSCLE' is the work of Edgar: Edgar (2004) *Nuc. Acid. Res.* **32**, 1792–1797.

Full details of the 'MUSCLE' algorithm, along with download and installation instructions can be obtained from:
http://www.drive5.com/muscle/.

See Also

seqaln, read.fasta, read.fasta.pdb, seqbind

Examples

```
## NOTE: FOLLOWING EXAMPLE NEEDS MUSCLE INSTALLED
if(check.utility("muscle")) {

##- Aligning a PDB sequence to an existing sequence alignment


##- Simple example
aln <- seqbind(c("X","C","X","X","A","G","K"),
               c("C","-","A","X","G","X","X","K"))

seqaln.pair(aln, outfile = tempfile())

}
```

---

seqbind *Combine Sequences by Rows Without Recycling*

Description

Take vectors and/or matrices arguments and combine them row-wise without recycling them (as is the case with rbind).

Usage

```
seqbind(..., blank = "-")
```

Arguments

...	vectors, matrices, and/or alignment 'fasta' objects to combine.
blank	a character to add to short arguments, to achieve the same length as the longer argument.

Value

Returns a list of class "fasta" with the following components:

ali	an alignment character matrix with a row per sequence and a column per equivalent aminoacid/nucleotide.
id	sequence names as identifers.
call	the matched call.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

seqaln, read.fasta, read.pdb, write.fasta, rbind

Examples

```
## Not run:
## Read two pdbs
a.pdb <- read.pdb("1bg2")
b.pdb <- read.pdb("1goj")

seqs <- seqbind(aa321(a.pdb$atom[a.pdb$calpha,"resid"]),
                aa321(b.pdb$atom[b.pdb$calpha,"resid"]))

# seqaln(seqs)

## End(Not run)
```

---

seqidentity *Percent Identity*

Description

Determine the percent identity scores for aligned sequences.

Usage

```
seqidentity(alignment, normalize=TRUE, similarity=FALSE, ncore=1, nseg.scale=1)
```

Arguments

alignment	sequence alignment obtained from read.fasta or an alignment character matrix.
normalize	logical, if TRUE output is normalized to values between 0 and 1 otherwise percent identity is returned.
similarity	logical, if TRUE sequence similarity is calculated instead of identity.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
nseg.scale	split input data into specified number of segments prior to running multiple core calculation. See fit.xyz.

Details

The percent identity value is a single numeric score determined for each pair of aligned sequences. It measures the number of identical residues ("matches") in relation to the length of the alignment.

Value

Returns a numeric matrix with all pairwise identity values.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, filter.identity, entropy, consensus

Examples

```
attach(kinesin)

ide.mat <- seqidentity(pdbs)

# Plot identity matrix
plot.dmat(ide.mat, color.palette=mono.colors,
          main="Sequence Identity", xlab="Structure No.",
          ylab="Structure No.")

# Histogram of pairwise identity values
hist(ide.mat[upper.tri(ide.mat)], breaks=30,xlim=c(0,1),
     main="Sequence Identity", xlab="Identity")

# Compare two sequences
seqidentity( rbind(pdbs$ali[1,], pdbs$ali[15,]) )
```

```
detach(kinesin)
```

`setup.ncore` *Setup for Running Bio3D Functions using Multiple CPU Cores*

Description

Internally used in parallelized Bio3D functions.

Usage

```
setup.ncore(ncore, bigmem = FALSE)
```

Arguments

`ncore`	User set (or default) value of 'ncore'.
`bigmem`	logical, if TRUE also check the availability of 'bigmemory' package.

Details

Check packages and set correct value of 'ncore'.

Value

The actual value of 'ncore'.

Examples

```
setup.ncore(NULL)
setup.ncore(1)
#  setup.ncore(2)
```

`sip` *Square Inner Product*

Description

Calculate the correlation between two atomic fluctuation vectors.

Usage

```
sip(...)

## S3 method for class 'nma'
sip(a, b, ...)

## S3 method for class 'enma'
sip(enma, ncore=NULL, ...)

## Default S3 method:
sip(v, w, ...)
```

Arguments

enma	an object of class "enma" obtained from function nma.pdbs.
ncore	number of CPU cores used to do the calculation. ncore>1 requires package 'parallel' installed.
a	an 'nma' object as object from function nma to be compared to b.
b	an 'nma' object as object from function nma to be compared to a.
v	a numeric vector containing the atomic fluctuation values.
w	a numeric vector containing the atomic fluctuation values.
...	arguments passed to associated functions.

Details

SIP is a measure for the similarity of atomic fluctuations of two proteins, e.g. experimental b-factors, theroetical RMSF values, or atomic fluctuations obtained from NMA.

Value

Returns the similarity coefficient(s).

Author(s)

Lars Skjaerven

References

Skjaerven, L. et al. (2014) *BMC Bioinformatics* **15**, 399. Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. Fuglebakk, E. et al. (2013) *JCTC* **9**, 5618–5628.

See Also

Other similarity measures: covsoverlap, bhattacharyya, rmsip.

Examples

```
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
a <- nma(pdb)
b <- nma(pdb, ff="anm")

sip(a$fluctuations, b$fluctuations)
```

`sse.bridges` *SSE Backbone Hydrogen Bonding*

Description

Determine backbone C=O to N-H hydrogen bonding in secondary structure elements.

Usage

```
sse.bridges(sse, type="helix", hbond=TRUE, energy.cut=-1.0)
```

Arguments

`sse`	an sse object as obtained with `dssp`.
`type`	character string specifying 'helix' or 'sheet'.
`hbond`	use hbond records in the dssp output.
`energy.cut`	cutoff for the dssp hbond energy.

Details

Simple functionality to parse the 'BP' and 'hbond' records of the DSSP output.

Requires input from function `dssp` with arguments `resno=FALSE` and `full=TRUE`.

Value

Returns a numeric matrix of two columns containing the residue ids of the paired residues.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`read.pdb`, `dssp`

Examples

```
## Not run:
# Read a PDB file
pdb <- read.pdb( system.file("examples/1hel.pdb", package="bio3d") )
sse <- dssp(pdb, resno=FALSE, full=TRUE)

sse.bridges(sse, type="helix")

## End(Not run)
```

`store.atom` *Store all-atom data from a PDB object*

Description

Not intended for public usage

Usage

```
store.atom(pdb=NULL)
```

Arguments

pdb	A pdb object as obtained from read.pdb

Details

This function was requested by a user and has not been extensively tested. Hence it is not yet recommended for public usage.

Value

Returns a matrix of all-atom data. If `pdb=NULL`, returns the default atom names to be stored.

Note

This function is still in development and is NOT part of the offical bio3d package

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`read.fasta.pdb`

Examples

```
## Not run:
pdb <- read.pdb( get.pdb("5p21", URLonly=TRUE) )
a <- store.atom(pdb)
a[,,1:2]

## End(Not run)
```

`struct.aln` *Structure Alignment Of Two PDB Files*

Description

Performs a sequence and structural alignment of two PDB entities.

Usage

```
struct.aln(fixed, mobile, fixed.inds=NULL, mobile.inds=NULL,
           write.pdbs=TRUE, outpath = "fitlsq", prefix=c("fixed",
           "mobile"), max.cycles=10, cutoff=0.5, ... )
```

Arguments

`fixed`	an object of class pdb as obtained from function `read.pdb`.
`mobile`	an object of class pdb as obtained from function `read.pdb`.
`fixed.inds`	atom and xyz coordinate indices obtained from `atom.select` that selects the elements of `fixed` upon which the calculation should be based.
`mobile.inds`	atom and xyz coordinate indices obtained from `atom.select` that selects the elements of `mobile` upon which the calculation should be based.
`write.pdbs`	logical, if TRUE the aligned structures are written to PDB files.
`outpath`	character string specifing the output directory when `write.pdbs` is TRUE.
`prefix`	a character vector of length 2 containing the filename prefix in which the fitted structures should be written.
`max.cycles`	maximum number of refinement cycles.
`cutoff`	standard deviation of the pairwise distances for aligned residues at which the fitting refinement stops.
`...`	extra arguments passed to `seqaln` function.

Details

This function performs a sequence alignment followed by a structural alignment of the two PDB entities. Cycles of refinement steps of the structural alignment are performed to improve the fit by removing atoms with a high structural deviation. The primary purpose of the function is to allow rapid structural alignment (and RMSD analysis) for protein structures with unequal, but related sequences.

The function reports the residues of `fixed` and `mobile` included in the final structural alignment, as well as the related RMSD values.

This function makes use of the underlying functions `seqaln`, `rot.lsq`, and `rmsd`.

Value

Returns a list with the following components:

`a.inds`	atom and xyz indices of `fixed`.
`b.inds`	atom and xyz indices of `mobile`.
`xyz`	fitted xyz coordinates of `mobile`.
`rmsd`	a numeric vector of RMSD values after each cycle of refinement.

Author(s)

Lars Skjarven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`rmsd`, `rot.lsq`, `seqaln`, `pdbaln`

Examples

```
# Needs MUSCLE installed - testing excluded

if(check.utility("muscle")) {

try({

     ## Stucture of PKA:
     a <- read.pdb("1cmk")

     ## Stucture of PKB:
     b <- read.pdb("2jdo")

     ## Align and fit b on to a:
     path = file.path(tempdir(), "struct.aln")
     aln <- struct.aln(a, b, outpath = path, outfile = tempfile())
```

```
     ## Should be the same as aln$rmsd (when using aln$a.inds and aln$b.inds)
     rmsd(a$xyz, b$xyz, aln$a.inds$xyz, aln$b.inds$xyz, fit=TRUE)

    invisible( cat("\nSee the output files:", list.files(path, full.names = TRUE), sep="\n") )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
}


## Not run:
     ## Align two subunits of GroEL (open and closed states)
     a <- read.pdb("1sx4")
     b <- read.pdb("1xck")

     ## Select chain A only
     a.inds <- atom.select(a, chain="A")
     b.inds <- atom.select(b, chain="A")

     ## Align and fit:
     aln <- struct.aln(a,b, a.inds, b.inds)

## End(Not run)
```

`torsion.pdb` *Calculate Mainchain and Sidechain Torsion/Dihedral Angles*

Description

Calculate all torsion angles for a given protein PDB structure object.

Usage

```
torsion.pdb(pdb)
```

Arguments

pdb	a PDB structure object as obtained from function `read.pdb`.

Details

The conformation of a polypeptide chain can be usefully described in terms of angles of internal rotation around its constituent bonds. See the related `torsion.xyz` function, which is called by this function, for details.

Value

Returns a list object with the following components:

`phi`	main chain torsion angle for atoms C,N,CA,C.
`psi`	main chain torsion angle for atoms N,CA,C,N.
`omega`	main chain torsion angle for atoms CA,C,N,CA.
`alpha`	virtual torsion angle between consecutive C-alpha atoms.
`chi1`	side chain torsion angle for atoms N,CA,CB,*G.
`chi2`	side chain torsion angle for atoms CA,CB,*G,*D.
`chi3`	side chain torsion angle for atoms CB,*G,*D,*E.
`chi4`	side chain torsion angle for atoms *G,*D,*E,*Z.
`chi5`	side chain torsion angle for atoms *D,*E,*Z, NH1.
`coords`	numeric matrix of 'justified' coordinates.
`tbl`	a numeric matrix of psi, phi and chi torsion angles.

Note

For the protein backbone, or main-chain atoms, the partial double-bond character of the peptide bond between 'C=N' atoms severely restricts internal rotations. In contrast, internal rotations around the single bonds between 'N-CA' and 'CA-C' are only restricted by potential steric collisions. Thus, to a good approximation, the backbone conformation of each residue in a given polypeptide chain can be characterised by the two angles phi and psi.

Sidechain conformations can also be described by angles of internal rotation denoted chi1 up to chi5 moving out along the sidechain.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`torsion.xyz`, `read.pdb`, `dssp`, `stride`.

Examples

```
# PDB server connection required - testing excluded
try({

##-- PDB torsion analysis
pdb <- read.pdb( "1bg2" )
tor <- torsion.pdb(pdb)
head(tor$tbl)
```

```
## basic Ramachandran plot
plot(tor$phi, tor$psi)

## torsion analysis of a single coordinate vector
#inds <- atom.select(pdb,"calpha")
#tor.ca <- torsion.xyz(pdb$xyz[inds$xyz], atm.inc=1)

##-- Compare two PDBs to highlight interesting residues
aln <- read.fasta(system.file("examples/kif1a.fa",package="bio3d"))
m <- read.fasta.pdb(aln)
a <- torsion.xyz(m$xyz[1,],1)
b <- torsion.xyz(m$xyz[2,],1)
d <- wrap.tor(a-b)
plot(m$resno[1,],d, typ="h")

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

`torsion.xyz` *Calculate Torsion/Dihedral Angles*

Description

Defined from the Cartesian coordinates of four successive atoms (A-B-C-D) the torsion or dihedral angle is calculated about an axis defined by the middle pair of atoms (B-C).

Usage

```
torsion.xyz(xyz, atm.inc = 4)
```

Arguments

`xyz`	a numeric vector of Cartisean coordinates.
`atm.inc`	a numeric value indicating the number of atoms to increment by between successive torsion evaluations (see below).

Details

The conformation of a polypeptide or nucleotide chain can be usefully described in terms of angles of internal rotation around its constituent bonds.

If a system of four atoms A-B-C-D is projected onto a plane normal to bond B-C, the angle between the projection of A-B and the projection of C-D is described as the torsion angle of A and D about bond B-C.

By convention angles are measured in the range -180 to +180, rather than from 0 to 360, with positive values defined to be in the clockwise direction.

With `atm.inc=1`, torsion angles are calculated for each set of four successive atoms contained in `xyz` (i.e. moving along one atom, or three elements of `xyz`, between sucessive evaluations). With `atm.inc=4`, torsion angles are calculated for each set of four successive non-overlapping atoms contained in `xyz` (i.e. moving along four atoms, or twelve elements of `xyz`, between sucessive evaluations).

Value

A numeric vector of torsion angles.

Note

Contributions from Barry Grant.

Author(s)

Karim ElSawy

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`torsion.pdb`, `pca.tor`, `wrap.tor`, `read.pdb`, `read.dcd`.

Examples

```
## Calculate torsions for cis & trans conformers
xyz <- rbind(c(0,-0.5,0,1,0,0,1,1,0,0,1.5,0),
             c(0,-0.5,0,1,0,0,1,1,0,2,1.5,0)-3)
cis.tor   <- torsion.xyz( xyz[1,] )
trans.tor <- torsion.xyz( xyz[2,] )
apply(xyz, 1, torsion.xyz)


plot(range(xyz), range(xyz), xlab="", ylab="", typ="n", axes=FALSE)
  apply(xyz, 1, function(x){
    lines(matrix(x, ncol=3, byrow=TRUE), lwd=4)
    points(matrix(x, ncol=3, byrow=TRUE), cex=2.5,
           bg="white", col="black", pch=21) } )

  text( t(apply(xyz, 1, function(x){
    apply(matrix(x, ncol=3, byrow=TRUE)[c(2,3),], 2, mean) })),
       labels=c(0,180), adj=-0.5, col="red")


# PDB server connection required - testing excluded
try({

##-- PDB torsion analysis
pdb <- read.pdb("1bg2")
```

```
tor <- torsion.pdb(pdb)
## basic Ramachandran plot
plot(tor$phi, tor$psi)

## torsion analysis of a single coordinate vector
inds <- atom.select(pdb,"calpha")
tor.ca <- torsion.xyz(pdb$xyz[inds$xyz], atm.inc=3)

##-- Compare two PDBs to highlight interesting residues
aln <- read.fasta(system.file("examples/kif1a.fa",package="bio3d"))
m <- read.fasta.pdb(aln)
a <- torsion.xyz(m$xyz[1,],1)
b <- torsion.xyz(m$xyz[2,],1)
## Note the periodicity of torsion angles
d <- wrap.tor(a-b)
plot(m$resno[1,],d, typ="h")

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

`trim` *Trim a PDB Object To A Subset of Atoms.*

Description

Produce a new smaller PDB object, containing a subset of atoms, from a given larger PDB object.

Usage

```
trim(...)

## S3 method for class 'pdb'
trim(pdb, ..., inds = NULL, sse = TRUE)
```

Arguments

pdb	a PDB structure object obtained from `read.pdb`.
...	additional arguments passed to `atom.select`. If `inds` is also provided, these arguments will be ignored.
inds	a list object of ATOM and XYZ indices as obtained from `atom.select`. If NULL, atom selection will be obtained from calling `atom.select(pdb, ...)`.
sse	logical, if 'FALSE' helix and sheet components are omitted from output.

Details

This is a basic utility function for creating a new PDB object based on a selection of atoms.

Value

Returns a list of class `"pdb"` with the following components:

`atom`	a character matrix containing all atomic coordinate ATOM data, with a row per ATOM and a column per record type. See below for details of the record type naming convention (useful for accessing columns).
`het`	a character matrix containing atomic coordinate records for atoms within "non-standard" HET groups (see `atom`).
`helix`	'start', 'end' and 'length' of H type sse, where start and end are residue numbers "resno".
`sheet`	'start', 'end' and 'length' of E type sse, where start and end are residue numbers "resno".
`seqres`	sequence from SEQRES field.
`xyz`	a numeric vector of ATOM coordinate data.
`xyz.models`	a numeric matrix of ATOM coordinate data for multi-model PDB files.
`calpha`	logical vector with length equal to `nrow(atom)` with TRUE values indicating a C-alpha "elety".

Note

`het` and `seqres` list components are returned unmodified.

For both `atom` and `het` list components the column names can be used as a convenient means of data access, namely: Atom serial number "eleno", Atom type "elety", Alternate location indicator "alt", Residue name "resid", Chain identifier "chain", Residue sequence number "resno", Code for insertion of residues "insert", Orthogonal coordinates "x", Orthogonal coordinates "y", Orthogonal coordinates "z", Occupancy "o", and Temperature factor "b". See examples for further details.

Author(s)

Barry Grant, Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html. .

See Also

`trim.pdbs`, `trim.xyz`, `read.pdb`, `atom.select`

Examples

```
## Not run:
## Read a PDB file from the RCSB online database
pdb <- read.pdb("1bg2")

## Select calpha atoms
sele <- atom.select(pdb, "calpha")

## Trim PDB
new.pdb <- trim.pdb(pdb, inds=sele)

## Or, simply
#new.pdb <- trim.pdb(pdb, "calpha")

## Write to file
write.pdb(new.pdb, file="calpha.pdb")

## End(Not run)
```

---

trim.mol2 *Trim a MOL2 Object To A Subset of Atoms.*

Description

Produce a new smaller MOL2 object, containing a subset of atoms, from a given larger MOL2 object.

Usage

```
## S3 method for class 'mol2'
trim(mol, ..., inds = NULL)
```

Arguments

`mol`	a MOL2 structure object obtained from `read.mol2`.
`...`	additional arguments passed to `atom.select`. If `inds` is also provided, these arguments will be ignored.
`inds`	a list object of ATOM and XYZ indices as obtained from `atom.select`. If NULL, atom selection will be obtained from calling `atom.select(mol, ...)`.

Details

This is a basic utility function for creating a new MOL2 object based on a selection of atoms.

Value

Returns a list of class `"mol2"`.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.mol2, atom.select.mol2, as.pdb.mol2, write.mol2,

Examples

```
## Not run:
## Read a MOL2 file from those included with the package
mol <- read.mol2( system.file("examples/aspirin.mol2", package="bio3d"))

## Trim away H-atoms
mol <- trim(mol, "noh")


## End(Not run)
```

---

trim.pdbs *Filter or Trim a PDBs Object*

Description

Trim residues and/or filter out structures from a PDBs object.

Usage

```
## S3 method for class 'pdbs'
trim(pdbs, row.inds=NULL, col.inds=NULL, ...)
```

Arguments

pdbs	an object of class pdbs as obtained from function pdbaln or read.fasta.pdb; a xyz matrix containing the cartesian coordinates of C-alpha atoms.
row.inds	a numeric vector of indices pointing to the PDB structures to keep (rows in the pdbs$ali matrix).
col.inds	a numeric vector of indices pointing to the alignment columns to keep (columns in the pdbs$ali matrix).
...	additional arguments passed to and from functions.

Details

Utility function to remove structures, or trim off columns, in a 'pdbs' object.

Value

Returns an updated 'pdbs' object with the following components:

`xyz`	numeric matrix of aligned C-alpha coordinates.
`resno`	character matrix of aligned residue numbers.
`b`	numeric matrix of aligned B-factor values.
`chain`	character matrix of aligned chain identifiers.
`id`	character vector of PDB sequence/structure names.
`ali`	character matrix of aligned sequences.
`call`	the matched call.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`pdbaln`, `gap.inspect`, `read.fasta`,`read.fasta.pdb`, `trim.pdb`,

Examples

```
## Not run:
## Fetch PDB files and split to chain A only PDB files
ids <- c("1a70_A", "1czp_A", "1frd_A", "1fxi_A", "1iue_A", "1pfd_A")
raw.files <- get.pdb(ids, path = "raw_pdbs")
files <- pdbsplit(raw.files, ids, path = "raw_pdbs/split_chain")

## Sequence Alignement, and connectivity check
pdbs <- pdbaln(files)

cons <- inspect.connectivity(pdbs)

## omit files with missing residues
trim.pdbs(pdbs, row.inds=which(cons))

## End(Not run)
```

`trim.xyz` *Trim a XYZ Object of Cartesian Coordinates.*

Description

Produce a new smaller XYZ object, containing a subset of atoms.

Usage

```
## S3 method for class 'xyz'
trim(xyz, row.inds = NULL, col.inds = NULL, ...)
```

Arguments

`xyz`	a XYZ object containing Cartesian coordinates, e.g. obtained from `read.pdb`, `read.ncdf`.
`row.inds`	a numeric vector specifying which rows of the xyz matrix to return.
`col.inds`	a numeric vector specifying which columns of the xyz matrix to return.
`...`	additional arguments passed to and from functions.

Details

This function provides basic functionality for subsetting a matrix of class 'xyz' while also maintaining the class attribute.

Value

Returns an object of class `xyz` with the Cartesian coordinates stored in a matrix object with dimensions M x 3N, where N is the number of atoms, and M number of frames.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`read.pdb`, `as.xyz`.

Examples

```
## Not run:
## Read a PDB file from the RCSB online database
pdb <- read.pdb("1bg2")

## Select calpha atoms
sele <- atom.select(pdb, "calpha")

## Trim XYZ
trim(pdb$xyz, col.inds=sele$xyz)

## Equals to
pdb$xyz[, sele$xyz, drop=FALSE]

## End(Not run)
```

---

unbound *Sequence Generation from a Bounds Vector*

Description

Generate a sequence of consecutive numbers from a bounds vector.

Usage

```
unbound(start, end = NULL)
```

Arguments

start	vector of starting values, or a matrix containing starting and end values such as that obtained from bounds.
end	vector of (maximal) end values, such as that obtained from bounds.

Details

This is a simple utility function that does the opposite of the bounds function. If start is a vector, end must be a vector having the same length as start. If start is a matrix with column names contain 'start' and 'end', such as that returned from bounds, end can be skipped and both starting and end values will be extracted from start.

Value

Returns a numeric sequence vector.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

bounds

Examples

```
test <- c(seq(1,5,1),8,seq(10,15,1))
b <- bounds(test)
unbound(b)
```

---

uniprot *Fetch UniProt Entry Data.*

Description

Fetch protein sequence and functional information from the UniProt database.

Usage

```
uniprot(accid)
```

Arguments

accid	UniProt accession id.

Details

This is a basic utility function for downloading information from the UniProt database. UniProt contains protein sequence and functional information.

Value

Returns a list object with the following components:

accession	a character vector with UniProt accession id's.
name	abbreviated name.
fullName	full recommended protein name.
shortName	short protein name.
sequence	protein sequence.
gene	gene names.
organism	organism.
taxon	taxonomic lineage.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See also the UniProt web-site for more information:
https://www.uniprot.org/.

See Also

blast.pdb, get.seq

Examples

```
## Not run:
# UNIPROT server connection required - testing excluded

prot <- uniprot('PH4H_HUMAN')
prot$fullName
prot$sequence

## End(Not run)
```

---

var.xyz *Pairwise Distance Variance in Cartesian Coordinates*

Description

Calculate the variance of all pairwise distances in an ensemble of Cartesian coordinates.

Usage

```
var.xyz(xyz, weights=TRUE)
var.pdbs(pdbs, ...)
```

Arguments

xyz	an object of class "xyz" containing Cartesian coordinates in a matrix.
weights	logical, if TRUE weights are calculated based on the pairwise distance variance.
pdbs	a 'pdbs' object as object from function pdbaln.
...	arguments passed to associated functions.

Details

This function calculates the variance of all pairwise distances in an ensemble of Cartesian coordinates. The primary use of this function is to calculate weights to scale the pair force constant for NMA.

Value

Returns the a matrix of the pairwise distance variance, formated as weights if 'weights=TRUE'.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`nma.pdbs`

`vec2resno` *Replicate Per-residue Vector Values*

Description

Replicate values in one vector based on consecutive entries in a second vector. Useful for adding per-residue data to all-atom PDB files.

Usage

```
vec2resno(vec, resno)
```

Arguments

`vec`	a vector of values to be replicated.
`resno`	a reference vector or a PDB structure object, obtained from `read.pdb`, upon which replication is based.

Details

This function can aid in mapping data to PDB structure files. For example, residue conservation per position (or any other one value per residue data) can be replicated to fit the B-factor field of an all atom PDB file which can then be rendered according to this field in a molecular viewer.

A basic check is made to ensure that the number of consecutively unique entries in the reference vector equals the length of the vector to be replicated.

Value

Returns a vector of replicated values.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.pdb, atom.select, write.pdb

Examples

```
vec2resno(c("a","b"), c(1,1,1,1,2,2))
```

---

vmd *View CNA Protein Structure Network Community Output in VMD*

Description

This function generates a VMD scene file and a PDB file that can be read and rendered by the VMD molecular viewer. Chose 'color by chain' to see corresponding regions of structure colored by community along with the community protein structure network.

Usage

```
vmd(...)

## S3 method for class 'cna'
vmd(x, pdb, layout = layout.cna(x, pdb, k=3),
  col.sphere=NULL, col.lines = "silver", weights = NULL,
  radius = table(x$communities$membership)/5, alpha = 1,
  vmdfile = "network.vmd", pdbfile = "network.pdb",
               full = FALSE, launch = FALSE, exefile=NULL, ...)
## S3 method for class 'ecna'
vmd(x, n=1, ...)
## S3 method for class 'cnapath'
vmd(x, pdb, out.prefix = "vmd.cnapath", spline = FALSE,
   colors = c("blue", "red"), launch = FALSE, exefile=NULL, mag=1.0, ...)
## S3 method for class 'ecnapath'
vmd(x, ...)
```

Arguments

x	A 'cna' or 'cnapath' class object, or a list of such objects, as obtained from functions cna or cnapath.
n	The index to indicate which network or path to view with vmd.
pdb	A 'pdb' class object such as obtained from 'read.pdb' function.
layout	A numeric matrix of Nx3 XYZ coordinate matrix, where N is the number of community spheres to be drawn.

col.sphere	A numeric vector containing the sphere colors.
col.lines	A character object specifying the color of the edges (default 'silver'). Must use VMD colors names.
weights	A numeric vector specifying the edge width. Default is taken from E(x$community.network)$weight.
radius	A numeric vector containing the sphere radii. Default is taken from the number of community members divided by 5.
alpha	A single element numeric vector specifying the VMD alpha transparency parameter. Default is set to 1.
vmdfile	A character element specifying the output VMD scene file name that will be loaded in VMD.
pdbfile	A character element specifying the output pdb file name to be loaded in VMD.
full	Logical, if TRUE the full all-atom network rather than the clustered community network will be drawn. Intra community edges are colored according to the community membership, while inter community edges are thicker and colored black.
launch	Logical. If TRUE, a VMD session will be started with the output of 'vmd.cna'.
out.prefix	Prefix for the names of output files, 'vmd.cnapath.vmd' and 'vmd.cnapath.pdb'.
spline	Logical, if TRUE all paths are displayed as spline curves.
colors	Character vector or integer scalar, define path colors. If a character vector, passed to colorRamp function to generate the color scales. If an integer, color all paths the same way with VMD color ID equal to the integer.
exefile	file path to the 'VMD' program on your system (i.e. how is 'VMD' invoked). If NULL, use OS-dependent default path to the program.
mag	A numeric factor to scale the maximal thickness of paths.
...	additional arguments passed to the function colorRamp (in vmd.cnapath).

Details

This function generates a scaled sphere (communities) and stick (edges) representation of the community network along with the corresponding protein structure divided into chains, one chain for each community. The sphere radii are proportional to the number of community members and the edge widths correspond to network edge weights.

Value

Two files are generated as output. A pdb file with the residue chains assigned according to the community and a text file containing The drawing commands for the community representation.

Author(s)

Barry Grant

References

Humphrey, W., Dalke, A. and Schulten, K., "VMD - Visual Molecular Dynamics" J. Molec. Graphics 1996, 14.1, 33-38.

Examples

```
## Not run:

if (!requireNamespace("igraph", quietly = TRUE)) {
   message('Need igraph installed to run this example')
} else {

# Load the correlation network from MD data
attach(hivp)

# Read the starting PDB file to determine atom correspondence
pdbfile <- system.file("examples/hivp.pdb", package="bio3d")
pdb <- read.pdb(pdbfile)

# View cna
vmd.cna(net, pdb, launch=FALSE)
## within VMD set 'coloring method' to 'Chain' and 'Drawing method' to Tube


##-- From NMA
pdb.gdi = read.pdb("1KJY")
pdb.gdi = trim.pdb(pdb.gdi, inds=atom.select(pdb.gdi, chain="A", elety="CA"))
modes.gdi = nma(pdb.gdi)
cij.gdi = dccm(modes.gdi)
net.gdi = cna(cij.gdi, cutoff.cij=0.35)
#vmd.cna(net.gdi, pdb.gdi, alpha = 0.7, launch=TRUE)

detach(hivp)

}

## End(Not run)
```

---

vmd_colors *VMD Color Palette*

Description

This function creates a character vector of the colors used by the VMD molecular graphics program.

Usage

```
vmd_colors(n=33, picker=FALSE, ...)
```

Arguments

n	The number of desired colors chosen in sequence from the VMD color palette (>=1)
picker	Logical, if TRUE a color wheel plot will be produced to aid with color choice.
...	Extra arguments passed to the rgb function, including alpha transparency.

Details

The function uses the underlying 33 RGB color codes from VMD, See http://www.ks.uiuc.edu/Research/vmd/. Note that colors will be recycled if "n" > 33 with a warning issued. When 'picker' is set to "TRUE" a color wheel of the requested colors will be plotted to the currently active device.

Value

Returns a character vector with color names.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

http://www.ks.uiuc.edu/Research/vmd/

See Also

bwr.colors

Examples

```
## Generate a vector of 10 colors
clrs <- vmd_colors(10)
vmd_colors(4, picker=TRUE)
```

---

wrap.tor *Wrap Torsion Angle Data*

Description

Adjust angular data so that the absolute difference of any of the observations from its mean is not greater than 180 degrees.

Usage

```
wrap.tor(data, wrapav=TRUE, avestruc=NULL)
```

Arguments

data	a numeric vector or matrix of torsion angle data as obtained from torsion.xyz.
wrapav	logical, if TRUE average structure is also 'wrapped'
avestruc	a numeric vector corresponding to the average structure

Details

This is a basic utility function for coping with the periodicity of torsion angle data, by 'wraping' angular data such that the absolute difference of any of the observations from its column-wise mean is not greater than 180 degrees.

Value

A numeric vector or matrix of wrapped torsion angle data.

Author(s)

Karim ElSawy

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

`torsion.xyz`

---

write.crd *Write CRD File*

Description

Write a CHARMM CARD (CRD) coordinate file.

Usage

```
write.crd(pdb = NULL, xyz = pdb$xyz, resno = NULL, resid = NULL,
   eleno = NULL, elety = NULL, segid = NULL, resno2 = NULL, b = NULL,
   verbose = FALSE, file = "R.crd")
```

Arguments

pdb	a structure object obtained from `read.pdb` or `read.crd`.
xyz	Cartesian coordinates as a vector or 3xN matrix.
resno	vector of residue numbers of length equal to length(xyz)/3.
resid	vector of residue types/ids of length equal to length(xyz)/3.
eleno	vector of element/atom numbers of length equal to length(xyz)/3.
elety	vector of element/atom types of length equal to length(xyz)/3.
segid	vector of segment identifiers with length equal to length(xyz)/3.
resno2	vector of alternate residue numbers of length equal to length(xyz)/3.
b	vector of weighting factors of length equal to length(xyz)/3.
verbose	logical, if TRUE progress details are printed.
file	the output file name.

Details

Only the xyz argument is strictly required. Other arguments assume a default poly-ALA C-alpha structure with a blank segid and B-factors equal to 0.00.

Value

Called for its effect.

Note

Check that resno and eleno do not exceed "9999".

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of CHARMM CARD (CRD) format see:
https://academiccharmm.org/documentation/version/c49b1/io#Coordinate.

See Also

read.crd, read.pdb, atom.select, write.pdb, read.dcd, read.fasta.pdb, read.fasta

Examples

```
## Not run:
# Read a PDB file
pdb <- read.pdb( "1bg2" )
summary(pdb)
# Convert to CHARMM format
new <- convert.pdb(pdb, type="charmm")
summary(new)
# Write a CRD file
write.crd(new, file="4charmm.crd")

## End(Not run)
```

---

write.fasta *Write FASTA Formated Sequences*

Description

Write aligned or un-aligned sequences to a FASTA format file.

Usage

```
write.fasta(alignment=NULL, ids=NULL, seqs=alignment$ali, gap=TRUE, file, append = FALSE)
```

Arguments

alignment	an alignment list object with id and ali components, similar to that generated by read.fasta.
ids	a vector of sequence names to serve as sequence identifers
seqs	an sequence or alignment character matrix or vector with a row per sequence
gap	logical, if FALSE gaps will be removed.
file	name of output file.
append	logical, if TRUE output will be appended to file; otherwise, it will overwrite the contents of file.

Value

Called for its effect.

Note

For a description of FASTA format see: https://www.ncbi.nlm.nih.gov/BLAST/blastcgihelp.shtml.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, read.fasta.pdb

Examples

```
# PDB server connection required - testing excluded
try({

## Read a PDB file
pdb <- read.pdb("1bg2")

## Extract sequence from PDB file
s <- aa321(pdb$seqres)                    # SEQRES
a <- aa321(pdb$atom[pdb$calpha,"resid"]) # ATOM

## Write simple fasta file
#write.fasta( seqs=seqbind(s,a), file="eg.fa")
```

```
#write.fasta( ids=c("seqres","atom"), seqs=seqbind(s,a), file="eg.fa" )

outfile1 = file.path(tempdir(), "eg.fa")
write.fasta(list( id=c("seqres"),ali=s ), file = outfile1)
write.fasta(list( id=c("atom"),ali=a ), file = outfile1, append=TRUE)

## Align seqres and atom records
#seqaln(seqbind(s,a))

## Read alignment
aln<-read.fasta(system.file("examples/kif1a.fa",package="bio3d"))

## Cut all but positions 130 to 245
aln$ali=aln$ali[,130:245]

outfile2 = file.path(tempdir(), "eg2.fa")
write.fasta(aln, file = outfile2)

invisible( cat("\nSee the output files:", outfile1, outfile2, sep="\n") )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

`write.mol2` *Write MOL2 Format Coordinate File*

Description

Write a Sybyl MOL2 file

Usage

```
write.mol2(mol, file = "R.mol2",  append = FALSE)
```

Arguments

`mol`	a MOL2 structure object obtained from `read.mol2`.
`file`	the output file name.
`append`	logical, if TRUE output is appended to the bottom of an existing file (used primarly for writing multi-model files).

Details

See examples for further details.

Value

Called for its effect.

Author(s)

Lars Skjaerven

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

Examples

```
# Read MOL2 file
mol <- read.mol2( system.file("examples/aspirin.mol2", package="bio3d") )

# Trim away H-atoms
mol <- trim(mol, "noh")

# Write new MOL2 file
#write.mol2(mol)
```

`write.ncdf` *Write AMBER Binary netCDF files*

Description

Write coordinate data to a binary netCDF trajectory file.

Usage

```
write.ncdf(x, trjfile = "R.ncdf", cell = NULL)
```

Arguments

`x`	A numeric matrix of xyz coordinates with a frame/structure per row and a Cartesian coordinate per column.
`trjfile`	name of the output trajectory file.
`cell`	A numeric matrix of cell information with a frame/structure per row and a cell length or angle per column. If NULL cell will not be written.

Details

Writes an AMBER netCDF (Network Common Data Form) format trajectory file with the help of David W. Pierce's (UCSD) ncdf4 package available from CRAN.

Value

Called for its effect.

Note

See AMBER documentation for netCDF format description.

NetCDF binary trajectory files are supported by the AMBER modules sander, pmemd and ptraj. Compared to formatted trajectory files, the binary trajectory files are smaller, higher precision and significantly faster to read and write.

NetCDF provides for file portability across architectures, allows for backwards compatible extensibility of the format and enables the files to be self-describing. Support for this format is available in VMD.

Author(s)

Barry Grant

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696. https://www.unidata.ucar.edu/software/netcdf/ https://cirrus.ucsd.edu/~pierce/ncdf/ https://ambermd.org/FileFormats.php#netcdf

See Also

read.dcd, read.ncdf, read.pdb, write.pdb, atom.select

Examples

```
## Not run:
##-- Read example trajectory file
trtfile <- system.file("examples/hivp.dcd", package="bio3d")
trj <- read.dcd(trtfile)

## Write to netCDF format
write.ncdf(trj, "newtrj.nc")

## Read trj
trj <- read.ncdf("newtrj.nc")

## End(Not run)
```

write.pdb *Write PDB Format Coordinate File*

Description

Write a Protein Data Bank (PDB) file for a given 'xyz' Cartesian coordinate vector or matrix.

Usage

```
write.pdb(pdb = NULL, file = "R.pdb", xyz = pdb$xyz, type = NULL, resno = NULL,
 resid = NULL, eleno = NULL, elety = NULL, chain = NULL, insert = NULL,
 alt = NULL, o = NULL, b = NULL, segid = NULL, elesy = NULL, charge = NULL,
 append = FALSE, verbose = FALSE, chainter = FALSE, end = TRUE, sse = FALSE,
 print.segid = FALSE)
```

Arguments

pdb	a PDB structure object obtained from read.pdb.
file	the output file name.
xyz	Cartesian coordinates as a vector or 3xN matrix.
type	vector of record types, i.e. "ATOM" or "HETATM", with length equal to length(xyz)/3.
resno	vector of residue numbers of length equal to length(xyz)/3.
resid	vector of residue types/ids of length equal to length(xyz)/3.
eleno	vector of element/atom numbers of length equal to length(xyz)/3.
elety	vector of element/atom types of length equal to length(xyz)/3.
chain	vector of chain identifiers with length equal to length(xyz)/3.
insert	vector of insertion code with length equal to length(xyz)/3.
alt	vector of alternate record with length equal to length(xyz)/3.
o	vector of occupancy values of length equal to length(xyz)/3.
b	vector of B-factors of length equal to length(xyz)/3.
segid	vector of segment id of length equal to length(xyz)/3.
elesy	vector of element symbol of length equal to length(xyz)/3.
charge	vector of atomic charge of length equal to length(xyz)/3.
append	logical, if TRUE output is appended to the bottom of an existing file (used primarly for writing multi-model files).
verbose	logical, if TRUE progress details are printed.
chainter	logical, if TRUE a TER line is inserted at termination of a chain.
end	logical, if TRUE END line is written.
sse	logical, if TRUE secondary structure annotations are written.
print.segid	logical, if FALSE segid will not be written.

Details

Only the xyz argument is strictly required. Other arguments assume a default poly-ALA C-alpha structure with a blank chain id, occupancy values of 1.00 and B-factors equal to 0.00.

If the input argument xyz is a matrix then each row is assumed to be a different structure/frame to be written to a "multimodel" PDB file, with frames separated by "END" records.

Value

Called for its effect.

Note

Check that: (1) chain is one character long e.g. "A", and (2) resno and eleno do not exceed "9999".

Author(s)

Barry Grant with contributions from Joao Martins.

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

read.pdb, read.dcd, read.fasta.pdb, read.fasta

Examples

```
# PDB server connection required - testing excluded
try({

# Read a PDB file
pdb <- read.pdb( "1bg2" )

# Renumber residues
nums <- as.numeric(pdb$atom[,"resno"])
nums <- nums - (nums[1] - 1)

# Write out renumbered PDB file
outfile = file.path(tempdir(), "eg.pdb")
write.pdb(pdb=pdb, resno = nums, file = outfile)

invisible( cat("\nSee the output file:", outfile, sep = "\n") )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
```

```
}
```

`write.pir` *Write PIR Formated Sequences*

Description

Write aligned or un-aligned sequences to a PIR format file.

Usage

```
write.pir(alignment=NULL, ids=NULL, seqs=alignment$ali,
   pdb.file = NULL, chain.first = NULL, resno.first = NULL,
   chain.last = NULL, resno.last = NULL, file, append = FALSE)
```

Arguments

`alignment`	an alignment list object with `id` and `ali` components, similar to that generated by `read.fasta`.
`ids`	a vector of sequence names to serve as sequence identifers
`seqs`	an sequence or alignment character matrix or vector with a row per sequence
`pdb.file`	a vector of pdb filenames; For sequence, provide "".
`chain.first`	a vector of chain id for the first residue.
`resno.first`	a vector of residue number for the first residue.
`chain.last`	a vector of chain id for the last residue.
`resno.last`	a vector of residue number for the last residue.
`file`	name of output file.
`append`	logical, if TRUE output will be appended to `file`; otherwise, it will overwrite the contents of `file`.

Value

Called for its effect.

Note

PIR is required format for input alignment file to use Modeller. For a description of PIR format see: https://salilab.org/modeller/manual/node501.html.

Author(s)

Xin-Qiu Yao

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

See Also

read.fasta, read.fasta.pdb, write.fasta

Examples

```
# Needs MUSCLE installed - testing excluded

if(check.utility("muscle")) {

try({

## Generate an input file for structural modeling of
## transducin G-alpha subunit using the template 3SN6_A

## Read transducin alpha subunit sequence
seq <- get.seq("P04695", outfile = tempfile())

## Read structure template
path = tempdir()
pdb.file <- get.pdb("3sn6_A", path = path, split = TRUE)
pdb <- read.pdb(pdb.file)

## Build an alignment between template and target
aln <- seqaln(seqbind(pdbseq(pdb), seq), id = c("3sn6_A", seq$id), outfile = tempfile())

## Write PIR format alignment file
outfile = file.path(tempdir(), "eg.pir")
write.pir(aln, pdb.file = c(pdb.file, ""), file = outfile)

invisible( cat("\nSee the output file:", outfile, sep = "\n") )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
}
```

---

write.pqr *Write PQR Format Coordinate File*

Description

Write a PQR file for a given 'xyz' Cartesian coordinate vector or matrix.

Usage

```
write.pqr(pdb = NULL, xyz = pdb$xyz, resno = NULL, resid = NULL, eleno =
NULL, elety = NULL, chain = NULL, o = NULL, b = NULL,
append = FALSE, verbose = FALSE, chainter = FALSE, file = "R.pdb")
```

Arguments

pdb	a PDB structure object obtained from read.pdb or read.pqr.
xyz	Cartesian coordinates as a vector or 3xN matrix.
resno	vector of residue numbers of length equal to length(xyz)/3.
resid	vector of residue types/ids of length equal to length(xyz)/3.
eleno	vector of element/atom numbers of length equal to length(xyz)/3.
elety	vector of element/atom types of length equal to length(xyz)/3.
chain	vector of chain identifiers with length equal to length(xyz)/3.
o	atomic partial charge values of length equal to length(xyz)/3.
b	atomic radii values of length equal to length(xyz)/3.
append	logical, if TRUE output is appended to the bottom of an existing file (used primarly for writing multi-model files).
verbose	logical, if TRUE progress details are printed.
chainter	logical, if TRUE a TER line is inserted between chains.
file	the output file name.

Details

PQR file format is basically the same as PDB format except for the fields of o and b. In PDB, these two fields are filled with 'Occupancy' and 'B-factor' values, respectively, with each field 6-column long. In PQR, they are atomic 'partial charge' and 'radii' values, respectively, with each field 8-column long.

Only the xyz argument is strictly required. Other arguments assume a default poly-ALA C-alpha structure with a blank chain id, atomic charge values of 0.00 and atomic radii equal to 1.00.

If the input argument xyz is a matrix then each row is assumed to be a different structure/frame to be written to a "multimodel" PDB file, with frames separated by "END" records.

Value

Called for its effect.

Note

Check that: (1) chain is one character long e.g. "A", and (2) resno and eleno do not exceed "9999".

Author(s)

Barry Grant with contributions from Joao Martins.

References

Grant, B.J. et al. (2006) *Bioinformatics* **22**, 2695–2696.

For a description of PDB format (version3.3) see:
http://www.wwpdb.org/documentation/format33/v3.3.html.

See Also

read.pqr, read.pdb, write.pdb, read.dcd, read.fasta.pdb, read.fasta

Examples

```
# PDB server connection required - testing excluded
try({

# Read a PDB file
pdb <- read.pdb( "1bg2" )

# Write out in PQR format
outfile = file.path(tempdir(), "eg.pqr")
write.pqr(pdb=pdb, file = outfile)

invisible( cat("\nSee the output file:", outfile, sep = "\n") )

}, silent=TRUE)
if(inherits(.Last.value, "try-error")) {
   message("Need internet to run the example")
}
```

Index

∗ **IO**
aln2html, 20
as.pdb, 24
get.seq, 125
read.all, 233
read.cif, 235
read.crd, 236
read.crd.amber, 238
read.crd.charmm, 239
read.dcd, 240
read.fasta, 242
read.fasta.pdb, 244
read.mol2, 246
read.ncdf, 249
read.pdb, 251
read.pdcBD, 254
read.pqr, 256
read.prmtop, 258
write.crd, 302
write.fasta, 303
write.mol2, 305
write.ncdf, 306
write.pdb, 308
write.pir, 310
write.pqr, 311
∗ **analysis**
cna, 55
community.aln, 65
community.tree, 67
dccm.enma, 82
dccm.gnm, 84
dccm.nma, 85
dccm.pca, 87
deformation.nma, 91
filter.cmap, 107
filter.dccm, 108
fluct.nma, 116
geostas, 119
inspect.connectivity, 136
nma, 155
nma.pdb, 156
nma.pdbs, 160
∗ **classes**
is.mol2, 139
is.pdb, 140
is.select, 141
is.xyz, 142
∗ **datasets**
aa.index, 8
aa.table, 9
atom.index, 28
elements, 102
example.data, 105
sdENM, 268
∗ **documentation**
bio3d-package, 6
∗ **hplot**
blast.pdb, 42
hclustplot, 129
plot.bio3d, 193
plot.cmap, 196
plot.cna, 198
plot.core, 200
plot.dccm, 202
plot.dmat, 205
plot.enma, 207
plot.fasta, 209
plot.fluct, 210
plot.geostas, 212
plot.hmmer, 214
plot.nma, 216
plot.pca, 218
plot.pca.loadings, 220
plot.rmsip, 221
∗ **manip**
orient.pdb, 164
rle2, 262
∗ **multivariate**

pca.pdbs, 170
pca.tor, 172
pca.xyz, 173
∗ **runs**
rle2, 262
∗ **utilities**
aa123, 10
aa2index, 11
aa2mass, 13
angle.xyz, 21
as.fasta, 22
as.select, 27
atom.select, 28
atom2ele, 32
atom2mass, 33
atom2xyz, 35
basename.pdb, 36
bhattacharyya, 37
binding.site, 38
blast.pdb, 42
bounds, 45
bwr.colors, 47
cat.pdb, 49
chain.pdb, 50
check.utility, 51
cmap, 53
cnapath, 59
com, 62
combine.select, 64
consensus, 69
conserv, 71
convert.pdb, 72
core.cmap, 74
core.find, 76
cov.nma, 79
covsoverlap, 80
dccm, 81
dccm.xyz, 88
diag.ind, 92
difference.vector, 93
dist.xyz, 94
dm, 96
dssp, 98
entropy, 103
filter.identity, 110
filter.rmsd, 112
fit.xyz, 113
formula2mass, 117
gap.inspect, 118
get.pdb, 124
get.seq, 125
hmmer, 131
inner.prod, 135
is.gap, 138
lbio3d, 144
load.enmff, 144
mask, 146
mktrj, 148
motif.find, 150
mustang, 151
normalize.vector, 163
overlap, 165
pairwise, 167
pca, 168
pca.array, 169
pca.pdbs, 170
pca.tor, 172
pca.xyz, 173
pdb.annotate, 176
pdb2aln, 177
pdb2aln.ind, 179
pdbaln, 182
pdbfit, 184
pdbs2pdb, 185
pdbs2sse, 187
pdbseq, 188
pdbsplit, 189
pfam, 191
print.cna, 222
print.core, 224
print.fasta, 225
print.xyz, 226
project.pca, 227
rgyr, 260
rmsd, 263
rmsf, 265
rmsip, 266
seq2aln, 269
seqaln, 270
seqaln.pair, 274
seqbind, 275
seqidentity, 276
setup.ncore, 278
sip, 278
sse.bridges, 280
store.atom, 281

struct.aln, 282
torsion.pdb, 284
torsion.xyz, 286
trim, 288
trim.mol2, 290
trim.pdbs, 291
trim.xyz, 293
unbound, 294
uniprot, 295
var.xyz, 296
vec2resno, 297
wrap.tor, 301
∗ **utility**
identify.cna, 134
layout.cna, 142
network.amendment, 153
prune.cna, 228
vmd, 298
vmd_colors, 300
.print.fasta.ali *(*print.fasta*)*, 225

aa.index, 8, *10*, *12*, *14*
aa.table, 9
aa123, *6*, 10
aa2index, 11
aa2mass, *10*, 13, *15*, *157*, *161*, *173*
aa321, *6*, *189*
aa321 *(*aa123*)*, 10
aanma, 14, *18, 19*, *145*
aanma.pdbs, 17, *17*
aln2html, *6*, 20, *210*
amsm.xyz, *120*
amsm.xyz *(*geostas*)*, 119
angle.xyz, 21
annotation *(*example.data*)*, 105
as.fasta, 22
as.pdb, 24, *236*, *238*, *253*, *260*
as.pdb.mol2, *247*, *291*
as.select, 27, *31*, *64*
as.xyz, *24*, *293*
as.xyz *(*is.xyz*)*, 142
atom.index, *10*, *14*, 28, *28*, *32–34*
atom.select, *6*, *15*, *24*, *26, 27*, 28, *30*, *32*, *34*, *36*, *39*, *49*, *51*, *54*, *64*, *74*, *97*, *121*, *125*, *127*, *141*, *147*, *157*, *165*, *188–190*, *236–238*, *240, 241*, *250*, *253*, *255*, *258*, *260*, *288–290*, *298*, *303*, *307*
atom.select.mol2, *247*, *291*
atom2ele, *28*, 32, *34*, *118*
atom2mass, *14*, 33, *33*, *63*, *118*
atom2xyz, 35

basename, *37*
basename.pdb, 36
bhattacharyya, *19*, 37, *81*, *162*, *267*, *279*
binding.site, 38
bio3d *(*bio3d-package*)*, 6
bio3d-package, 6
biounit, *6*, 40, *252, 253*
blast.pdb, *6*, 42, *43*, *126*, *133*, *214*, *272*, *296*
bounds, 45, *294, 295*
bounds.sse, 46, *182*
build.hessian, *6*, *15*, *146*, *157*
build.hessian *(*nma.pdb*)*, 156
bwr.colors, 47, *301*

cat.pdb, 49, *236*, *253*
chain.pdb, 50
check.utility, 51
clean.pdb, 52
cm.colors, *48*
cmap, 53, *107*, *109*, *198*
cna, *6*, 55, *59, 60*, *66*, *68*, *109*, *154*, *223*, *229*
cna.dccm, *60*
cnapath, *6*, 59
col2rgb, *48*
colorRamp, *299*
colors, *48*
com, 62
combine.select, *30, 31*, 64
community.aln, 65
community.tree, 67, *154*
consensus, *6*, 69, *104*, *111*, *277*
conserv, *6*, 71
contour, *204*, *206*
convert.pdb, 72
cor, *90*
core *(*example.data*)*, 105
core.cmap, 74
core.find, *6*, *75*, 76, *106*, *183*, *201, 202*, *224*, *234*, *245*
cov.enma, *19*, *162*
cov.enma *(*cov.nma*)*, 79
cov.nma, 79
covsoverlap, *19*, *38*, 80, *81*, *162*, *267*, *279*
cutree, *130*

dccm, *6*, *54*, 81, *87*, *90*, *109*, *121, 122*, *147*, *231*
dccm.egnm *(*dccm.gnm*)*, 84
dccm.enma, *19*, 82, *82*, *85*, *87*, *90*, *162*
dccm.gnm, 84
dccm.nma, *6*, *17*, *82, 83*, 85, *85*, *87*, *90*, *109*, *159*
dccm.pca, *82*, 87, *90*
dccm.xyz, *82*, *87*, 88, *109*
deformation.nma, *6*, 91
diag, *93*
diag.ind, 92
difference.vector, 93, *166*
dirname, *37*
dist, *54*, *95*
dist.xyz, *54*, 94
dm, *39*, *54*, *95*, 96, *137*, *198*, *205, 206*
dssp, 98, *100*, *182*, *188*, *194, 195*, *197, 198*, *203, 204*, *215*, *280*, *285*
dssp.pdb, *99*

edge.betweenness.community, *57*
eigen, *159*
elements, *10*, *28*, *33, 34*, 102
entropy, *6*, *71*, 103, *111*, *210*, *277*
example.data, 105

fastgreedy.community, *57*
ff.aaenm *(*load.enmff*)*, 144
ff.aaenm2 *(*load.enmff*)*, 144
ff.anm *(*load.enmff*)*, 144
ff.calpha *(*load.enmff*)*, 144
ff.pfanm *(*load.enmff*)*, 144
ff.reach *(*load.enmff*)*, 144
ff.sdenm *(*load.enmff*)*, 144
filled.contour, *204*, *206*
filter.cmap, 107
filter.dccm, 108
filter.identity, 110, *277*
filter.rmsd, 112
fit.xyz, *6*, *54*, *75, 76*, *78*, *89*, *95*, 113, *142*, *165*, *173*, *182–185*, *227, 228*, *234*, *244, 245*, *261*, *263–265*, *277*
fluct.nma, *6*, *17*, 116, *159*
formula2mass, *33*, 117

gap.inspect, *6*, 118, *137, 138*, *292*
geostas, *6*, 119, *121*, *213*
get.blast *(*blast.pdb*)*, 42
get.pdb, *6*, *45*, 124, *126*, *190*
get.seq, *6*, *23*, 125, *133*, *192*, *272*, *296*
get.shortest.paths, *60*
gnm, *84, 85*, 127
gnm.pdbs, *129*
graph.adjacency, *57*
gray, *48*

hclust, *6*, *112*, *120, 121*, *130*, *209*
hclustplot, 129
hivp *(*example.data*)*, 105
hmmer, *6*, *45*, 131, *192*, *214*
hsv, *48*

identify, *134*
identify.cna, 134
igraph.plotting, *134*, *143*, *200*, *223*
image, *204*, *206*, *222*
infomap.community, *57*
inner.prod, 135, *163*
inspect.connectivity, 136
is.gap, *6*, 138
is.mol2, 139
is.pdb, 140
is.pdbs *(*is.pdb*)*, 140
is.select, 141
is.xyz, 142, *227*

kinesin *(*example.data*)*, 105
kmeans, *120, 121*

layout.cna, 142
lbio3d, 144
load.enmff, *15*, *17*, 144, *158, 159*
lower.tri, *93*

mask, 146
matrix, *93*
mktrj, *120*, *122*, 148
mktrj.enma, *19*, *162*
mktrj.nma, *6*, *17*, *159*
mktrj.pca, *6*, *174*
mono.colors *(*bwr.colors*)*, 47
motif.find, 150
mustang, *6*, 151

network.amendment, *68*, 153
nma, *6*, *19*, *80*, *83*, *86*, *91, 92*, *116, 117*, *120*, *122*, *136*, *146*, *149*, 155, *155*, *163*, *166*, *171*, *208*, *217*, *222*, *267*
nma.pdb, *17*, *149*, *155*, 156, *157, 158*, *162*, *174*

nma.pdbs, *6*, *19*, *120*, *149*, *155*, 160, *161*, *208*, *211*, *212*, *297*
normalize.vector, *136*, 163

orient.pdb, *6*, 164
overlap, *6*, *94*, *159*, 165, *222*, *267*

pairwise, *6*, 167
palette, *48*
pca, *149*, *155*, 168, *171*, *174*, *267*
pca.array, 169, *215*, *216*
pca.pdbs, *6*, *169*, 170, *174*
pca.tor, *6*, *169*, 172, *174*, *228*, *287*
pca.xyz, *6*, *87*, *149*, *166*, *169–172*, 173, *174*, *218–220*, *228*
pdb.annotate, *106*, 176
pdb.pfam *(*pdb.annotate*)*, 176
pdb2aln, 177, *179*, *180*
pdb2aln.ind, *178*, 179, *179*
pdb2sse, *46*, *47*, 181
pdbaln, *6*, *23*, *29*, *54*, *75*, *76*, *96*, *99*, *106*, *120*, *138*, *140*, *149*, *153*, *155*, *160–162*, *169*, *171*, *179*, 182, *184–186*, *188*, *225*, *226*, *230*, *272*, *283*, *292*
pdbfit, *6*, *106*, 184
pdbs *(*example.data*)*, 105
pdbs2pdb, 185
pdbs2sse, 187
pdbseq, *6*, *11*, *151*, *183*, 188, *251*, *259*
pdbsplit, *124*, *125*, 189
pfam, *133*, 191
plot.bio3d, *6*, *101*, 193, *198*, *204*, *212*, *217*, *219*
plot.blast, *6*, *45*, *133*, *214*
plot.blast *(*blast.pdb*)*, 42
plot.cmap, *107*, 196
plot.cna, *6*, *57*, *66*, *134*, *143*, 198, *229*
plot.cnapath *(*cnapath*)*, 59
plot.communities, *134*, *143*, *200*
plot.core, *6*, *78*, 200, *224*
plot.dccm, *6*, *82*, *83*, *85–87*, *109*, 202, *213*, *215*, *216*
plot.default, *195*, *198*, *204*
plot.dendrogram, *130*
plot.dmat, *97*, *198*, *204*, 205
plot.ecna *(*plot.cna*)*, 198
plot.ecnapath *(*cnapath*)*, 59
plot.enma, *19*, *162*, 207
plot.fasta, *153*, 209, *272*
plot.fluct, *208*, 210
plot.geostas, *122*, 212
plot.hclust, *130*
plot.hmmer, 214
plot.igraph, *134*, *143*, *200*
plot.matrix.loadings, 215
plot.nma, *6*, 216
plot.pca, *6*, *172*, *174*, 218, *220*
plot.pca.loadings, *6*, *172*, 220
plot.rmsip, 221
plotb3, *208*
plotb3 *(*plot.bio3d*)*, 193
points, *217*
polygon, *212*
print, *157*, *161*
print.cna, 222
print.cnapath *(*cnapath*)*, 59
print.core, *202*, 224
print.default, *262*
print.enma *(*nma.pdbs*)*, 160
print.fasta, 225
print.geostas *(*geostas*)*, 119
print.igraph, *223*
print.mol2 *(*read.mol2*)*, 246
print.nma *(*nma.pdb*)*, 156
print.pca *(*pca.xyz*)*, 173
print.pdb *(*read.pdb*)*, 251
print.prmtop *(*read.prmtop*)*, 258
print.rle2 *(*rle2*)*, 262
print.select *(*atom.select*)*, 28
print.sse *(*dssp*)*, 98
print.xyz, 226
project.pca, *174*, 227
prune.cna, 228
pymol, 230
pymol.dccm, *6*, *82*
pymol.modes, *6*, *149*
pymol.pdbs, *183*, *245*

rbind, *275*, *276*
read.all, *18*, *19*, *54*, *96*, *183*, 233, *245*
read.cif, 235
read.crd, *26*, *31*, *99*, *101*, 236, *260*, *302*, *303*
read.crd.amber, *24*, *237*, 238
read.crd.charmm, *237*, *238*, 239
read.dcd, *6*, *22*, *31*, *74*, *77*, *99*, *101*, *113*, *115*, *120*, *122*, *142*, *227*, *236*, *237*, 240, *240*, *250*, *252–255*, *257*, *258*, *265*, *287*, *303*, *307*, *309*, *313*

read.fasta, *6*, *11, 12*, *20, 21*, *69–72*, *74*, *103, 104*, *110, 111*, *118, 119*, *125, 126*, *138*, *151*, *153*, *178, 179*, *183*, *189*, *192*, *210*, *225, 226*, *233, 234*, *240*, 242, *244, 245*, *253*, *255*, *258*, *269–272*, *274–277*, *292*, *303, 304*, *309–311*, *313*
read.fasta.pdb, *6*, *29*, *54*, *72*, *74–76*, *78*, *96*, *99*, *112–115*, *118–120*, *125, 126*, *138*, *140*, *149*, *153*, *155*, *160–162*, *178, 179*, *183–186*, *188*, *225, 226*, *230*, *240*, *243*, 244, *253*, *255*, *258*, *261*, *264, 265*, *270*, *272*, *275*, *281*, *292*, *303, 304*, *309*, *311*, *313*
read.mol2, *24*, *30*, *139*, 246, *290, 291*, *305*
read.ncdf, *6*, *26*, *31*, *77*, *99*, *101*, *120*, *122*, *142*, *227*, *236–238*, 249, *252, 253*, *260*, *293*, *307*
read.pdb, *6*, *11*, *15*, *22*, *24*, *26, 27*, *29*, *31*, *33, 34*, *36*, *39*, *41*, *46*, *49–52*, *54*, *59*, *63, 64*, *73*, *77*, *96, 97*, *99*, *101*, *113–115*, *120*, *122*, *125*, *127*, *140*, *142*, *147*, *149*, *155*, *157*, *164, 165*, *181*, *183*, *185, 186*, *188–190*, *194*, *197*, *203*, *215*, *227*, *233, 234*, *236–241*, *244, 245*, *247*, *250*, 251, *251*, *258*, *260, 261*, *264*, *276*, *280*, *285*, *287–289*, *293*, *297, 298*, *302, 303*, *307–309*, *312, 313*
read.pdb2 *(*read.pdb*)*, 251
read.pdcBD, 254
read.pqr, 256, *312, 313*
read.prmtop, *24*, *30, 31*, *101*, *236–238*, *253*, 258, *259*
regexpr, *151*
rgb, *48*
rgyr, 260
rle2, 262
rmsd, *6*, *112, 113*, *115*, *185*, *261*, 263, *283*
rmsf, *6*, *211, 212*, 265
rmsip, *6*, *19*, *38*, *159*, *162*, *166*, *222*, 266, *279*
rot.lsq, *6*, *165*, *264*, *283*
rot.lsq *(*fit.xyz*)*, 113
rtb *(*aanma*)*, 14

sdENM, 268
seq2aln, *178–180*, 269
seqaln, *6*, *21*, *23*, *45*, *110, 111*, *133*, *138*, *153*, *178, 179*, *183*, *209, 210*, *225, 226*, *269*, 270, *270*, *274–276*, *283*
seqaln.pair, *179, 180*, 274
seqbind, *23*, *270–272*, *274*, 275, *275*
seqidentity, *6*, *110, 111*, *168*, 276
setup.ncore, 278
sip, *19*, *38*, *81*, *162*, *267*, 278
sse.bridges, 280
store.atom, 281
str.igraph, *223*
stride, *99*, *182*, *194, 195*, *197, 198*, *203, 204*, *215*, *285*
stride *(*dssp*)*, 98
struct.aln, 282
summary.cna, *57*, *68*, *154*, *229*
summary.cna *(*print.cna*)*, 222
summary.cnapath *(*cnapath*)*, 59
summary.pdb, *6*
summary.pdb *(*read.pdb*)*, 251

t.test, *212*
torsion.pdb, *6*, *22*, *101*, 284, *287*
torsion.xyz, *6*, *22*, *101*, *172*, *285*, 286, *302*
transducin *(*example.data*)*, 105
trim, 288
trim.mol2, *247*, 290
trim.pdb, *31, 32*, *34*, *49*, *51*, *64*, *236*, *253*, *292*
trim.pdbs, *289*, 291
trim.xyz, *289*, 293

unbound, 294
uniprot, *133*, *192*, 295
upper.tri, *93*

var.pdbs *(*var.xyz*)*, 296
var.xyz, *161*, 296
vec2resno, 297
vmd, 298
vmd.cna, *57*, *60*, *66*, *229*
vmd.cnapath, *60*
vmd_colors, *48*, 300

walktrap.community, *57*
wrap.tor, *287*, 301
write.crd, *237*, *240*, 302
write.fasta, *6*, *21*, *276*, 303, *311*
write.mol2, *247*, *291*, 305
write.ncdf, *6*, *250*, 306
write.pdb, *6*, *31*, *49*, *51*, *74*, *125*, *149*, *165*, *190*, *236, 237*, *240, 241*, *250*, *253*, *255*, *258*, *298*, *303*, *307*, 308, *313*

write.pir, 310
write.pqr, *258*, 311

xyz2atom *(*atom2xyz*)*, 35
xyz2z.pca *(*project.pca*)*, 227

z2xyz.pca *(*project.pca*)*, 227