

Package: GeneralizedUmatrixGPU (via r-universe)

May 28, 2026

Type Package

Title Credible Visualization for Two-Dimensional Projections of Data

Version 0.1.14

Date 2026-01-26

Maintainer Quirin Stier <Quirin_Stier@gmx.de>

Description Projections are common dimensionality reduction methods, which represent high-dimensional data in a two-dimensional space. However, when restricting the output space to two dimensions, which results in a two dimensional scatter plot (projection) of the data, low dimensional similarities do not represent high dimensional distances coercively [Thrun, 2018] <DOI:10.1007/978-3-658-20540-9>. This could lead to a misleading interpretation of the underlying structures [Thrun, 2018]. By means of the 3D topographic map the generalized Umatrix is able to depict errors of these two-dimensional scatter plots. The package is derived from the book of Thrun, M.C.: ``Projection Based Clustering through Self-Organization and Swarm Intelligence" (2018) <DOI:10.1007/978-3-658-20540-9> and the main algorithm called simplified self-organizing map for dimensionality reduction methods is published in Thrun, M.C. and Ultsch, A.: ``Uncovering High-dimensional Structures of Projections from Dimensionality Reduction Methods" (2020) <DOI:10.1016/j.mex.2020.101093>.

License GPL-3

Imports Rcpp (>= 1.0.8), RcppParallel (>= 5.1.4), ggplot2, GeneralizedUmatrix

Suggests DataVisualizations, rgl, grid, mgcv, png, reshape2, fields, ABCanalysis, plotly, deldir, methods, knitr (>= 1.12), rmarkdown (>= 0.9)

LinkingTo Rcpp, RcppArmadillo, RcppParallel

Depends R (>= 3.0)

NeedsCompilation yes

SystemRequirements C++17, GNU make, pandoc (>=1.12.3, needed for vignettes), OpenCL shared library (provided by an SDK such as AMD/NVIDIA)

LazyLoad yes

LazyData TRUE

Encoding UTF-8

Author Quirin Stier [aut, cre] (ORCID: <<https://orcid.org/0000-0002-7896-4737>>), Michael Thrun [aut, cph] (ORCID: <<https://orcid.org/0000-0001-9542-5543>>), The Khronos Group Inc. [cph]

Config/pak/sysreqs make ocl-icd-openssl-dev

Repository <https://cran.r-universe.dev>

Date/Publication 2026-01-27 15:30:02 UTC

RemoteUrl <https://github.com/cran/GeneralizedUmatrixGPU>

RemoteRef HEAD

RemoteSha 21e72a53305683f4b72fd54bc8b501bc8bd3b08c

Contents

| | |
|---|---|
| GeneralizedUmatrixGPU-package | 2 |
| Chainlink | 4 |
| DefaultColorSequence | 5 |
| GeneralizedUmatrixGPU | 5 |

| | |
|--------------|----------|
| Index | 8 |
|--------------|----------|

GeneralizedUmatrixGPU-package

Credible Visualization for Two-Dimensional Projections of Data

Description

Projections are common dimensionality reduction methods, which represent high-dimensional data in a two-dimensional space. However, when restricting the output space to two dimensions, which results in a two dimensional scatter plot (projection) of the data, low dimensional similarities do not represent high dimensional distances coercively [Thrun, 2018] <DOI: 10.1007/978-3-658-20540-9>. This could lead to a misleading interpretation of the underlying structures [Thrun, 2018]. By means of the 3D topographic map the generalized Umatrix is able to depict errors of these two-dimensional scatter plots. The package is derived from the book of Thrun, M.C.: "Projection Based Clustering through Self-Organization and Swarm Intelligence" (2018) <DOI:10.1007/978-3-658-20540-9> and the main algorithm called simplified self-organizing map for dimensionality reduction methods is published in Thrun, M.C. and Ultsch, A.: "Uncovering High-dimensional Structures of Projections from Dimensionality Reduction Methods" (2020) <DOI:10.1016/j.mex.2020.101093>.

Details

For a brief introduction to **GeneralizedUmatrixGPU** please see the vignette of the CRAN package [GeneralizedUmatrix](#).

For further details regarding the generalized Umatrix see [Thrun, 2018], chapter 4-5, or [Thrun/Ultsch, 2020].

If you want to verify your clustering result externally, you can use Heatmap or SilhouettePlot of the CRAN package DataVisualizations.

Index of help topics:

| | |
|-------------------------------|---|
| Chainlink | Chainlink is part of the Fundamental Clustering Problem Suit (FCPS) [Thrun/Ultsch, 2020]. |
| DefaultColorSequence | Default color sequence for plots |
| GeneralizedUmatrixGPU | Generalized U-Matrix on GPU for Projection Methods published in [Thrun/Ultsch, 2020] |
| GeneralizedUmatrixGPU-package | Credible Visualization for Two-Dimensional Projections of Data |

Author(s)

Quirin Stier

References

[Thrun/Ultsch, 2020] Thrun, M. C., & Ultsch, A.: Uncovering High-Dimensional Structures of Projections from Dimensionality Reduction Methods, *MethodsX*, Vol. 7, pp. 101093, DOI [doi:10.1016/j.mex.2020.101093](https://doi.org/10.1016/j.mex.2020.101093), 2020.

[Thrun, 2018] Thrun, M. C.: Projection Based Clustering through Self-Organization and Swarm Intelligence, doctoral dissertation 2017, Springer, Heidelberg, ISBN: 978-3-658-20539-3, [doi:10.1007/9783658205409](https://doi.org/10.1007/9783658205409), 2018.

[Ultsch/Thrun, 2017] Ultsch, A., & Thrun, M. C.: Credible Visualizations for Planar Projections, in Cottrell, M. (Ed.), 12th International Workshop on Self-Organizing Maps and Learning Vector Quantization, Clustering and Data Visualization (WSOM), IEEE Xplore, France, 2017.

Examples

```
data("Chainlink")
SampleIdx = sample(1:1000, 200)
Data=Chainlink$Data[SampleIdx,]
Cls=Chainlink$Cls[SampleIdx]
InputDistances=as.matrix(dist(Data))
res=cmdscales(d=InputDistances, k = 2, eig = TRUE, add = FALSE, x.ret = FALSE)
ProjectedPoints=as.matrix(res$points)
```

```
# see also R package 'ProjectionBasedClustering' for other common projection methods
# see DatabionicSwarm for projection method without parameters or objective function
# ProjectedPoints=DatabionicSwarm::Pswarm(Data)$ProjectedPoints
```

```
resUmatrix=GeneralizedUmatrixGPU(Data,ProjectedPoints)
#library(GeneralizedUmatrix)
#plotTopographicMap(resUmatrix$Umatrix,resUmatrix$Bestmatches,Cls)
```

| | |
|-----------|--|
| Chainlink | <i>Chainlink is part of the Fundamental Clustering Problem Suit (FCPS) [Thrun/Ultsch, 2020].</i> |
|-----------|--|

Description

linear not separable dataset of two intertwined chains.

Usage

```
data("Chainlink")
```

Details

Size 1000, Dimensions 3, stored in Chainlink\$Data

Two clusters, stored in Chainlink\$Cls

Published in [Ultsch et al.,1994] in German and [Ultsch 1995] in English.

References

[Thrun/Ultsch, 2020] Thrun, M. C., & Ultsch, A.: Clustering Benchmark Datasets Exploiting the Fundamental Clustering Problems, Data in Brief, Vol. 30(C), pp. 105501, DOI 10.1016/j.dib.2020.105501, 2020.

[Ultsch 1995] Ultsch, A.: Self organizing neural networks perform different from statistical k-means clustering, Proc. Society for Information and Classification (GFKL), Vol. 1995, Basel 8th-10th March, 1995.

[Ultsch et al.,1994] Ultsch, A., Guimaraes, G., Korus, D., & Li, H.: Knowledge extraction from artificial neural networks and applications, Parallele Datenverarbeitung mit dem Transputer, pp. 148-16Chainlink, Springer, 1994.

Examples

```
data(Chainlink)
str(Chainlink)

## Not run:
require(DataVisualizations)
DataVisualizations::Plot3D(Chainlink$Data,Chainlink$Cls)

## End(Not run)
```

DefaultColorSequence *Default color sequence for plots*

Description

Defines the default color sequence for plots made within the Projections package.

Usage

```
data("DefaultColorSequence")
```

Format

A vector with 562 different strings describing colors for plots.

GeneralizedUmatrixGPU *Generalized U-Matrix on GPU for Projection Methods published in [Thrun/Ultsch, 2020]*

Description

Generalized U-Matrix visualizes high-dimensional distance and density based structures in two-dimensional scatter plots of projection methods like CCA, MDS, PCA or NeRV [Ultsch/Thrun, 2017] with the help of a topographic map with hypsometric tints [Thrun et al. 2016] using a simplified emergent SOM published in [Thrun/Ultsch, 2020].

Usage

```
GeneralizedUmatrixGPU(Data, ProjectedPoints, PlotIt = FALSE, CIs = NULL,
Toroid = TRUE, Tiled = FALSE, DataPerEpoch = 1, Verbose = 0, ...)
```

Arguments

| | |
|-----------------|---|
| Data | [1:n,1:d] array of data: n cases in rows, d variables in columns. |
| ProjectedPoints | [1:n,2] matrix containing coordinates of the Projection: A matrix of the fitted configuration. |
| PlotIt | Optional, bool, default=FALSE, if =TRUE: U-Matrix of every current Position of Databots will be shown. |
| CIs | Optional, For plotting, see plotUmatrix in package Umatrix. |
| Toroid | Optional, Default=TRUE, ==FALSE planar computation with borders defined by projection method ==TRUE: toroid borderless (toroidal) computation, the four borders defined by projection method are ignored. |
| Tiled | Optional, For plotting see plotUmatrix in package Umatrix |

| | |
|--------------|---|
| DataPerEpoch | Optional, scalar, value above zero and below 1 starts sampling and defines percentage of data points sampled in each epoch during the learning phase. Beware: Experimental! |
| Verbose | Integer, determining text output during computation (Verbose > 0) or silent mode (Verbose=0). |
| ... | Further parameters. |

Details

Introduced first in the PhD thesis in [Thrun, 2018, p.46]. Furthermore the two parts of the work were peer-reviewed and published in [Ultsch/Thrun, 2017, Thrun/Ultsch, 2020].

Value

| | |
|-----------------|---|
| List with | |
| Umatrix | [1:Lines,1:Columns] Umatrix to be plotted, numerical matrix storing the U-heights, see [Thrun, 2018] for definition. |
| EsomNeurons | [1:Lines,1:Columns,1:weights] 3-dimensional numeric array (wide format), not wts (long format). |
| Bestmatches | [1:n,1:2] Positions of GridConverted Projected Points on the Umatrix to the pre-defined Grid by Lines and Columns, First Columns has the content of the Line No and second Column of the Column number. |
| sESOMparamaters | internals for debugging |
| Lines | Number of Lines |
| Columns | Number of Columns |
| gplotres | output of ggplot2 |

Note

With the update of 01.01.2024, version 1.3 a minor change is included that is not mentioned in the referenced papers: for large number of cases and small radii the learning rate decays to 0.1 instead of remaining constant (any other case).

Author(s)

Quirin Stier, Michael Thrun

References

[Thrun et al., 2016] Thrun, M. C., Lerch, F., Loetsch, J., & Ultsch, A.: Visualization and 3D Printing of Multivariate Data of Biomarkers, in Skala, V. (Ed.), International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision (WSCG), Vol. 24, Plzen, <http://wscg.zcu.cz/wscg2016/short/A43-full.pdf>, 2016.

[Thrun, 2018] Thrun, M. C.: Projection Based Clustering through Self-Organization and Swarm Intelligence, doctoral dissertation 2017, Springer, Heidelberg, ISBN: 978-3-658-20539-3, [doi:10.1007/9783658205409](https://doi.org/10.1007/9783658205409), 2018.

[Ultsch/Thrun, 2017] Ultsch, A., & Thrun, M. C.: Credible Visualizations for Planar Projections, in Cottrell, M. (Ed.), 12th International Workshop on Self-Organizing Maps and Learning Vector Quantization, Clustering and Data Visualization (WSOM), IEEE Xplore, France, 2017.

[Thrun/Ultsch, 2020] Thrun, M. C., & Ultsch, A.: Uncovering High-Dimensional Structures of Projections from Dimensionality Reduction Methods, *MethodsX*, Vol. 7, pp. 101093, DOI [doi:10.1016/j.mex.2020.101093](https://doi.org/10.1016/j.mex.2020.101093), 2020.

Examples

```
data("Chainlink")
SampleIdx = sample(1:1000, 200)
Data=Chainlink$Data[SampleIdx,]
Cls=Chainlink$Cls[SampleIdx]
InputDistances=as.matrix(dist(Data))
res=cmdscale(d=InputDistances, k = 2, eig = TRUE, add = FALSE, x.ret = FALSE)
ProjectedPoints=as.matrix(res$points)

resUmatrix=GeneralizedUmatrixGPU(Data,ProjectedPoints)
#library(GeneralizedUmatrix)
#plotTopographicMap(resUmatrix$Umatrix,resUmatrix$Bestmatches,Cls)
```

Index

- * **Chainlink**
 - Chainlink, 4
 - * **DR**
 - GeneralizedUmatrixGPU-package, 2
 - * **DimensionalityReduction**
 - GeneralizedUmatrixGPU-package, 2
 - * **FCPS**
 - Chainlink, 4
 - * **GPU**
 - GeneralizedUmatrixGPU-package, 2
 - * **Generalized U-matrix**
 - GeneralizedUmatrixGPU, 5
 - * **GeneralizedUmatrixGPU**
 - GeneralizedUmatrixGPU, 5
 - * **GeneralizedUmatrix**
 - GeneralizedUmatrixGPU, 5
 - GeneralizedUmatrixGPU-package, 2
 - * **Projection**
 - GeneralizedUmatrixGPU-package, 2
 - * **U-Matrix**
 - GeneralizedUmatrixGPU, 5
 - GeneralizedUmatrixGPU-package, 2
 - * **U-matrix**
 - GeneralizedUmatrixGPU-package, 2
 - * **Umatrix**
 - GeneralizedUmatrixGPU, 5
 - GeneralizedUmatrixGPU-package, 2
 - * **Visualization**
 - GeneralizedUmatrixGPU-package, 2
 - * **datasets**
 - Chainlink, 4
 - * **visualization**
 - GeneralizedUmatrixGPU, 5
- Chainlink, 4
- DefaultColorSequence, 5
- GeneralizedUmatrixGPU, 5
- GeneralizedUmatrixGPU-package, 2
- getUmatrix4Projection
(GeneralizedUmatrixGPU), 5