

Package: maxentcpp (via r-universe)

May 18, 2026

Type Package

Title Maximum Entropy Species Distribution Modeling ('C++' Implementation)

Version 1.0.0

Description 'C++' implementation of Maximum Entropy (Maxent) species distribution modeling with R bindings via 'Rcpp'. Provides a high-performance reimplementation of the Maxent algorithm for modeling species geographic distributions from occurrence data and environmental variables, following Phillips et al. (2006) <[doi:10.1016/j.ecolmodel.2005.03.026](https://doi.org/10.1016/j.ecolmodel.2005.03.026)>. Supports linear, quadratic, product, hinge, and threshold feature transformations, spatial projection in raw, logistic, and cloglog scales, and model diagnostics including Area Under the ROC Curve (AUC), variable importance, response curves, and Multivariate Environmental Similarity Surfaces (MESS) maps.

URL <https://github.com/alrobles/maxentcpp>,
<https://alrobles.github.io/maxentcpp/>

BugReports <https://github.com/alrobles/maxentcpp/issues>

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clamp_grids *Clamp Environmental Grids*

Description

Restricts environmental variable values to the training range. Returns clamped grids and a clamping indicator grid.

Usage

clamp_grids(grid_ptrs, var_mins, var_maxs)

Arguments

- grid_ptrs List of external pointers to Grid<float> objects.
- var_mins Numeric vector of minimum training values per variable.
- var_maxs Numeric vector of maximum training values per variable.

Value

A named list with:

- clamped_grids** List of external pointers to clamped Grid<float>
- clamp_grid** External pointer to Grid<float> with clamping magnitudes

compute_mess	<i>Compute MESS (Multivariate Environmental Similarity Surface)</i>
--------------	---

Description

Measures how similar each cell is to the training environment. Negative values indicate novel (non-analog) conditions.

Usage

```
compute_mess(grid_ptrs, reference_values, feature_names)
```

Arguments

grid_ptrs	List of external pointers to Grid<float> objects.
reference_values	List of numeric vectors with reference values for each variable (e.g. values at training sites).
feature_names	Character vector of variable names.

Value

A named list with:

mess_grid	External pointer to Grid<float> with MESS values
mod_grid	External pointer to Grid<float> with MoD variable index (1-based)

compute_mess_range	<i>Compute MESS from Min/Max Ranges</i>
--------------------	---

Description

Simplified MESS using only the min/max of reference data.

Usage

```
compute_mess_range(grid_ptrs, var_mins, var_maxs)
```

Arguments

grid_ptrs	List of external pointers to Grid<float> objects.
var_mins	Numeric vector of minimum reference values.
var_maxs	Numeric vector of maximum reference values.

Value

A named list with mess_grid and mod_grid (external pointers).

compute_percent_contribution
Compute Percent Contribution

Description

Computes variable contribution based on sum of absolute lambda values for features derived from each variable.

Usage

```
compute_percent_contribution(fs_ptr, feature_names)
```

Arguments

fs_ptr External pointer to a FeaturedSpace object.
feature_names Character vector of base variable names.

Value

A data.frame with columns: name, contribution.

compute_permutation_importance
Compute Permutation Importance

Description

Measures how much each environmental variable contributes to model prediction quality by permuting each variable and measuring AUC drop.

Usage

```
compute_permutation_importance(  
  fs_ptr,  
  grid_ptrs,  
  feature_names,  
  presence_rows,  
  presence_cols,  
  absence_rows,  
  absence_cols,  
  seed = 42L  
)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
grid_ptrs	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.
presence_rows	Integer vector of presence site row indices.
presence_cols	Integer vector of presence site column indices.
absence_rows	Integer vector of absence site row indices.
absence_cols	Integer vector of absence site column indices.
seed	Random seed for reproducibility.

Value

A data.frame with columns: name, permutation_importance.

compute_response_curve

Compute Java-compatible Marginal Response Curve

Description

Like compute_response_curve() but applies the Java Maxent cloglog: $\text{cloglog_java} = 1 - \exp(-\exp(H) * \text{raw_java})$

Usage

```
compute_response_curve(
  fs_ptr,
  grid_ptrs,
  feature_names,
  var_index,
  n_steps = 100L
)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
grid_ptrs	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.
var_index	0-based index of the variable to vary.
n_steps	Number of steps across the variable range.

Details

This matches the response curves produced by Java Maxent and dismo.

Value

A data.frame with columns: value, prediction.

```
compute_response_curve_fixed
```

Compute Java-compatible Response Curve with Fixed Values

Description

Like compute_response_curve_fixed() but applies the Java Maxent cloglog: $\text{cloglog_java} = 1 - \exp(-\exp(H) * \text{raw_java})$

Usage

```
compute_response_curve_fixed(
  fs_ptr,
  fixed_values,
  feature_names,
  var_index,
  var_min,
  var_max,
  n_steps = 100L
)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
fixed_values	Numeric vector of fixed values for each variable.
feature_names	Character vector of environment variable names.
var_index	0-based index of the variable to vary.
var_min	Minimum value of the target variable.
var_max	Maximum value of the target variable.
n_steps	Number of steps.

Value

A data.frame with columns: value, prediction.

`compute_variable_ranges`*Compute Variable Ranges from Grids*

Description

Scans all valid cells to determine min/max of each variable.

Usage

```
compute_variable_ranges(grid_ptrs)
```

Arguments

`grid_ptrs` List of external pointers to Grid<float> objects.

Value

A data.frame with columns: min, max.

`coords_to_rowcol`*Convert geographic coordinates to row/col*

Description

Convert geographic coordinates to row/col

Usage

```
coords_to_rowcol(dim_ptr, lon, lat)
```

Arguments

`dim_ptr` External pointer to GridDimension
`lon` Longitude
`lat` Latitude

Value

Integer vector with row and column indices

create_grid_dimension *Create a GridDimension object*

Description

Creates a grid dimension specifying the spatial extent and resolution

Usage

```
create_grid_dimension(nrows, ncols, xll, yll, cellsize)
```

Arguments

nrows	Number of rows
ncols	Number of columns
xll	X coordinate of lower-left corner
yll	Y coordinate of lower-left corner
cellsize	Cell size (assumed square cells)

Value

External pointer to GridDimension object

create_grid_float *Create a float Grid object*

Description

Creates a raster grid for environmental variables

Usage

```
create_grid_float(dim_ptr, name, nodata_value = -9999)
```

Arguments

dim_ptr	External pointer to GridDimension
name	Grid layer name
nodata_value	Value representing missing data

Value

External pointer to Grid<float> object

create_hinge_feature *Create a HingeFeature object*

Description

Creates a piecewise-linear hinge feature. Forward hinge: $\text{eval}(i) = (\text{values}[i] > \text{min_knot}) ? (\text{values}[i] - \text{min_knot}) / (\text{max_knot} - \text{min_knot}) : 0$. Reverse hinge: $\text{eval}(i) = (\text{values}[i] < \text{max_knot}) ? (\text{max_knot} - \text{values}[i]) / (\text{max_knot} - \text{min_knot}) : 0$.

Usage

```
create_hinge_feature(values, name, min_knot, max_knot, is_reverse = FALSE)
```

Arguments

values	Numeric vector of environmental variable values
name	Feature name/identifier
min_knot	Lower knot of the hinge
max_knot	Upper knot of the hinge (must be > min_knot)
is_reverse	If TRUE, use reverse hinge; if FALSE (default), use forward hinge

Value

External pointer to HingeFeature object

create_layer *Create a Layer metadata object*

Description

Create a Layer metadata object

Usage

```
create_layer(name, type_str)
```

Arguments

name	Layer name.
type_str	Type string: "Continuous", "Categorical", "Bias", "Mask", "Probability", "Cumulative", "DebiasAvg", or "Unknown".

Value

External pointer to a Layer object.

create_linear_feature *Create a LinearFeature object*

Description

Creates a linear (normalized) feature: $\text{eval}(i) = (\text{values}[i] - \text{min}) / (\text{max} - \text{min})$. Returns 0 when $\text{min} == \text{max}$.

Usage

```
create_linear_feature(values, name, min_val, max_val)
```

Arguments

values	Numeric vector of environmental variable values
name	Feature name/identifier
min_val	Minimum value for normalization
max_val	Maximum value for normalization

Value

External pointer to LinearFeature object

create_product_feature
Create a ProductFeature object

Description

Creates a product (interaction) feature between two environmental variables: $\text{eval}(i) = \text{norm}(\text{values1}[i]) * \text{norm}(\text{values2}[i])$.

Usage

```
create_product_feature(values1, values2, name, min1, max1, min2, max2)
```

Arguments

values1	Numeric vector for the first environmental variable
values2	Numeric vector for the second environmental variable
name	Feature name/identifier
min1	Minimum of the first variable
max1	Maximum of the first variable
min2	Minimum of the second variable
max2	Maximum of the second variable

Value

External pointer to ProductFeature object

create_quadratic_feature

Create a QuadraticFeature object

Description

Creates a quadratic feature: $\text{eval}(i) = \text{linear_val}^2$ where $\text{linear_val} = (\text{values}[i] - \text{min}) / (\text{max} - \text{min})$.

Usage

create_quadratic_feature(values, name, min_val, max_val)

Arguments

values	Numeric vector of environmental variable values
name	Feature name/identifier
min_val	Minimum value for normalization
max_val	Maximum value for normalization

Value

External pointer to QuadraticFeature object

create_sample

Create a Sample object

Description

Creates a species occurrence sample point

Usage

create_sample(point, row, col, lat, lon, name)

Arguments

point	Point identifier
row	Row index in grid
col	Column index in grid
lat	Latitude coordinate
lon	Longitude coordinate
name	Sample name/identifier

Value

External pointer to Sample object

create_threshold_feature

Create a ThresholdFeature object

Description

Creates a binary step feature: $\text{eval}(i) = 1.0$ if $\text{values}[i] > \text{threshold}$, else 0.0.

Usage

create_threshold_feature(values, name, threshold)

Arguments

values	Numeric vector of environmental variable values
name	Feature name/identifier
threshold	The threshold value

Value

External pointer to ThresholdFeature object

csv_close

Close a CsvReader

Description

Close a CsvReader

Usage

csv_close(reader_ptr)

Arguments

reader_ptr	External pointer to a CsvReader object.
------------	---

Value

Called for side effects; returns invisibly.

csv_headers	<i>Get CSV column headers</i>
-------------	-------------------------------

Description

Get CSV column headers

Usage

```
csv_headers(reader_ptr)
```

Arguments

reader_ptr External pointer to a CsvReader object.

Value

Character vector of header names.

csv_next_record	<i>Read the next CSV record</i>
-----------------	---------------------------------

Description

Read the next CSV record

Usage

```
csv_next_record(reader_ptr)
```

Arguments

reader_ptr External pointer to a CsvReader object.

Value

Character vector of field values, or NULL on EOF.

csv_open	<i>Open a CSV file for reading</i>
----------	------------------------------------

Description

Open a CSV file for reading

Usage

```
csv_open(filename, has_header = TRUE)
```

Arguments

filename	Path to the CSV file.
has_header	Logical: first line contains column names (default TRUE).

Value

External pointer to a CsvReader object.

csv_read_double_column	<i>Read an entire named column as doubles</i>
------------------------	---

Description

Reads from the current position to EOF.

Usage

```
csv_read_double_column(reader_ptr, field)
```

Arguments

reader_ptr	External pointer to a CsvReader object.
field	Column name.

Value

Numeric vector.

csv_writer_close	<i>Close a CsvWriter</i>
------------------	--------------------------

Description

Close a CsvWriter

Usage

```
csv_writer_close(writer_ptr)
```

Arguments

writer_ptr	External pointer to a CsvWriter object.
------------	---

Value

Called for side effects; returns invisibly.

csv_writer_open	<i>Open a CSV file for writing</i>
-----------------	------------------------------------

Description

Open a CSV file for writing

Usage

```
csv_writer_open(filename, append = FALSE, precision = 4L)
```

Arguments

filename	Path to the output CSV file.
append	Logical: append to existing file (default FALSE).
precision	Number of decimal places for doubles (default 4).

Value

External pointer to a CsvWriter object.

csv_writer_print	<i>Write a value into the current row of a CSV</i>
------------------	--

Description

Write a value into the current row of a CSV

Usage

```
csv_writer_print(writer_ptr, column, value)
```

Arguments

writer_ptr	External pointer to a CsvWriter object.
column	Column name.
value	Value to write (character).

Value

Called for side effects; returns invisibly.

csv_writer_print_double	<i>Write a numeric value into the current row of a CSV</i>
-------------------------	--

Description

Write a numeric value into the current row of a CSV

Usage

```
csv_writer_print_double(writer_ptr, column, value)
```

Arguments

writer_ptr	External pointer to a CsvWriter object.
column	Column name.
value	Numeric value.

Value

Called for side effects; returns invisibly.

csv_writer_println *Flush the current CSV row to disk*

Description

Flush the current CSV row to disk

Usage

```
csv_writer_println(writer_ptr)
```

Arguments

writer_ptr External pointer to a CsvWriter object.

Value

Called for side effects; returns invisibly.

eval_auc *Compute AUC (Area Under the ROC Curve)*

Description

Computes the Wilcoxon-Mann-Whitney AUC statistic from prediction scores at presence and absence sites.

Usage

```
eval_auc(presence, absence)
```

Arguments

presence Numeric vector of prediction scores at presence sites.

absence Numeric vector of prediction scores at absence sites.

Value

A named list with elements: auc, max_kappa, max_kappa_thresh.

eval_correlation	<i>Compute Pearson Correlation</i>
------------------	------------------------------------

Description

Computes Pearson correlation coefficient between two numeric vectors.

Usage

```
eval_correlation(x, y)
```

Arguments

x	Numeric vector.
y	Numeric vector (same length as x).

Value

Correlation coefficient in [-1, 1].

eval_logloss	<i>Compute Log-Loss</i>
--------------	-------------------------

Description

Computes average cross-entropy log-loss from predictions at presence and absence sites.

Usage

```
eval_logloss(presence, absence)
```

Arguments

presence	Numeric vector of prediction scores at presence sites.
absence	Numeric vector of prediction scores at absence sites.

Value

Average log-loss value.

`eval_misclassification`*Compute Misclassification Rate*

Description

Fraction of misclassified samples at threshold 0.5.

Usage

```
eval_misclassification(presence, absence)
```

Arguments

presence	Numeric vector of prediction scores at presence sites.
absence	Numeric vector of prediction scores at absence sites.

Value

Misclassification rate in [0, 1].

`eval_model`*Full Model Evaluation*

Description

Computes all evaluation metrics at once: AUC, correlation, log-loss, squared error, misclassification, max kappa, and prevalence.

Usage

```
eval_model(presence, absence)
```

Arguments

presence	Numeric vector of prediction scores at presence sites.
absence	Numeric vector of prediction scores at absence sites.

Value

A named list with: auc, max_kappa, max_kappa_thresh, correlation, square_error, logloss, misclassification, prevalence.

eval_square_error	<i>Compute Mean Squared Error</i>
-------------------	-----------------------------------

Description

Presence sites contribute $(1 - \text{pred})^2$, absence sites contribute pred^2 .

Usage

```
eval_square_error(presence, absence)
```

Arguments

presence	Numeric vector of prediction scores at presence sites.
absence	Numeric vector of prediction scores at absence sites.

Value

Mean squared error.

example_occ_df	<i>Species occurrence points from Abeillia abeillei presence points after download and clean from GBIF. This is a hummingbird example. A dataset with three variables. Contains scientific name, longitude and latitude.</i>
----------------	--

Description

Species occurrence points from Abeillia abeillei presence points after download and clean from GBIF. This is a hummingbird example. A dataset with three variables. Contains scientific name, longitude and latitude.

Usage

```
example_occ_df
```

Format

A data frame with 73 rows and 3 variables:

species	Species name
long	Decimal longitude geographical coordinate, in degrees
lat	Decimal latitude geographical coordinate, in degrees

Source

<doi:10.1016/j.ecolmodel.2021.109823>

extract_predictions_raw

Extract Java-compatible Raw Predictions at Sample Locations

Description

Gets Java Maxent raw scores ($\text{raw_java} = \exp(\text{lp} - \text{lpNorm}) / \text{densityNorm}$) at specific grid cell locations.

Usage

```
extract_predictions_raw(fs_ptr, grid_ptrs, feature_names, rows, cols)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
grid_ptrs	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.
rows	Integer vector of row indices.
cols	Integer vector of column indices.

Value

Numeric vector of Java raw scores. NaN for NODATA cells.

feature_eval

Evaluate a feature at a given index

Description

Evaluate a feature at a given index

Usage

```
feature_eval(feature_ptr, index)
```

Arguments

feature_ptr	External pointer to a Feature object
index	0-based index into the data vector

Value

Feature value at that index (double)

feature_get_info	<i>Get feature metadata</i>
------------------	-----------------------------

Description

Returns a list with name, type, lambda, min, and max values.

Usage

```
feature_get_info(feature_ptr)
```

Arguments

feature_ptr External pointer to a Feature object

Value

Named list with feature properties

generate_features	<i>Generate features from a list of environmental variable vectors</i>
-------------------	--

Description

Generates all configured feature types (linear, quadratic, product, threshold, hinge) from the supplied data vectors.

Usage

```
generate_features(
  data_list,
  feature_types = as.character(c("linear", "quadratic", "product", "threshold", "hinge")),
  n_thresholds = 10L,
  n_hinges = 10L
)
```

Arguments

data_list Named list of numeric vectors, one per environmental variable

feature_types Character vector of feature types to generate. Valid values: "linear", "quadratic", "product", "threshold", "hinge". Defaults to all types.

n_thresholds Number of threshold knots per variable (default: 10)

n_hinges Number of hinge knots per variable (default: 10)

Value

List of external pointers to Feature objects

`get_grid_dimension_info`*Get grid dimension properties*

Description

Get grid dimension properties

Usage

```
get_grid_dimension_info(dim_ptr)
```

Arguments

`dim_ptr` External pointer to GridDimension

Value

List with dimension properties

`get_layer_info`*Get layer metadata*

Description

Get layer metadata

Usage

```
get_layer_info(layer_ptr)
```

Arguments

`layer_ptr` External pointer to a Layer object.

Value

Named list with name and type (string).

get_sample_info	<i>Get sample properties</i>
-----------------	------------------------------

Description

Get sample properties

Usage

```
get_sample_info(sample_ptr)
```

Arguments

sample_ptr	External pointer to Sample
------------	----------------------------

Value

List with sample properties

grid_float_from_matrix	<i>Create a GridFloat from an R matrix</i>
------------------------	--

Description

Create a GridFloat from an R matrix

Usage

```
grid_float_from_matrix(mat, xll, yll, cellsize, nodata = -9999, name = "")
```

Arguments

mat	Numeric matrix with grid data (NA becomes NODATA).
xll	X coordinate of lower-left corner.
yll	Y coordinate of lower-left corner.
cellsize	Cell size.
nodata	NODATA value (default -9999).
name	Grid name (default "").

Value

External pointer to a GridFloat object.

grid_float_info *Get grid information for an ASC-loaded grid*

Description

Returns metadata and basic statistics for a GridFloat.

Usage

```
grid_float_info(grid_ptr)
```

Arguments

grid_ptr External pointer to a GridFloat object.

Value

Named list with nrows, ncols, xll, yll, cellsize, nodata, name, count_data.

grid_float_to_matrix *Extract the data from a GridFloat as an R matrix*

Description

Extract the data from a GridFloat as an R matrix

Usage

```
grid_float_to_matrix(grid_ptr)
```

Arguments

grid_ptr External pointer to a GridFloat object.

Value

Numeric matrix (nrows × ncols). NODATA cells are set to NA.

grid_from_matrix	<i>Set grid from matrix</i>
------------------	-----------------------------

Description

Set grid from matrix

Usage

```
grid_from_matrix(grid_ptr, mat)
```

Arguments

grid_ptr	External pointer to Grid
mat	Numeric matrix of values

Value

Called for side effects; returns invisibly.

grid_get_value	<i>Get grid value</i>
----------------	-----------------------

Description

Get grid value

Usage

```
grid_get_value(grid_ptr, row, col)
```

Arguments

grid_ptr	External pointer to Grid
row	Row index
col	Column index

Value

Grid value

grid_get_values_batch *Extract multiple values from a Grid at given row/col indices (batch)*

Description

Extract multiple values from a Grid at given row/col indices (batch)

Usage

```
grid_get_values_batch(grid_ptr, rows, cols)
```

Arguments

grid_ptr	External pointer to a Grid<float>.
rows	Integer vector of 0-based row indices.
cols	Integer vector of 0-based column indices.

Value

Numeric vector of extracted values (NA for NODATA cells).

grid_has_data *Check if grid cell has data*

Description

Check if grid cell has data

Usage

```
grid_has_data(grid_ptr, row, col)
```

Arguments

grid_ptr	External pointer to Grid
row	Row index
col	Column index

Value

TRUE if cell has valid data

grid_read_asc	<i>Read an ESRI ASCII grid (.asc) file</i>
---------------	--

Description

Reads an ASC raster file and returns a float Grid external pointer.

Usage

```
grid_read_asc(filename)
```

Arguments

filename	Path to the .asc file.
----------	------------------------

Value

External pointer to a GridFloat object.

grid_read_file	<i>Read a grid from file (auto-detect format)</i>
----------------	---

Description

Currently supports .asc format. Returns a float Grid.

Usage

```
grid_read_file(filename)
```

Arguments

filename	Path to the grid file.
----------	------------------------

Value

External pointer to a GridFloat object.

grid_set_value	<i>Set grid value</i>
----------------	-----------------------

Description

Set grid value

Usage

```
grid_set_value(grid_ptr, row, col, value)
```

Arguments

grid_ptr	External pointer to Grid
row	Row index
col	Column index
value	Value to set

Value

Called for side effects; returns invisibly.

grid_to_matrix	<i>Get grid as matrix</i>
----------------	---------------------------

Description

Get grid as matrix

Usage

```
grid_to_matrix(grid_ptr)
```

Arguments

grid_ptr	External pointer to Grid
----------	--------------------------

Value

Numeric matrix of grid values

grid_write_asc	<i>Write a float Grid to an ESRI ASCII (.asc) file</i>
----------------	--

Description

Write a float Grid to an ESRI ASCII (.asc) file

Usage

```
grid_write_asc(grid_ptr, filename, scientific = TRUE)
```

Arguments

grid_ptr	External pointer to a GridFloat object.
filename	Output file path.
scientific	Logical: use scientific notation (default TRUE).

Value

Called for side effects; returns invisibly.

layer_name_from_path	<i>Extract a layer name from a file path</i>
----------------------	--

Description

Strips directory and extension, e.g. "/data/bio1.asc" → "bio1".

Usage

```
layer_name_from_path(path)
```

Arguments

path	File path.
------	------------

Value

Character: layer name.

 maxent_append_results_csv

Append a Row to maxentResults.csv

Description

Appends one row of species-level summary statistics to a `maxentResults.csv` file, creating the file (with a header) if it does not yet exist. Column names match the Java Maxent output for cross-tool compatibility.

Usage

```
maxent_append_results_csv(
  results_file,
  species,
  n_training,
  n_test = 0L,
  training_gain,
  training_auc,
  test_gain = NA_real_,
  test_auc = NA_real_,
  entropy,
  contributions_df,
  perm_imp_df
)
```

Arguments

<code>results_file</code>	Character: path to the results CSV file.
<code>species</code>	Character: species name.
<code>n_training</code>	Integer: number of training presence points.
<code>n_test</code>	Integer: number of test presence points (default 0).
<code>training_gain</code>	Numeric: regularized training gain.
<code>training_auc</code>	Numeric: training AUC.
<code>test_gain</code>	Numeric or NA: regularized test gain.
<code>test_auc</code>	Numeric or NA: test AUC.
<code>entropy</code>	Numeric: model entropy.
<code>contributions_df</code>	A data.frame with columns name and contribution (from maxent_percent_contribution).
<code>perm_imp_df</code>	A data.frame with columns name and permutation_importance (from maxent_permutation_importance).

Value

Invisibly returns `results_file`.

Examples

```
maxent_append_results_csv(  
  file.path(tempdir(), "maxentResults.csv"),  
  species = "Sp1", n_training = 50L, training_gain = 1.23,  
  training_auc = 0.95, entropy = 6.7,  
  contributions_df = contrib, perm_imp_df = perm_imp)
```

maxent_auc

Compute AUC (Area Under the ROC Curve)

Description

Computes the Wilcoxon-Mann-Whitney AUC statistic from prediction scores at presence and absence sites. Also returns max-Kappa and its threshold.

Usage

```
maxent_auc(presence, absence)
```

Arguments

presence Numeric vector of prediction scores at presence sites.
absence Numeric vector of prediction scores at absence sites.

Value

A named list with elements:

auc AUC value in [0, 1]

max_kappa Best Cohen's Kappa found

max_kappa_thresh Threshold at best Kappa

Examples

```
result <- maxent_auc(c(0.8, 0.9, 1.0), c(0.1, 0.2, 0.3))  
result$auc # 1.0
```

`maxent_background_indices`*Generate Background Sample Indices*

Description

Randomly selects valid (non-NODATA) cells from a reference grid for use as background points in MaxEnt modeling.

Usage

```
maxent_background_indices(grid, n = 10000L, seed = NULL)
```

Arguments

<code>grid</code>	External pointer to a GridFloat object used as a reference (e.g. an environmental layer). Only cells with valid data are eligible.
<code>n</code>	Integer: number of background points to sample (default 10000L).
<code>seed</code>	Integer or NULL: random seed for reproducibility. If NULL (default), no seed is set.

Value

A named list with:

rows Integer vector of row indices (0-based).

cols Integer vector of column indices (0-based).

indices Integer vector of 0-based flat indices (row * ncol + col), suitable for [maxent_featured_space](#).

Examples

```
dim <- maxent_dimension(100, 100, -120, 35, 0.1)
grid <- maxent_grid(dim, "env1")
bg <- maxent_background_indices(grid, n = 5000, seed = 42)
bg$indices # 0-based flat indices for FeaturedSpace
```

maxent_clamp	<i>Clamp Environmental Grids</i>
--------------	----------------------------------

Description

Restricts environmental variable values to the range observed during training. Values below min are set to min, values above max are set to max. A clamping grid records the total absolute clamping at each cell.

Usage

```
maxent_clamp(env_grids, var_mins, var_maxs)
```

Arguments

env_grids	List of external pointers to Grid<float> objects.
var_mins	Numeric vector of minimum training values per variable.
var_maxs	Numeric vector of maximum training values per variable.

Value

A named list with:

clamped_grids List of external pointers to clamped grids

clamp_grid External pointer to clamping magnitude grid

Examples

```
result <- maxent_clamp(list(g1, g2), c(0, 50), c(30, 200))
clamped <- result$clamped_grids
clamp_mat <- maxent_grid_to_matrix(result$clamp_grid)
```

maxent_color_ramp	<i>Generate the Maxent Canonical Color Ramp</i>
-------------------	---

Description

Produces a vector of hex color strings matching the color ramp used by the Java Maxent software (density/Display.java::showColor()). The default palette cycles Red → Yellow → Green → Cyan → Blue across 1020 steps, with higher values rendered as red and lower values as blue.

Usage

```
maxent_color_ramp(n = 1020L, mode = "plain")
```

Arguments

n	Integer: number of colors to generate (default 1020, matching the Java implementation).
mode	Character: one of "plain" (default), "log" (logarithmic spacing), "blackandwhite" (greyscale, white = high, black = low), or "redandyellow" (red–yellow ramp).

Value

Character vector of n hex color strings of the form "#RRGGBB".

Examples

```
pal <- maxent_color_ramp(1020)
pal[1]      # "#FF0000" (max value → red)
pal[510]    # near "#00FF00" (mid-point → green)
pal[1020]   # "#0000FF" (min value → blue)
```

maxent_correlation *Compute Pearson Correlation*

Description

Computes the Pearson correlation coefficient between two numeric vectors.

Usage

```
maxent_correlation(x, y)
```

Arguments

x	Numeric vector.
y	Numeric vector (same length as x).

Value

Correlation coefficient in [-1, 1].

Examples

```
maxent_correlation(c(1, 2, 3), c(2, 4, 6)) # 1.0
```

maxent_csv_close	<i>Close a CSV Reader</i>
------------------	---------------------------

Description

Close a CSV Reader

Usage

```
maxent_csv_close(reader)
```

Arguments

reader External pointer to a CsvReader object.

Value

Invisibly returns NULL.

maxent_csv_headers	<i>Get CSV Column Headers</i>
--------------------	-------------------------------

Description

Get CSV Column Headers

Usage

```
maxent_csv_headers(reader)
```

Arguments

reader External pointer to a CsvReader object.

Value

Character vector of column names.

maxent_csv_next	<i>Read the Next CSV Record</i>
-----------------	---------------------------------

Description

Read the Next CSV Record

Usage

```
maxent_csv_next(reader)
```

Arguments

reader	External pointer to a CsvReader object.
--------	---

Value

Character vector of field values, or NULL on EOF.

maxent_csv_open	<i>Open a CSV File for Reading</i>
-----------------	------------------------------------

Description

Opens a CSV file and reads column headers.

Usage

```
maxent_csv_open(filename, has_header = TRUE)
```

Arguments

filename	Character: path to the CSV file.
has_header	Logical: first line is header (default TRUE).

Value

External pointer to a CsvReader C++ object.

`maxent_csv_read_column`*Read an Entire Column as Doubles*

Description

Reads from the current file position to EOF.

Usage

```
maxent_csv_read_column(reader, field)
```

Arguments

<code>reader</code>	External pointer to a CsvReader object.
<code>field</code>	Character: column name.

Value

Numeric vector.

`maxent_csv_write`*Write a String Value to the Current CSV Row*

Description

Adds a `column = value` pair (as a character string) to the current row buffer. Call [maxent_csv_write_row](#) to flush the row.

Usage

```
maxent_csv_write(writer, column, value)
```

Arguments

<code>writer</code>	External pointer to a CsvWriter object.
<code>column</code>	Character: column name.
<code>value</code>	Character: value to write.

Value

Invisibly returns the writer object.

`maxent_csv_write_close`*Close a CSV Writer*

Description

Flushes any pending data and closes the CSV file.

Usage

```
maxent_csv_write_close(writer)
```

Arguments

`writer` External pointer to a CsvWriter object.

Value

Invisibly returns NULL.

`maxent_csv_write_num` *Write a Numeric Value to the Current CSV Row*

Description

Adds a column = value pair (as a double) to the current row buffer. Call [maxent_csv_write_row](#) to flush the row.

Usage

```
maxent_csv_write_num(writer, column, value)
```

Arguments

`writer` External pointer to a CsvWriter object.
`column` Character: column name.
`value` Numeric: value to write.

Value

Invisibly returns the writer object.

maxent_csv_write_open *Open a CSV File for Writing*

Description

Opens a CSV file and returns a writer object. Use `maxent_csv_write`, `maxent_csv_write_num`, `maxent_csv_write_row`, and `maxent_csv_write_close` to write data and close the file.

Usage

```
maxent_csv_write_open(filename, append = FALSE, precision = 4L)
```

Arguments

filename	Character: output file path.
append	Logical: append to an existing file (default FALSE).
precision	Integer: number of decimal places for numeric values (default 4).

Value

External pointer to a CsvWriter C++ object.

maxent_csv_write_row *Flush the Current Row to the CSV File*

Description

Writes all buffered column values as a single CSV row and starts a new row buffer.

Usage

```
maxent_csv_write_row(writer)
```

Arguments

writer	External pointer to a CsvWriter object.
--------	---

Value

Invisibly returns the writer object.

maxent_dimension *Create a Grid Dimension Object*

Description

Defines the spatial extent and resolution of a raster grid.

Usage

```
maxent_dimension(nrows, ncols, xll, yll, cellsize)
```

Arguments

nrows	Number of rows
ncols	Number of columns
xll	X coordinate of lower-left corner
yll	Y coordinate of lower-left corner
cellsize	Cell size (square cells)

Value

GridDimension object (external pointer)

Examples

```
dim <- maxent_dimension(  
  nrows = 100, ncols = 100,  
  xll = -120.0, yll = 35.0,  
  cellsize = 0.1  
)
```

maxent_evaluate *Full Model Evaluation*

Description

Computes all evaluation metrics at once: AUC, correlation, log-loss, squared error, misclassification, max Kappa, and prevalence.

Usage

```
maxent_evaluate(presence, absence)
```

Arguments

presence Numeric vector of prediction scores at presence sites.
 absence Numeric vector of prediction scores at absence sites.

Value

A named list with:

auc AUC value
max_kappa Best Cohen's Kappa
max_kappa_thresh Threshold at best Kappa
correlation Pearson correlation with labels
square_error Mean squared error
logloss Cross-entropy log-loss
misclassification Misclassification rate
prevalence Fraction of presence sites

Examples

```
res <- maxent_evaluate(c(0.9, 0.85, 0.95), c(0.1, 0.15, 0.2))
res$auc                # 1.0
res$correlation        # > 0
```

maxent_extract_lambdas

Extract Lambda Values from a Maxent Run Result

Description

Retrieves the trained lambda (weight) coefficients from the output of `maxent_run`, returning them as a named numeric vector. Each element is the lambda value for the corresponding feature, and the name of each element is the feature name (e.g. "bio1", "bio1^2", "bio1'1").

Usage

```
maxent_extract_lambdas(run_result)
```

Arguments

run_result A named list as returned by `maxent_run`. Must contain an element `model` holding the trained `FeaturedSpace` external pointer.

Details

The function reads lambdas directly from the trained model object, so it also works correctly after reloading coefficients with `maxent_load_lambdas`.

Value

A named numeric vector of lambda values, one per feature. Names are the feature names as stored in the model.

Examples

```
stack_path      <- system.file("extdata", "stack_1_12_crop.rds",
                               package = "maxentcpp")
example_rasters <- terra::unwrap(readRDS(stack_path))
grids <- list(
  bio1 = maxent_grid_from_terra(example_rasters[[1]]),
  bio12 = maxent_grid_from_terra(example_rasters[[2]])
)
data(example_occ_df)

result <- maxent_run(
  species = "Abeillia_abeillei",
  env_grids = grids,
  occ_df = example_occ_df,
  output_dir = tempdir(),
  lon_col = "long",
  lat_col = "lat")

lambdas <- maxent_extract_lambdas(result)
print(lambdas)
```

maxent_extract_occurrence_env_terra

Extract environmental values for occurrences from a terra SpatRaster

Description

Streams finite raster rows through the same callback-backed provider path used by [maxent_featured_space_from_rast](#), then returns values at occurrence locations.

Usage

```
maxent_extract_occurrence_env_terra(
  rast,
  occurrences,
  lon_col = "longitude",
  lat_col = "latitude"
)
```

Arguments

rast	A terra::SpatRaster.
occurrences	Either a two-column matrix/data.frame (x,y) or a vector of 1-based raster cell indices.
lon_col	Longitude column name when occurrences is a data.frame.
lat_col	Latitude column name when occurrences is a data.frame.

Value

Numeric matrix with one row per retained occurrence and one column per raster layer.

maxent_extract_predictions_cloglog

Extract Cloglog Predictions at Sample Locations

Description

Gets Java Maxent cloglog scores at specific grid cell locations:

$$cloglog = 1 - \exp(-\exp(H) \cdot raw)$$

Usage

```
maxent_extract_predictions_cloglog(model, env_grids, feature_names, rows, cols)
```

Arguments

model	External pointer to a FeaturedSpace object.
env_grids	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.
rows	Integer vector of row indices.
cols	Integer vector of column indices.

Value

Numeric vector of cloglog scores in [0, 1]. NaN for NODATA cells.

See Also

[maxent_extract_predictions_raw](#), [maxent_project_cloglog](#)

`maxent_extract_predictions_logistic`*Extract Logistic Predictions at Sample Locations*

Description

Gets Java Maxent logistic scores at specific grid cell locations:

$$\text{logistic} = \frac{\exp(H) \cdot \text{raw}}{1 + \exp(H) \cdot \text{raw}}$$

Usage

```
maxent_extract_predictions_logistic(  
  model,  
  env_grids,  
  feature_names,  
  rows,  
  cols  
)
```

Arguments

<code>model</code>	External pointer to a FeaturedSpace object.
<code>env_grids</code>	List of external pointers to Grid<float> objects.
<code>feature_names</code>	Character vector of environment variable names.
<code>rows</code>	Integer vector of row indices.
<code>cols</code>	Integer vector of column indices.

Value

Numeric vector of logistic scores in [0, 1]. NaN for NODATA cells.

See Also

[maxent_extract_predictions_raw](#), [maxent_project_logistic](#)

`maxent_extract_predictions_raw`*Extract Raw Predictions at Sample Locations*

Description

Gets Java Maxent raw scores at specific grid cell locations:

$$raw = \frac{\exp(lp - lpNorm)}{densityNorm}$$

Usage

```
maxent_extract_predictions_raw(model, env_grids, feature_names, rows, cols)
```

Arguments

<code>model</code>	External pointer to a FeaturedSpace object.
<code>env_grids</code>	List of external pointers to Grid<float> objects.
<code>feature_names</code>	Character vector of environment variable names.
<code>rows</code>	Integer vector of row indices.
<code>cols</code>	Integer vector of column indices.

Details

This matches the raw output of Java Maxent and **dismo**.

Value

Numeric vector of Java raw scores. NaN for NODATA cells.

See Also

[maxent_project_raw](#)

maxent_feature_eval *Evaluate a Feature at a Given Index*

Description

Evaluates the feature function at the specified index (1-based, as is standard in R). Internally converts to 0-based indexing for C++.

Usage

```
maxent_feature_eval(feature, index)
```

Arguments

feature	External pointer to a Feature C++ object.
index	1-based integer index into the data vector.

Value

Numeric scalar: the feature value at that index.

Examples

```
vals <- c(0, 5, 10)
f <- maxent_linear_feature(vals, "temp")
maxent_feature_eval(f, 2) # 5/10 = 0.5
```

maxent_feature_info *Get Feature Properties*

Description

Returns a list of metadata for a feature object.

Usage

```
maxent_feature_info(feature)
```

Arguments

feature	External pointer to a Feature C++ object.
---------	---

Value

Named list with elements: name, type, lambda, min, max, size.

Examples

```
vals <- c(0, 5, 10)
f <- maxent_linear_feature(vals, "temp")
maxent_feature_info(f)
```

maxent_featured_space *Create a FeaturedSpace Object*

Description

Constructs a MaxEnt FeaturedSpace from background point data, occurrence sample indices, and a list of pre-built Feature objects.

Usage

```
maxent_featured_space(
  num_points,
  sample_indices,
  features,
  bias_weights = NULL
)
```

Arguments

num_points	Integer: total number of background points.
sample_indices	Integer vector: 0-based indices (into the background array) of the occurrence sample locations.
features	List of external pointers to Feature objects, as returned by maxent_linear_feature(), maxent_hinge_feature(), maxent_generate_features(), etc.
bias_weights	Optional numeric vector of per-point bias weights (length num_points). When supplied, background density is computed as $\text{bias}[i] * \exp(\text{lp}[i] - \text{lpn})$ instead of the standard $\exp(\text{lp}[i] - \text{lpn})$. This mirrors Java Maxent's biasFile parameter. Pass NULL (default) for uniform (unbiased) background.

Value

External pointer to a FeaturedSpace C++ object.

Examples

```
n <- 100L
idx <- 90:99 # 0-based sample indices
env <- seq(0, 1, length.out = n)
f <- maxent_linear_feature(env, "env1")
fs <- maxent_featured_space(n, idx, list(f))
```

```
maxent_featured_space_create
```

Create a FeaturedSpace object

Description

Constructs a MaxEnt FeaturedSpace from background point count, occurrence sample indices, and a list of Feature objects.

Usage

```
maxent_featured_space_create(
  num_points,
  sample_indices,
  feature_ptrs,
  bias_weights = numeric(0)
)
```

Arguments

num_points	Integer: number of background points.
sample_indices	Integer vector: 0-based indices of occurrence samples in the background array.
feature_ptrs	List of external pointers to Feature objects (from create_linear_feature() etc.).
bias_weights	Optional numeric vector of per-point bias weights (length num_points). When supplied, background density is computed as $\text{bias}[i] * \exp(\text{lp}[i] - \text{lpn})$ instead of the standard $\exp(\text{lp}[i] - \text{lpn})$. Pass an empty vector (default) for uniform (unbiased) background.

Value

External pointer to a FeaturedSpace object.

```
maxent_featured_space_from_callback
```

Create a FeaturedSpace from a streaming background provider

Description

Builds a FeaturedSpace by draining a callback-style background provider (typically backed by a terra::SpatRaster block loop) one tile at a time, then constructing features from the concatenated (num_points x num_layers) matrix via [generate_features](#).

Usage

```
maxent_featured_space_from_callback(
  num_points,
  num_layers,
  layer_names,
  sample_indices,
  feature_types,
  n_thresholds,
  n_hinges,
  next_tile_fn,
  reset_fn,
  use_cache = TRUE
)
```

Arguments

<code>num_points</code>	Integer: total number of finite background points the provider will emit (sum of <code>nrow()</code> across tiles).
<code>num_layers</code>	Integer: number of environmental variables / raster layers per tile row.
<code>layer_names</code>	Character vector of length <code>num_layers</code> giving the name for each layer / column (used when generating feature names such as <code>bio1^2</code> , <code>bio1*bio2</code>).
<code>sample_indices</code>	Integer vector: 0-based indices of occurrence samples in the concatenated background stream.
<code>feature_types</code>	Character vector of feature types to generate. See maxent_generate_features .
<code>n_thresholds</code>	Number of threshold knots per variable.
<code>n_hinges</code>	Number of hinge knots per variable.
<code>next_tile_fn</code>	R function returning the next tile as a numeric matrix (<code>nrow</code> x <code>num_layers</code>), or a 0-row matrix / NULL when the stream is exhausted. The function is responsible for filtering out rows containing NAs.
<code>reset_fn</code>	R function (no arguments) that rewinds the underlying stream to the beginning.
<code>use_cache</code>	Logical; wrap the callback stream in <code>CachingBackgroundProvider</code> .

Details

This is the C++ entry point used by [maxent_featured_space_from_rast](#); end users should prefer that R-level wrapper.

Value

External pointer to a `FeaturedSpace` object.

```
maxent_featured_space_from_rast
```

Create a FeaturedSpace directly from a terra SpatRaster

Description

Streams a `terra::SpatRaster` block-by-block into the C++ `FeaturedSpace` streaming constructor, filtering NA cells on the fly and handing the concatenated (`num_points` x `nlyr(rast)`) matrix to [maxent_generate_features](#) so feature objects are built inside C++ without the R caller having to materialise the full raster stack first.

Usage

```
maxent_featured_space_from_rast(
  rast,
  sample_indices,
  feature_types = c("linear", "quadratic", "product", "threshold", "hinge"),
  n_thresholds = 10L,
  n_hinges = 10L,
  enable_streaming_eval = TRUE
)
```

Arguments

<code>rast</code>	A <code>terra::SpatRaster</code> with one layer per environmental variable. Layers must be named; names are passed through to maxent_generate_features so generated features carry the same identifiers as the layer names (e.g. <code>bio1^2</code> , <code>bio1*bio2</code>).
<code>sample_indices</code>	Integer vector: 0-based indices of occurrence samples in the concatenated stream of finite background cells. See maxent_raster_sample_indices for a helper that converts occurrence data.frames into these indices.
<code>feature_types</code>	Character vector of feature types to generate. Any subset of <code>c("linear", "quadratic", "product", "threshold", "hinge")</code> . Defaults to all types.
<code>n_thresholds</code>	Integer; number of threshold knots per variable.
<code>n_hinges</code>	Integer; number of hinge knots per variable.
<code>enable_streaming_eval</code>	Logical; when TRUE, enables streaming-evaluation mode after object construction.

Details

This is the Phase E.2 entry point described in `docs/ARCHITECTURE_terra_raster.md` (sections 3.1 and 3.2). The result is bit-for-bit identical to the dense path ([maxent_generate_features](#) -> [maxent_featured_space](#)) when the same data, sample indices, and feature configuration are used.

Value

External pointer to a FeaturedSpace object.

See Also

[maxent_featured_space](#), [maxent_featured_space_from_callback](#), [maxent_generate_features](#).

Examples

```
stack_path <- system.file("extdata", "stack_1_12_crop.rds",
                          package = "maxentcpp")
r <- terra::unwrap(readRDS(stack_path))
fs <- maxent_featured_space_from_rast(
  r,
  sample_indices = c(0L, 1L, 2L),
  feature_types = c("linear", "quadratic")
)
```

maxent_featured_space_info

Get FeaturedSpace metadata

Description

Get FeaturedSpace metadata

Usage

```
maxent_featured_space_info(fs_ptr)
```

Arguments

fs_ptr External pointer to a FeaturedSpace object.

Value

Named list with num_points, num_samples, num_features, density_normalizer, linear_predictor_normalizer, has_bias.

maxent_fit

*Train a MaxEnt Model***Description**

Runs the sequential coordinate-ascent MaxEnt optimization on a FeaturedSpace.

Usage

```
maxent_fit(
  featured_space,
  max_iter = 500L,
  convergence = 1e-05,
  beta_multiplier = 1,
  min_deviation = 0.001
)
```

Arguments

featured_space External pointer to a FeaturedSpace object (from maxent_featured_space()).

max_iter Maximum number of training iterations (default 500).

convergence Convergence threshold: stop when the per-20-iteration loss improvement is below this value (default 1e-5).

beta_multiplier Regularization multiplier (default 1.0). Higher values increase regularization strength.

min_deviation Minimum sample deviation floor used in regularization (default 0.001).

Value

Named list with:

loss Final regularized loss (scalar).

entropy Shannon entropy of the trained distribution.

iterations Number of training iterations completed.

converged Logical: whether the convergence threshold was reached.

lambdas Numeric vector of final lambda (weight) values.

Examples

```
n <- 50L
idx <- c(5L, 15L, 25L, 35L, 45L)
env <- list(bio1 = runif(n), bio12 = runif(n))
feats <- maxent_generate_features(env, types = "linear")
fs <- maxent_featured_space(n, idx, feats)
result <- maxent_fit(fs, max_iter = 100, convergence = 1e-5)
result$loss
```

`maxent_generate_features`*Generate Features from Environmental Variable Data*

Description

Automatically generates all configured feature types from one or more environmental variable vectors.

Usage

```
maxent_generate_features(  
  data,  
  types = c("linear", "quadratic", "product", "threshold", "hinge"),  
  n_thresholds = 10L,  
  n_hinges = 10L  
)
```

Arguments

<code>data</code>	Named list of numeric vectors, one per environmental variable.
<code>types</code>	Character vector of feature types to generate. Valid values: "linear", "quadratic", "product", "threshold", "hinge". Defaults to all types.
<code>n_thresholds</code>	Integer; number of threshold knots per variable (default: 10).
<code>n_hinges</code>	Integer; number of hinge knots per variable (default: 10).

Value

Named list of external pointers to Feature C++ objects.

Examples

```
env_data <- list(  
  temperature = c(15, 20, 25, 18, 22),  
  precipitation = c(100, 200, 150, 80, 300)  
)  
features <- maxent_generate_features(env_data, types = c("linear", "hinge"))  
length(features)
```

maxent_get_entropy *Get entropy of a FeaturedSpace distribution*

Description

Get entropy of a FeaturedSpace distribution

Usage

```
maxent_get_entropy(fs_ptr)
```

Arguments

fs_ptr External pointer to a FeaturedSpace object.

Value

Shannon entropy (non-negative scalar).

maxent_get_loss *Get current loss of a FeaturedSpace*

Description

Get current loss of a FeaturedSpace

Usage

```
maxent_get_loss(fs_ptr)
```

Arguments

fs_ptr External pointer to a FeaturedSpace object.

Value

Scalar loss value (negative log-likelihood).

maxent_get_weights	<i>Get current distribution weights from a FeaturedSpace</i>
--------------------	--

Description

Get current distribution weights from a FeaturedSpace

Usage

```
maxent_get_weights(fs_ptr)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
--------	---

Value

Numeric vector of normalized weights (sums to 1).

maxent_grid	<i>Create a Grid Object</i>
-------------	-----------------------------

Description

Creates a raster grid for storing environmental variable data.

Usage

```
maxent_grid(dim, name = "", nodata_value = -9999)
```

Arguments

dim	GridDimension object defining spatial extent
name	Grid layer name
nodata_value	Value representing missing data (default: -9999)

Value

Grid object (external pointer)

Examples

```
dim <- maxent_dimension(100, 100, -120, 35, 0.1)
grid <- maxent_grid(dim, "temperature")
```

 maxent_grid_from_matrix

Create a Grid from an R Matrix

Description

Builds a GridFloat from a numeric matrix and spatial parameters. NA values in the matrix are stored as the nodata value.

Usage

```
maxent_grid_from_matrix(mat, xll, yll, cellsize, nodata = -9999, name = "")
```

Arguments

mat	Numeric matrix.
xll	X coordinate of lower-left corner.
yll	Y coordinate of lower-left corner.
cellsize	Cell size.
nodata	NODATA sentinel value (default -9999).
name	Grid name (default "").

Value

External pointer to a GridFloat C++ object.

 maxent_grid_from_terra

Convert a terra SpatRaster to a maxentcpp GridFloat

Description

Converts a single-layer terra::SpatRaster into a maxentcpp GridFloat external pointer. The raster must have exactly one layer and square cells (equal x and y resolution).

Usage

```
maxent_grid_from_terra(r, name = NULL)
```

Arguments

r	A single-layer terra::SpatRaster object.
name	Character: grid name (default: layer name from the raster).

Details

NA values in the raster are stored as NODATA (sentinel -9999).

Requires the **terra** package (listed in Suggests).

For the **raster** package, an equivalent workflow is:

```
library(raster)
r <- raster("bio1.tif")
mat <- as.matrix(r)
e <- extent(r)
g <- maxent_grid_from_matrix(mat, xll = e@xmin, yll = e@ymin,
                             cellsize = res(r)[1],
                             name = names(r))
```

Value

External pointer to a GridFloat C++ object.

Examples

```
stack_path <- system.file("extdata", "stack_1_12_crop.rds",
                           package = "maxentcpp")
r <- terra::unwrap(readRDS(stack_path))
g <- maxent_grid_from_terra(r[[1]])
maxent_grid_info(g)
```

maxent_grid_info	<i>Get Grid Information</i>
------------------	-----------------------------

Description

Returns metadata about a GridFloat object read from a file.

Usage

```
maxent_grid_info(grid)
```

Arguments

grid External pointer to a GridFloat object.

Value

Named list with: nrows, ncols, xll, yll, cellsize, nodata, name, count_data.

maxent_grid_to_matrix *Convert Grid to R Matrix*

Description

Extracts the data from a GridFloat as an R numeric matrix. NODATA cells are converted to NA.

Usage

```
maxent_grid_to_matrix(grid)
```

Arguments

grid External pointer to a GridFloat object.

Value

Numeric matrix (nrows \times ncols).

maxent_grid_to_terra *Convert a maxentcpp GridFloat to a terra SpatRaster*

Description

Creates a terra::SpatRaster from a maxentcpp GridFloat external pointer.

Usage

```
maxent_grid_to_terra(grid, crs = "EPSG:4326")
```

Arguments

grid External pointer to a GridFloat C++ object.
crs Character: coordinate reference system string (default "EPSG:4326", i.e. WGS 84 longitude/latitude).

Details

Requires the **terra** package (listed in Suggests).

For the **raster** package, an equivalent workflow is:

```

library(raster)
info <- maxent_grid_info(grid)
mat <- maxent_grid_to_matrix(grid)
r <- raster(mat,
            xmn = info$xll,
            xmx = info$xll + info$ncols * info$cellsize,
            ymn = info$yll,
            ymx = info$yll + info$nrows * info$cellsize,
            crs = "+proj=longlat +datum=WGS84")

```

Value

A single-layer terra::SpatRaster.

Examples

```

stack_path <- system.file("extdata", "stack_1_12_crop.rds",
                          package = "maxentcpp")
r <- terra::unwrap(readRDS(stack_path))
g <- maxent_grid_from_terra(r[[1]])
r2 <- maxent_grid_to_terra(g)

```

maxent_hinge_feature *Create a Hinge Feature*

Description

Creates a piecewise-linear hinge feature.

Usage

```
maxent_hinge_feature(values, name, min_knot, max_knot, reverse = FALSE)
```

Arguments

values	Numeric vector of environmental variable values.
name	Character string: feature name/identifier.
min_knot	Lower knot of the hinge.
max_knot	Upper knot of the hinge (must be strictly greater than min_knot).
reverse	Logical; if TRUE, use reverse hinge. Default is FALSE (forward hinge).

Details

Forward hinge (reverse = FALSE): $\text{eval}(i) = \max(0, (\text{values}[i] - \text{min_knot}) / (\text{max_knot} - \text{min_knot}))$

Reverse hinge (reverse = TRUE): $\text{eval}(i) = \max(0, (\text{max_knot} - \text{values}[i]) / (\text{max_knot} - \text{min_knot}))$

Value

External pointer to a HingeFeature C++ object.

Examples

```
vals <- c(0, 5, 10, 3)
f <- maxent_hinge_feature(vals, "temperature_hinge", min_knot = 2, max_knot = 8)
maxent_feature_eval(f, 2) # values[2] = 5 -> (5-2)/(8-2) = 0.5
```

maxent_layer	<i>Create a Layer Metadata Object</i>
--------------	---------------------------------------

Description

Create a Layer Metadata Object

Usage

```
maxent_layer(name, type = "Continuous")
```

Arguments

name	Character: layer name.
type	Character: layer type. One of "Continuous", "Categorical", "Bias", "Mask", "Probability", "Cumulative", "DebiasAvg", or "Unknown".

Value

External pointer to a Layer C++ object.

maxent_layer_info	<i>Get Layer Metadata</i>
-------------------	---------------------------

Description

Get Layer Metadata

Usage

```
maxent_layer_info(layer)
```

Arguments

layer	External pointer to a Layer object.
-------	-------------------------------------

Value

Named list with name and type.

maxent_layer_name	<i>Extract Layer Name from a File Path</i>
-------------------	--

Description

Strips directory prefix and extension.

Usage

```
maxent_layer_name(path)
```

Arguments

path	Character: file path.
------	-----------------------

Value

Character: layer name (e.g., "/data/bio1.asc" → "bio1").

maxent_linear_feature	<i>Create a Linear Feature</i>
-----------------------	--------------------------------

Description

Creates a linear (normalized) feature that evaluates to $(\text{values}[i] - \text{min}) / (\text{max} - \text{min})$. Returns 0 when $\text{min} == \text{max}$.

Usage

```
maxent_linear_feature(values, name, min_val = NULL, max_val = NULL)
```

Arguments

values	Numeric vector of environmental variable values.
name	Character string: feature name/identifier.
min_val	Minimum value for normalization. If NULL (default), computed as $\text{min}(\text{values})$.
max_val	Maximum value for normalization. If NULL (default), computed as $\text{max}(\text{values})$.

Value

External pointer to a LinearFeature C++ object.

Examples

```
vals <- c(0, 5, 10, 3)
f <- maxent_linear_feature(vals, "temperature")
maxent_feature_eval(f, 1) # index 1 (R) -> 0-based index 0
```

maxent_load_lambdas *Load Model Lambdas from File*

Description

Reads model coefficients from a .lambdas file and applies them to a FeaturedSpace that was created with the same features.

Usage

```
maxent_load_lambdas(featured_space, file)
```

Arguments

featured_space External pointer to a FeaturedSpace object (must have features with the same names as those in the file).
file Character: path to the lambdas file.

Value

Invisibly returns the FeaturedSpace external pointer (updated in-place).

Examples

```
maxent_load_lambdas(fs, tempfile(fileext = ".lambdas"))
```

maxent_logloss *Compute Log-Loss*

Description

Computes the average cross-entropy log-loss from predictions at presence and absence sites.

Usage

```
maxent_logloss(presence, absence)
```

Arguments

presence Numeric vector of prediction scores at presence sites.
absence Numeric vector of prediction scores at absence sites.

Value

Average log-loss value (lower is better).

Examples

```
maxent_logloss(c(0.9, 0.8), c(0.1, 0.2))
```

maxent_mess

Compute MESS (Multivariate Environmental Similarity Surface)

Description

Measures how similar each cell is to the training environment using the full distribution of reference values. Negative MESS values indicate novel (non-analog) environments.

Usage

```
maxent_mess(env_grids, reference_values, feature_names)
```

Arguments

`env_grids` List of external pointers to Grid<float> objects.

`reference_values` List of numeric vectors with reference values for each variable (e.g. values at training sites).

`feature_names` Character vector of variable names.

Value

A named list with:

mess_grid External pointer to Grid<float> with MESS values

mod_grid External pointer to Grid<float> with Most Dissimilar Variable index (1-based)

Examples

```
result <- maxent_mess(list(g1, g2),
  list(temp_train_vals, precip_train_vals),
  c("temp", "precip"))
mess_mat <- maxent_grid_to_matrix(result$mess_grid)
mod_mat <- maxent_grid_to_matrix(result$mod_grid)
```

maxent_mess_range *Compute MESS from Min/Max Ranges*

Description

Simplified MESS analysis using only the min/max of the reference data rather than the full distribution.

Usage

```
maxent_mess_range(env_grids, var_mins, var_maxs)
```

Arguments

env_grids	List of external pointers to Grid<float> objects.
var_mins	Numeric vector of minimum reference values per variable.
var_maxs	Numeric vector of maximum reference values per variable.

Value

A named list with mess_grid and mod_grid (external pointers).

maxent_misclassification
Compute Misclassification Rate

Description

Fraction of misclassified samples at threshold 0.5.

Usage

```
maxent_misclassification(presence, absence)
```

Arguments

presence	Numeric vector of prediction scores at presence sites.
absence	Numeric vector of prediction scores at absence sites.

Value

Misclassification rate in [0, 1].

Examples

```
maxent_misclassification(c(0.8, 0.9), c(0.1, 0.2)) # 0.0
```

maxent_model_entropy *Get Model Entropy*

Description

Returns the Shannon entropy of the current MaxEnt distribution.

Usage

maxent_model_entropy(featured_space)

Arguments

featured_space External pointer to a FeaturedSpace object.

Value

Scalar: Shannon entropy (non-negative).

maxent_model_loss *Get Model Loss*

Description

Returns the current (negative log-likelihood) loss of the model.

Usage

maxent_model_loss(featured_space)

Arguments

featured_space External pointer to a FeaturedSpace object.

Value

Scalar: current loss value.

maxent_model_weights *Get Model Distribution Weights*

Description

Returns the normalized probability weights of the current MaxEnt distribution over the background points.

Usage

```
maxent_model_weights(featured_space)
```

Arguments

featured_space External pointer to a FeaturedSpace object.

Value

Numeric vector of weights that sum to 1.

maxent_percent_contribution
 Compute Percent Contribution

Description

Computes variable contribution based on sum of absolute lambda values for features derived from each variable. Results sum to 100

Usage

```
maxent_percent_contribution(model, feature_names)
```

Arguments

model External pointer to a FeaturedSpace object.
 feature_names Character vector of base variable names.

Value

A data.frame with columns:

name Variable name

contribution Percent contribution

Examples

```
n <- 50L
idx <- c(5L, 15L, 25L, 35L, 45L)
env <- list(temp = runif(n), precip = runif(n))
feats <- maxent_generate_features(env, types = "linear")
model <- maxent_featured_space(n, idx, feats)
maxent_fit(model, max_iter = 100, convergence = 1e-3)
contrib <- maxent_percent_contribution(model, c("temp", "precip"))
contrib # data.frame with name and contribution
```

```
maxent_permutation_importance
```

Compute Permutation Importance

Description

Measures how much each environmental variable contributes to model prediction quality by permuting each variable and measuring AUC drop. Results are normalised so that all importances sum to 100

Usage

```
maxent_permutation_importance(
  model,
  env_grids,
  feature_names,
  presence_rows,
  presence_cols,
  absence_rows,
  absence_cols,
  seed = 42L
)
```

Arguments

model	External pointer to a FeaturedSpace object.
env_grids	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names, matching the order of env_grids.
presence_rows	Integer vector of presence site row indices (0-based).
presence_cols	Integer vector of presence site column indices (0-based).
absence_rows	Integer vector of absence/background site row indices.
absence_cols	Integer vector of absence/background site column indices.
seed	Random seed for reproducibility (default 42).

Value

A data.frame with columns:

name Variable name

permutation_importance Normalised importance (%)

Examples

```
imp <- maxent_permutation_importance(model, list(g1, g2),
  c("temp", "precip"),
  pres_rows, pres_cols, abs_rows, abs_cols)
imp # data.frame with name and permutation_importance
```

maxent_plot_response_curves

Write Response Curve PNGs for All Variables

Description

Generates response curve plots for each environmental variable and saves them as PNG files, replicating density/ResponsePlot.java::makeplot(). A full-size PNG and an optional thumbnail are written for every variable.

Usage

```
maxent_plot_response_curves(
  model,
  env_grids,
  feature_names,
  output_dir,
  species,
  var_indices = NULL,
  n_steps = 100L,
  thumbnail = TRUE,
  write_dat = FALSE
)
```

Arguments

model	External pointer to a trained FeaturedSpace object.
env_grids	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names (one entry per element of env_grids).
output_dir	Character: directory under which a plots/ sub-directory will be created.
species	Character: species name (used in file names).
var_indices	Integer vector of 0-based variable indices to plot. Defaults to all variables.

n_steps	Integer: number of steps in each curve (default 100).
thumbnail	Logical: also write a 210 × 140 pixel thumbnail PNG (default TRUE).
write_dat	Logical: also write a tab-delimited .dat file of the curve data (default FALSE).

Value

Invisibly returns a named list of file paths written.

Examples

```
maxent_plot_response_curves(
  model, list(g1, g2), c("bio1", "bio12"),
  output_dir = tempdir(), species = "Sp1")
```

maxent_plot_variable_importance

Write a Variable Importance Bar Chart PNG

Description

Creates a horizontal bar chart comparing percent contribution and permutation importance for each environmental variable, replicating `density/Runner.java::makeJackknifePlots()`.

Usage

```
maxent_plot_variable_importance(
  contributions_df,
  perm_imp_df,
  species,
  output_dir
)
```

Arguments

contributions_df	A data.frame with columns name and contribution (from maxent_percent_contribution).
perm_imp_df	A data.frame with columns name and permutation_importance (from maxent_permutation_importance).
species	Character: species name (used in the filename).
output_dir	Character: directory under which a plots/ sub-directory will be created.

Value

Invisibly returns the path to the PNG file.

Examples

```
maxent_plot_variable_importance(contrib, perm_imp,
  species = "Sp1", output_dir = tempdir())
```

maxent_predict	<i>Predict with a trained FeaturedSpace model</i>
----------------	---

Description

Computes raw Gibbs distribution scores for new environmental data.

Usage

```
maxent_predict(fs_ptr, new_data)
```

Arguments

fs_ptr	External pointer to a trained FeaturedSpace object.
new_data	Numeric matrix with one row per new point and one column per feature (values must be pre-evaluated, i.e., the feature transformation already applied).

Value

Numeric vector of raw scores (unnormalized).

maxent_predict_model	<i>Predict with a Trained MaxEnt Model</i>
----------------------	--

Description

Computes raw Gibbs distribution scores for new environmental data, using the feature lambdas stored in the trained FeaturedSpace.

Usage

```
maxent_predict_model(featured_space, newdata)
```

Arguments

featured_space	External pointer to a trained FeaturedSpace object.
newdata	Numeric matrix: one row per new point, one column per feature. Column values must be the <i>already-evaluated</i> feature values (e.g., from running <code>maxent_feature_eval()</code> for each feature and each point).

Value

Numeric vector of raw (unnormalized) prediction scores.

Examples

```
# After training, predict on 5 new points with 2 features each
newdata <- matrix(runif(10), nrow = 5, ncol = 2)
preds <- maxent_predict_model(fs, newdata)
```

maxent_print_results *Print Maxent Model Results*

Description

Prints a summary of Maxent model performance metrics to the console, replicating the style of the **dismo** package's MaxEnt output. The report includes sample counts, training (and optionally test) evaluation statistics, and a ranked variable-contributions table.

Usage

```
maxent_print_results(
  species,
  eval_result,
  contributions_df,
  perm_imp_df,
  n_presence,
  n_background,
  test_eval_result = NULL,
  n_test = 0L,
  fit_result = NULL
)
```

Arguments

species	Character: species name.
eval_result	Named list returned by maxent_evaluate (training predictions vs background).
contributions_df	Data.frame with columns name and contribution (from maxent_percent_contribution).
perm_imp_df	Data.frame with columns name and permutation_importance (from maxent_permutation_importance).
n_presence	Integer: number of training presence records.
n_background	Integer: number of background records.
test_eval_result	Named list returned by maxent_evaluate for test data, or NULL (default).
n_test	Integer: number of test presence records (default 0L).
fit_result	Named list returned by maxent_fit or NULL. Used to report regularized training gain and entropy.

Value

Invisibly returns a named list with all reported metrics.

Examples

```
maxent_print_results(
  species      = "Sp1",
  eval_result  = maxent_evaluate(pres_preds, bg_preds),
  contributions_df = contrib,
  perm_imp_df  = perm_imp,
  n_presence   = length(pres_rows),
  n_background  = length(bg_rows))
```

maxent_product_feature

Create a Product Feature

Description

Creates an interaction feature between two environmental variables: $\text{eval}(i) = \text{norm}(\text{values1}[i]) * \text{norm}(\text{values2}[i])$.

Usage

```
maxent_product_feature(
  values1,
  values2,
  name,
  min1 = NULL,
  max1 = NULL,
  min2 = NULL,
  max2 = NULL
)
```

Arguments

values1	Numeric vector for the first environmental variable.
values2	Numeric vector for the second environmental variable (must have the same length as values1).
name	Character string: feature name/identifier.
min1	Minimum of the first variable. If NULL (default), computed as $\min(\text{values1})$.
max1	Maximum of the first variable. If NULL (default), computed as $\max(\text{values1})$.
min2	Minimum of the second variable. If NULL (default), computed as $\min(\text{values2})$.
max2	Maximum of the second variable. If NULL (default), computed as $\max(\text{values2})$.

Value

External pointer to a ProductFeature C++ object.

Examples

```
temp <- c(0, 5, 10)
prec <- c(100, 200, 150)
f <- maxent_product_feature(temp, prec, "temp_x_prec")
maxent_feature_eval(f, 2)
```

maxent_project_cloglog

Project Model onto Grids (Cloglog Output)

Description

Applies the Java Maxent cloglog transform to grid predictions:

$$cloglog = 1 - \exp(-\exp(H) \cdot raw)$$

Usage

```
maxent_project_cloglog(model, env_grids, feature_names)
```

Arguments

model External pointer to a FeaturedSpace object.
 env_grids List of external pointers to Grid<float> objects.
 feature_names Character vector of environment variable names.

Details

where H is the model entropy and raw is the normalised probability. This matches the cloglog output of Java Maxent and **dismo**, and is the recommended output for reporting.

Value

External pointer to a Grid<float> with cloglog scores in [0, 1].

See Also

[maxent_project_raw](#), [maxent_project_logistic](#)

 maxent_project_logistic

Project Model onto Grids (Logistic Output)

Description

Applies the Java Maxent logistic transform to grid predictions:

$$\text{logistic} = \frac{\exp(H) \cdot \text{raw}}{1 + \exp(H) \cdot \text{raw}}$$

Usage

```
maxent_project_logistic(model, env_grids, feature_names)
```

Arguments

model External pointer to a FeaturedSpace object.
 env_grids List of external pointers to Grid<float> objects.
 feature_names Character vector of environment variable names.

Details

where H is the model entropy and raw is the normalised probability. This matches the logistic output of Java Maxent and **dismo**.

Value

External pointer to a Grid<float> with logistic scores in [0, 1].

See Also

[maxent_project_raw](#), [maxent_project_cloglog](#)

 maxent_project_raw

Project Model onto Grids (Raw Output)

Description

Produces Java Maxent "raw" scores for every grid cell:

$$\text{raw} = \frac{\exp(lp - lpNorm)}{\text{densityNorm}}$$

Usage

```
maxent_project_raw(model, env_grids, feature_names)
```

Arguments

model	External pointer to a FeaturedSpace object.
env_grids	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.

Details

This matches the raw output of the Java Maxent software and the **dismo** R package. See `vignette("PREDICTION_SCALES")` or `docs/PREDICTION_SCALES.md` for a full description of prediction scales.

Value

External pointer to a Grid<float> with Java raw scores.

See Also

[maxent_project_cloglog](#), [maxent_project_logistic](#)

maxent_quadratic_feature

Create a Quadratic Feature

Description

Creates a quadratic feature that evaluates to linear_val^2 where $\text{linear_val} = (\text{values}[i] - \text{min}) / (\text{max} - \text{min})$.

Usage

```
maxent_quadratic_feature(values, name, min_val = NULL, max_val = NULL)
```

Arguments

values	Numeric vector of environmental variable values.
name	Character string: feature name/identifier.
min_val	Minimum value for normalization. If NULL (default), computed as <code>min(values)</code> .
max_val	Maximum value for normalization. If NULL (default), computed as <code>max(values)</code> .

Value

External pointer to a QuadraticFeature C++ object.

Examples

```
vals <- c(0, 5, 10)
f <- maxent_quadratic_feature(vals, "temperature_sq")
maxent_feature_eval(f, 2) # evaluates at index 2 (1-based -> 0-based: 1)
```

maxent_raster_sample_indices

Convert occurrence coordinates to 0-based stream indices

Description

Maps occurrence cell indices (as produced by `terra::cellFromXY`) into 0-based indices within the concatenated stream of finite (non-NA) background cells emitted by `maxent_featured_space_from_rast`.

Usage

```
maxent_raster_sample_indices(rast, cells)
```

Arguments

`rast` A `terra::SpatRaster`.
`cells` Integer vector of 1-based cell indices (as returned by `terra::cellFromXY`).

Value

Integer vector of 0-based indices within the finite-cell stream. Occurrence cells that fall on NA raster values (and therefore never appear in the stream) are silently dropped and a warning is emitted.

maxent_read_asc

Read an ESRI ASCII Grid File

Description

Reads a `.asc` raster file into a `GridFloat` object.

Usage

```
maxent_read_asc(filename)
```

Arguments

`filename` Character: path to the `.asc` file.

Value

External pointer to a `GridFloat` C++ object.

Examples

```
g <- maxent_read_asc("bio1.asc")
info <- maxent_grid_info(g)
print(info)
```

maxent_read_grid	<i>Read a Grid File (Auto-Detect Format)</i>
------------------	--

Description

Reads a raster grid file. The format is detected from the file extension. Currently supports .asc (ESRI ASCII Grid).

Usage

```
maxent_read_grid(filename)
```

Arguments

filename	Character: path to the grid file.
----------	-----------------------------------

Value

External pointer to a GridFloat C++ object.

maxent_read_lambdas	<i>Read feature lambdas from a file</i>
---------------------	---

Description

Restores model coefficients from a .lambdas file. The FeaturedSpace must have been created with the same features (same names and order).

Usage

```
maxent_read_lambdas(fs_ptr, filename)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
filename	Character: path to the lambdas file.

Value

Called for side effects; returns invisibly.

 maxent_read_occurrences

Read Species Occurrence Data

Description

Reads species presence records from a CSV file or an R data . frame and converts them to row/column indices suitable for [maxent_featured_space](#).

Usage

```
maxent_read_occurrences(
  file_or_df,
  dim,
  lon_col = "longitude",
  lat_col = "latitude",
  name_col = NULL
)
```

Arguments

file_or_df	Either a character path to a CSV file, or a data . frame already loaded in R (e.g. from <code>rgbif::occ_data()</code> , GBIF download, or <code>read.csv()</code>).
dim	A <code>GridDimension</code> object (from maxent_dimension) defining the study area grid.
lon_col	Character: name of the longitude column (default "longitude").
lat_col	Character: name of the latitude column (default "latitude").
name_col	Character or NULL: column for sample names. If NULL (default), sequential names are generated.

Value

A named list with:

samples List of Sample external pointers.

rows Integer vector of row indices (0-based).

cols Integer vector of column indices (0-based).

indices Integer vector of 0-based flat indices ($\text{row} * \text{ncols} + \text{col}$), suitable for [maxent_featured_space](#).

Examples

```
dim <- maxent_dimension(100, 100, -120, 35, 0.1)
occ <- data.frame(longitude = c(-118.5, -119.0),
                 latitude = c(36.5, 37.0))
result <- maxent_read_occurrences(occ, dim)
result$indices # 0-based flat indices for FeaturedSpace
```

maxent_response_curve *Compute Marginal Response Curve*

Description

Generates a response curve by varying one environmental variable from its minimum to maximum value while holding all other variables at their mean. Applies the Java Maxent cloglog transform, matching the output of Java Maxent and **dismo**:

$$\text{cloglog} = 1 - \exp(-\exp(H) \cdot \text{raw})$$

Usage

```
maxent_response_curve(
  model,
  env_grids,
  feature_names,
  var_index,
  n_steps = 100L
)
```

Arguments

model	External pointer to a FeaturedSpace object.
env_grids	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.
var_index	0-based index of the variable to vary.
n_steps	Number of steps across the variable range (default 100).

Value

A data.frame with columns:

value Environmental variable value

prediction Cloglog-transformed prediction

See Also

[maxent_response_curve_fixed](#)

Examples

```
curve <- maxent_response_curve(model, list(g1, g2),
  c("temp", "precip"), var_index = 0)
plot(curve$value, curve$prediction, type = "l")
```

 maxent_response_curve_fixed

Compute Response Curve with Fixed Values

Description

Like `maxent_response_curve` but the user supplies explicit fixed values for the non-target variables. Applies the Java Maxent cloglog transform, matching the output of Java Maxent and **dismo**:

$$\text{cloglog} = 1 - \exp(-\exp(H) \cdot \text{raw})$$

Usage

```
maxent_response_curve_fixed(
  model,
  fixed_values,
  feature_names,
  var_index,
  var_min,
  var_max,
  n_steps = 100L
)
```

Arguments

<code>model</code>	External pointer to a <code>FeaturedSpace</code> object.
<code>fixed_values</code>	Numeric vector of fixed values for each variable.
<code>feature_names</code>	Character vector of environment variable names.
<code>var_index</code>	0-based index of the variable to vary.
<code>var_min</code>	Minimum value of the target variable.
<code>var_max</code>	Maximum value of the target variable.
<code>n_steps</code>	Number of steps (default 100).

Value

A `data.frame` with columns: `value`, `prediction`.

See Also

[maxent_response_curve](#)

maxent_run

Run a Complete Maxent Species Distribution Modelling Workflow

Description

Provides a single high-level entry point that mirrors running the Java Maxent GUI with one click. Starting from raw environmental grids and occurrence records, the function:

1. Reads and validates occurrence records.
2. Samples background points.
3. Extracts environmental values and builds features.
4. Trains the Maxent model.
5. Projects the model onto the full landscape (cloglog output).
6. Evaluates model performance (AUC).
7. Computes percent contribution and permutation importance.
8. Writes all standard output files (lambdas, prediction PNG, response curve PNGs, omission CSV, sample-predictions CSV, and maxentResults.csv).
9. Prints a performance summary to the console.

Usage

```
maxent_run(
  species,
  env_grids,
  occ_df,
  output_dir,
  lon_col = "long",
  lat_col = "lat",
  n_background = 10000L,
  types = c("linear", "quadratic", "hinge"),
  n_hinges = 15L,
  max_iter = 500L,
  seed = 42L,
  bias_weights = NULL,
  response_curves = TRUE,
  pictures = TRUE
)
```

Arguments

species	Character: species name (used in file names and the console report).
env_grids	Named list of external pointers to Grid<float> objects. The <i>names</i> of the list are used as the environmental variable names.
occ_df	A data.frame (or CSV path) with occurrence records.

output_dir	Character: directory where all output files are written (created if it does not exist).
lon_col	Character: longitude column name in occ_df (default "long").
lat_col	Character: latitude column name in occ_df (default "lat").
n_background	Integer: number of background points (default 10000).
types	Character vector of feature types passed to <code>maxent_generate_features</code> (default <code>c("linear", "quadratic", "hinge")</code>).
n_hinges	Integer: number of hinge knots (default 15).
max_iter	Integer: maximum training iterations (default 500).
seed	Integer: random seed for background sampling (default 42).
bias_weights	Optional numeric vector of per-background-point bias weights. Must have length equal to <code>n_background</code> (the background points only, not including occurrence points). When supplied, the background density is weighted by $\text{bias}[i] * \exp(\log[\text{bias}[i]] - \log[\text{pn}])$, mirroring Java Maxent's <code>biasFile</code> . Pass NULL (default) for uniform (unbiased) background.
response_curves	Logical: write response curve PNGs (default TRUE).
pictures	Logical: write prediction map PNG (default TRUE).

Value

A named list with:

model Trained `FeaturedSpace` external pointer.

fit_result List returned by `maxent_fit`.

evaluation List returned by `maxent_evaluate`.

contributions `Data.frame` of percent contributions.

permutation_importance `Data.frame` of permutation importances.

output_dir The output directory used.

Examples

```
stack_path      <- system.file("extdata", "stack_1_12_crop.rds",
                             package = "maxentcpp")
example_rasters <- terra::unwrap(readRDS(stack_path))
grids <- list(
  bio1 = maxent_grid_from_terra(example_rasters[[1]]),
  bio12 = maxent_grid_from_terra(example_rasters[[2]])
)
data(example_occ_df)

result <- maxent_run(
  species      = "Abeillia_abeillei",
  env_grids    = grids,
  occ_df       = example_occ_df,
  output_dir   = tempdir(),
```

```

lon_col = "long",
lat_col = "lat")

result$evaluation$auc

```

maxent_sample *Create a MaxEnt Sample Object*

Description

Creates a sample point representing a species occurrence location.

Usage

```
maxent_sample(lon, lat, name = "", dim = NULL)
```

Arguments

lon	Longitude coordinate
lat	Latitude coordinate
name	Sample identifier/name
dim	Optional GridDimension object to calculate row/col indices

Value

Sample object (external pointer)

Examples

```
sample <- maxent_sample(lon = -118.5, lat = 36.5, name = "site1")
```

maxent_save_lambdas *Save Model Lambdas to File*

Description

Writes the trained model coefficients (lambdas) to a CSV file in the standard Maxent .lambdas format.

Usage

```
maxent_save_lambdas(featured_space, file)
```

Arguments

featured_space External pointer to a trained FeaturedSpace object.
 file Character: path to the output file.

Value

Invisibly returns the output file path.

Examples

```
maxent_save_lambdas(fs, tempfile(fileext = ".lambdas"))
```

maxent_sequential_fit *Train a MaxEnt Model with the Java-Equivalent Sequential Optimizer*

Description

Runs the full density.Sequential optimizer ported from the original Java Maxent 3.4.4 on a FeaturedSpace. Unlike maxent_fit(), which uses the historical goodAlpha-only loop, this trainer reproduces the real Java optimizer: feature selection via deltaLossBound, Newton step with 1-D line search (searchAlpha), every-10-iteration doParallelUpdate with undo on loss-violating batch steps, and per-feature state tracking.

Usage

```
maxent_sequential_fit(  
  featured_space,  
  max_iter = 500L,  
  convergence = 1e-05,  
  beta_multiplier = 1,  
  min_deviation = 0.001,  
  parallel_update_frequency = 10L,  
  disable_convergence_test = FALSE,  
  trajectory_iterations = integer(0)  
)
```

Arguments

featured_space External pointer to a FeaturedSpace object (from maxent_featured_space()).
 max_iter Maximum number of iterations (default 500L).
 convergence Convergence threshold on the per-20-iteration loss improvement (default 1e-5). Ignored when disable_convergence_test = TRUE.
 beta_multiplier Regularization multiplier (default 1.0).
 min_deviation Minimum sample-deviation floor used in regularization (default 0.001).

`parallel_update_frequency`
Iteration frequency at which `doParallelUpdate` runs (default 10L, matching Java).

`disable_convergence_test`
Logical: when TRUE, the loop runs a fixed `max_iter` iterations with no early stop. This is required for deterministic per-iteration trajectory comparisons against the Java oracle. Default FALSE.

`trajectory_iterations`
Integer vector of 1-based iteration indices at which to capture (loss, entropy, lambdas) snapshots. May be empty. Snapshots outside `[1, max_iter]` are silently dropped.

Details

The lambda trajectory produced by this trainer matches the Java oracle's to 10^{-6} on $\|\Delta\lambda\|_\infty$ at every checkpoint, on both the symmetric and asymmetric fixtures in `maxentcppCompTest` — see `docs/ARCHITECTURE_xtensor_openmp.md` and the Phase C baseline report for details.

Value

Named list with:

loss Final regularized loss (scalar).

entropy Shannon entropy of the trained distribution.

iterations Number of training iterations completed.

converged Logical: whether the convergence threshold was reached (always FALSE when `disable_convergence_test = TRUE`).

lambdas Numeric vector of final lambda values.

trajectory A data.frame with one row per captured checkpoint and columns `iteration`, `loss`, `entropy`, `lambda_0`, `lambda_1`, ..., `lambda_{J-1}`.

See Also

[maxent_fit](#), [maxent_featured_space](#).

Examples

```
fs <- maxent_featured_space(100L, 90:99, list(f))
res <- maxent_sequential_fit(
  fs,
  max_iter           = 500L,
  disable_convergence_test = TRUE,
  trajectory_iterations = c(1L, 2L, 5L, 10L, 50L, 100L, 500L))
print(res$trajectory)
```

maxent_set_sample_expectations

Set sample expectations for a FeaturedSpace

Description

Computes sample expectations and regularization deviations for each feature. Called automatically by maxent_train(), but exposed for advanced use.

Usage

```
maxent_set_sample_expectations(
    fs_ptr,
    beta_multiplier = 1,
    min_deviation = 0.001
)
```

Arguments

fs_ptr External pointer to a FeaturedSpace object.
beta_multiplier Regularization multiplier (default 1.0).
min_deviation Minimum sample deviation (default 0.001).

Value

Called for side effects; returns invisibly.

maxent_space_info

Get FeaturedSpace Information

Description

Returns basic metadata about a FeaturedSpace object.

Usage

```
maxent_space_info(featured_space)
```

Arguments

featured_space External pointer to a FeaturedSpace object.

Value

Named list with: num_points, num_samples, num_features, density_normalizer, linear_predictor_normalizer.

maxent_square_error *Compute Mean Squared Error*

Description

Presence sites contribute $(1 - \text{pred})^2$, absence sites contribute pred^2 .

Usage

```
maxent_square_error(presence, absence)
```

Arguments

presence	Numeric vector of prediction scores at presence sites.
absence	Numeric vector of prediction scores at absence sites.

Value

Mean squared error.

Examples

```
maxent_square_error(c(1.0, 1.0), c(0.0, 0.0)) # 0.0
```

maxent_threshold_feature
 Create a Threshold Feature

Description

Creates a binary step feature: $\text{eval}(i) = 1$ if $\text{values}[i] > \text{threshold}$, else 0.

Usage

```
maxent_threshold_feature(values, name, threshold)
```

Arguments

values	Numeric vector of environmental variable values.
name	Character string: feature name/identifier.
threshold	The threshold value.

Value

External pointer to a ThresholdFeature C++ object.

Examples

```
vals <- c(1, 5, 10, 3)
f <- maxent_threshold_feature(vals, "temperature_threshold", threshold = 5)
maxent_feature_eval(f, 3) # values[3] = 10 > 5 -> 1
```

maxent_train

Train a FeaturedSpace model

Description

Runs the sequential coordinate-ascent MaxEnt optimization.

Usage

```
maxent_train(
  fs_ptr,
  max_iter = 500L,
  convergence = 1e-05,
  beta_multiplier = 1,
  min_deviation = 0.001
)
```

Arguments

`fs_ptr` External pointer to a FeaturedSpace object.

`max_iter` Maximum number of training iterations (default 500).

`convergence` Convergence threshold (default 1e-5).

`beta_multiplier` Regularization multiplier (default 1.0).

`min_deviation` Minimum sample deviation floor (default 0.001).

Value

Named list with elements: loss, entropy, iterations, converged, lambdas.

maxent_train_terra *Train MaxEnt directly from a terra SpatRaster*

Description

High-level convenience wrapper that builds a streaming FeaturedSpace from rast, maps occurrence locations to finite-stream sample indices, and trains with [maxent_fit](#).

Usage

```
maxent_train_terra(
  rast,
  occurrences,
  lon_col = "longitude",
  lat_col = "latitude",
  feature_types = c("linear", "quadratic", "product", "threshold", "hinge"),
  n_thresholds = 10L,
  n_hinges = 10L,
  max_iter = 500L,
  convergence = 1e-05,
  beta_multiplier = 1,
  min_deviation = 0.001
)
```

Arguments

rast	A terra::SpatRaster.
occurrences	Either a two-column matrix/data.frame (x,y) or a vector of 1-based raster cell indices.
lon_col	Longitude column name when occurrences is a data.frame.
lat_col	Latitude column name when occurrences is a data.frame.
feature_types	Feature type set passed to feature generation.
n_thresholds	Number of threshold knots.
n_hinges	Number of hinge knots.
max_iter	Maximum training iterations.
convergence	Convergence threshold.
beta_multiplier	Regularization multiplier.
min_deviation	Minimum deviation floor.

Value

A named list with training results plus model and sample_indices.

 maxent_variable_ranges

Compute Variable Ranges from Grids

Description

Scans all valid cells in the grids to determine the [min, max] range of each environmental variable.

Usage

```
maxent_variable_ranges(env_grids)
```

Arguments

env_grids List of external pointers to Grid<float> objects.

Value

A data.frame with columns: min, max (one row per variable).

 maxent_write_asc

Write a Grid to ESRI ASCII Format

Description

Writes a GridFloat to a .asc file.

Usage

```
maxent_write_asc(grid, filename, scientific = TRUE)
```

Arguments

grid External pointer to a GridFloat object.
 filename Character: output file path.
 scientific Logical: use scientific notation for floating-point values (default TRUE).

Value

Invisibly returns the output file path.

Examples

```
maxent_write_asc(g, tempfile(fileext = ".asc"))
```

maxent_write_lambdas *Write feature lambdas to a file*

Description

Saves the trained model coefficients in CSV format compatible with the original Java Maxent .lambdas file format.

Usage

```
maxent_write_lambdas(fs_ptr, filename)
```

Arguments

fs_ptr	External pointer to a trained FeaturedSpace object.
filename	Character: path to the output file.

Value

Called for side effects; returns invisibly.

maxent_write_omission_csv
Write an Omission / Threshold CSV

Description

Computes cumulative predictions at all background + presence locations and derives nine standard threshold statistics, writing the result to <output_dir>/<species>_omission.csv. The output format mirrors density/Runner.java::writeCumulativeIndex().

Usage

```
maxent_write_omission_csv(
  model,
  env_grids,
  feature_names,
  presence_rows,
  presence_cols,
  output_dir,
  species,
  test_rows = NULL,
  test_cols = NULL
)
```

Arguments

model	External pointer to a trained FeaturedSpace object.
env_grids	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.
presence_rows	Integer vector of presence row indices (0-based).
presence_cols	Integer vector of presence column indices (0-based).
output_dir	Character: directory for output files.
species	Character: species name (used in the filename).
test_rows	Integer vector of test row indices (0-based) or NULL (default).
test_cols	Integer vector of test column indices (0-based) or NULL (default).

Value

Invisibly returns the path to the written CSV file.

Examples

```
maxent_write_omission_csv(model, list(g1, g2), c("bio1", "bio12"),
  pres_rows, pres_cols, output_dir = tempdir(), species = "Sp1")
```

maxent_write_prediction_png

Write a Maxent Prediction Grid as a PNG Image

Description

Converts a GridFloat prediction grid to a colour PNG image using the canonical Maxent colour ramp (red = high, blue = low). Optionally overlays presence and test-point locations, and renders a small legend.

Usage

```
maxent_write_prediction_png(
  grid,
  filename,
  presence_rows = NULL,
  presence_cols = NULL,
  test_rows = NULL,
  test_cols = NULL,
  mode = "plain",
  legend = TRUE,
  width = 800L,
  height = 600L
)
```

Arguments

grid	External pointer to a GridFloat prediction grid (e.g. from <code>maxent_project_cloglog</code>).
filename	Character: path for the output PNG file.
presence_rows	Integer vector of presence row indices (0-based) or NULL (default).
presence_cols	Integer vector of presence column indices (0-based) or NULL (default).
test_rows	Integer vector of test-set row indices (0-based) or NULL (default).
test_cols	Integer vector of test-set column indices (0-based) or NULL (default).
mode	Colour mode passed to <code>maxent_color_ramp</code> : one of "plain" (default), "log", "blackandwhite", or "redandyellow".
legend	Logical: draw a colour-bar legend (default TRUE).
width	Integer: PNG width in pixels (default 800).
height	Integer: PNG height in pixels (default 600).

Value

Invisibly returns filename.

Examples

```
pred <- maxent_project_cloglog(model, list(g1, g2), c("bio1", "bio12"))
maxent_write_prediction_png(pred, tempfile(fileext = ".png"))
```

```
maxent_write_sample_predictions
      Write Sample Predictions CSV
```

Description

Computes model predictions at presence (and optionally test) locations and writes `<output_dir>/<species>_samplePredi`

Usage

```
maxent_write_sample_predictions(
  model,
  env_grids,
  feature_names,
  presence_rows,
  presence_cols,
  output_dir,
  species,
  test_rows = NULL,
  test_cols = NULL
)
```

Arguments

model	External pointer to a trained FeaturedSpace object.
env_grids	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.
presence_rows	Integer vector of presence row indices (0-based).
presence_cols	Integer vector of presence column indices (0-based).
output_dir	Character: directory for the output file.
species	Character: species name (used in the filename).
test_rows	Integer vector of test row indices (0-based) or NULL (default).
test_cols	Integer vector of test column indices (0-based) or NULL (default).

Value

Invisibly returns the path to the written CSV.

Examples

```
maxent_write_sample_predictions(model, list(g1, g2), c("bio1", "bio12"),
  pres_rows, pres_cols, output_dir = tempdir(), species = "Sp1")
```

print.maxent_sample *Print Sample Information*

Description

Print Sample Information

Usage

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

Arguments

x	Sample object
...	Additional arguments (ignored)

Value

Invisibly returns x.

project_cloglog	<i>Project Model onto Grids (Java-compatible cloglog output)</i>
-----------------	--

Description

Applies the Java Maxent cloglog formula: $\text{cloglog_java} = 1 - \exp(-\exp(H) * \text{raw_java})$

Usage

```
project_cloglog(fs_ptr, grid_ptrs, feature_names)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
grid_ptrs	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.

Details

where H is the model entropy and raw_java is the normalised probability. This matches the cloglog output of Java Maxent and dismo.

Value

External pointer to a Grid<float> with Java cloglog scores in [0, 1].

project_logistic	<i>Project Model onto Grids (Java-compatible logistic output)</i>
------------------	---

Description

Applies the Java Maxent logistic formula: $\text{logistic_java} = (\exp(H) * \text{raw_java}) / (1 + \exp(H) * \text{raw_java})$

Usage

```
project_logistic(fs_ptr, grid_ptrs, feature_names)
```

Arguments

fs_ptr	External pointer to a FeaturedSpace object.
grid_ptrs	List of external pointers to Grid<float> objects.
feature_names	Character vector of environment variable names.

Details

where H is the model entropy and `raw_java` is the normalised probability. This matches the logistic output of Java Maxent and `dismo`.

Value

External pointer to a `Grid<float>` with Java logistic scores in $[0, 1]$.

project_raw	<i>Project Model onto Grids (Java-compatible raw output)</i>
-------------	--

Description

Applies a trained `FeaturedSpace` model to produce Java Maxent "raw" scores: $\text{raw_java} = \exp(\text{lp} - \text{lpNorm}) / \text{densityNorm}$

Usage

```
project_raw(fs_ptr, grid_ptrs, feature_names)
```

Arguments

fs_ptr	External pointer to a <code>FeaturedSpace</code> object.
grid_ptrs	List of external pointers to <code>Grid<float></code> objects.
feature_names	Character vector of environment variable names.

Details

This matches the raw output of the Java Maxent software and the `dismo` R package.

Value

External pointer to a `Grid<float>` with Java raw scores.

sample_get_feature *Get feature value from a sample*

Description

Get feature value from a sample

Usage

```
sample_get_feature(sample_ptr, feature_name, default_val = 0)
```

Arguments

sample_ptr	External pointer to Sample
feature_name	Name of the feature
default_val	Default value if feature not found

Value

Feature value

sample_set_feature *Set feature value on a sample*

Description

Set feature value on a sample

Usage

```
sample_set_feature(sample_ptr, feature_name, value)
```

Arguments

sample_ptr	External pointer to Sample
feature_name	Name of the feature
value	Feature value

Value

Called for side effects; returns invisibly.

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