

Package ‘GEVcdn’

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Type Package

Title GEV Conditional Density Estimation Network

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Description Implements a flexible nonlinear modelling framework for nonstationary generalized extreme value analysis in hydroclimatology following Cannon (2010) <doi:10.1002/hyp.7506>.

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R topics documented:

GEVcdn-package	2
gevcdn.bag	2
gevcdn.bootstrap	5
gevcdn.cost	8
gevcdn.evaluate	9
gevcdn.fit	10
gevcdn.identity	13
gevcdn.initialize	14
gevcdn.logistic	14
gevcdn.reshape	15

Index	16
--------------	-----------

Description

Parameters in a Generalized Extreme Value (GEV) distribution are specified as a function of covariates using a conditional density estimation network (CDN), which is a probabilistic variant of the multilayer perceptron neural network. If the covariate is time or is dependent on time, then the GEV CDN model can be used to perform nonlinear, nonstationary GEV analysis of hydrological or climatological time series. Owing to the flexibility of the neural network architecture, the model is capable of representing a wide range of nonstationary relationships, including those involving interactions between covariates. Model parameters are estimated by generalized maximum likelihood, an approach that is tailored to the estimation of GEV parameters from geophysical time series.

Details

Procedures for fitting GEV CDN models are provided by the functions [gevcdn.fit](#) and [gevcdn.bag](#). Once a model has been developed, [gevcdn.evaluate](#) is used to evaluate the GEV distribution parameters as a function of covariates. Confidence intervals for GEV parameters and specified quantiles can be estimated using [gevcdn.bootstrap](#). All other functions are used internally and should not normally need to be called directly by the user.

Note: the GEV distribution functions are provided by the [VGAM](#) package. The convention for the sign of the shape parameter is opposite to that used in hydrology and thus differs from Cannon (2010).

References

- Cannon, A.J., 2010. A flexible nonlinear modelling framework for nonstationary generalized extreme value analysis in hydroclimatology. *Hydrological Processes*, 24: 673-685. DOI: 10.1002/hyp.7506
- Cannon, A.J., 2011. GEVcdn: an R package for nonstationary extreme value analysis by generalized extreme value conditional density estimation network, *Computers & Geosciences*, 37: 1532-1533. DOI: 10.1016/j.cageo.2011.03.005

See Also

[VGAM](#)

Description

Used to fit an ensemble of GEV CDN models using bootstrap aggregation (bagging) and, optionally, early stopping.

Usage

```
gevcdn.bag(x, y, iter.max = 1000, iter.step = 10,
           n.bootstrap = 30, n.hidden = 3, Th = gevcdn.logistic,
           fixed = NULL, init.range = c(-0.25, 0.25),
           scale.min = .Machine$double.eps, beta.p = 3.3,
           beta.q = 2, sd.norm = Inf,
           method = c("BFGS", "Nelder-Mead"), max.fails = 100,
           silent = TRUE, ...)
```

Arguments

<code>x</code>	covariate matrix with number of rows equal to the number of samples and number of columns equal to the number of variables.
<code>y</code>	column matrix of target values with number of rows equal to the number of samples.
<code>iter.max</code>	maximum number of iterations of optimization algorithm.
<code>iter.step</code>	number of iterations between which the value of the cost function is calculated on the out-of-bootstrap samples; used during stopped training.
<code>n.bootstrap</code>	number of ensemble members trained during bootstrap aggregation (bagging).
<code>n.hidden</code>	number of hidden nodes in each GEV CDN ensemble member.
<code>Th</code>	hidden layer transfer function; defaults to gevcdn.logistic .
<code>fixed</code>	vector indicating GEV parameters to be held constant; elements chosen from <code>c("location", "scale", "shape")</code>
<code>init.range</code>	range for random weights on <code>[min(init.range), max(init.range)]</code>
<code>scale.min</code>	minimum allowable value for the GEV scale parameter.
<code>beta.p</code>	shape1 parameter for shifted beta distribution prior for GEV shape parameter
<code>beta.q</code>	shape2 parameter for shifted beta distribution prior for GEV shape parameter
<code>sd.norm</code>	sd parameter for normal distribution prior for the magnitude of input-hidden layer weights; equivalent to weight penalty regularization.
<code>method</code>	optimization method for optim function; must be chosen from <code>c("BFGS", "Nelder-Mead")</code> .
<code>max.fails</code>	maximum number of repeated exceptions allowed during optimization.
<code>silent</code>	logical value indicating whether or not cost function information should be reported every <code>iter.step</code> iterations.
<code>...</code>	additional arguments passed to the control list of optim function.

Details

Bootstrap aggregation (bagging) (Breiman, 1996) is used as an alternative to [gevcdn.fit](#) for fitting an ensemble of nonstationary GEV CDN models (Cannon, 2010). Each ensemble member is trained on bootstrapped `x` and `y` sample pairs. As an added check on overfitting, early stopping, whereby training is stopped prior to convergence of the optimization algorithm, can be turned on. In this case, the "best" iteration for stopping optimization is chosen based on model performance on out-of-bag samples. Additional details on the bagging/early stopping procedure can be found in Cannon

and Whitfield (2001, 2002). Unlike `gevcn.fit`, where models of increasing complexity are fitted and the one that satisfies some model selection criterion is chosen for final use, model selection in `gevcn.bag` is implicit. Ensemble averaging and, optionally, early stopping are used to limit model complexity. One need only set `n.hidden` to avoid underfitting.

Note: values of `x` and `y` need not be standardized or rescaled by the user. All variables are automatically scaled to range between 0 and 1 prior to fitting and parameters are automatically rescaled by `gevcn.evaluate`.

Value

a list of length `n.bootstrap` with elements consisting of

W1 input-hidden layer weights
W2 hidden-output layer weights

Attributes indicating the minimum/maximum values of `x` and `y`; the values of `Th`, `fixed`, `scale.min`; a logical value `stopped.training` indicating whether or not early stopping was used; and the minimum value of the cost function on the out-of-bag samples `cost.valid` are also returned.

References

- Breiman, L., 1996. Bagging predictors. *Machine Learning*, 24(2): 123-140. DOI: 10.1007/BF00058655
- Cannon, A.J., 2010. A flexible nonlinear modelling framework for nonstationary generalized extreme value analysis in hydroclimatology. *Hydrological Processes*, 24: 673-685. DOI: 10.1002/hyp.7506
- Cannon, A.J. and P.H. Whitfield, 2001. Modeling transient pH depressions in coastal streams of British Columbia using neural networks, 37(1): 73-89. DOI: 10.1111/j.1752-1688.2001.tb05476.x
- Cannon, A.J. and P.H. Whitfield, 2002. Downscaling recent streamflow conditions in British Columbia, Canada using ensemble neural network models. *Journal of Hydrology*, 259: 136-151. DOI: 10.1016/S0022-1694(01)00581-9

See Also

[gevcn.cost](#), [gevcn.evaluate](#), [gevcn.fit](#), [gevcn.bootstrap](#), [dgev](#), [optim](#)

Examples

```
## Generate synthetic data, quantiles

x <- as.matrix(seq(0.1, 1, length = 50))

loc <- x^2
scl <- x/2
shp <- seq(-0.1, 0.3, length = length(x))

set.seed(100)
y <- as.matrix(rgev(length(x), location = loc, scale = scl,
                    shape = shp))
q <- sapply(c(0.1, 0.5, 0.9), qgev, location = loc, scale = scl,
            shape = shp)
```

```

## Not run:
## Fit ensemble of models with early stopping turned on

weights.on <- gevcdn.bag(x = x, y = y, iter.max = 100,
                        iter.step = 10, n.bootstrap = 10,
                        n.hidden = 2)

parms.on <- lapply(weights.on, gevcdn.evaluate, x = x)

## 10th, 50th, and 90th percentiles

q.10.on <- q.50.on <- q.90.on <- matrix(NA, ncol=length(parms.on),
                                       nrow=nrow(x))

for(i in seq_along(parms.on)){
  q.10.on[,i] <- qgev(p = 0.1,
                    location = parms.on[[i]][,"location"],
                    scale = parms.on[[i]][,"scale"],
                    shape = parms.on[[i]][,"shape"])
  q.50.on[,i] <- qgev(p = 0.5,
                    location = parms.on[[i]][,"location"],
                    scale = parms.on[[i]][,"scale"],
                    shape = parms.on[[i]][,"shape"])
  q.90.on[,i] <- qgev(p = 0.9,
                    location = parms.on[[i]][,"location"],
                    scale = parms.on[[i]][,"scale"],
                    shape = parms.on[[i]][,"shape"])
}

## Plot data and quantiles

matplot(cbind(y, q, rowMeans(q.10.on), rowMeans(q.50.on),
              rowMeans(q.90.on)), type = c("b", rep("l", 6)),
        lty = c(1, rep(c(1, 2, 1), 2)),
        lwd = c(1, rep(c(3, 2, 3), 2)),
        col = c("red", rep("orange", 3), rep("blue", 3)),
        pch = 19, xlab = "x", ylab = "y",
        main = "gevcdn.bag (early stopping on)")

## End(Not run)

```

gevcdn.bootstrap	<i>Bootstrapped confidence intervals for GEV CDN parameters and quantiles</i>
------------------	---

Description

Used to assist in the calculation of bootstrapped confidence intervals for GEV location, scale, and shape parameters, as well as for specified quantiles. Residual and parametric bootstrap estimates are supported.

Usage

```
gevcdn.bootstrap(n.bootstrap, x, y, iter.max = 1000, n.hidden = 2,
  Th = gevcdn.logistic, fixed = NULL,
  init.range = c(-0.25, 0.25),
  scale.min = .Machine$double.eps,
  beta.p = 3.3, beta.q = 2, sd.norm = Inf,
  n.trials = 5, method = c("BFGS", "Nelder-Mead"),
  boot.method = c("residual", "parametric"),
  init.from.prev = TRUE, max.fails = 100,
  probs = c(0.01, 0.05, 0.1, 0.25, 0.5, 0.75, 0.9,
  0.95, 0.99), ...)
```

Arguments

n.bootstrap	number of bootstrap trials used to calculate confidence intervals.
x	covariate matrix with number of rows equal to the number of samples and number of columns equal to the number of variables.
y	column matrix of target values with number of rows equal to the number of samples.
iter.max	maximum number of iterations of optimization algorithm.
n.hidden	number of hidden nodes in each GEV CDN ensemble member.
Th	hidden layer transfer function; defaults to gevcdn.logistic .
fixed	vector indicating GEV parameters to be held constant; elements chosen from c("location", "scale", "shape")
init.range	range for random weights on [min(init.range), max(init.range)]
scale.min	minimum allowable value for the GEV scale parameter.
beta.p	shape1 parameter for shifted beta distribution prior for GEV shape parameter
beta.q	shape2 parameter for shifted beta distribution prior for GEV shape parameter
sd.norm	sd parameter for normal distribution prior for the magnitude of input-hidden layer weights; equivalent to weight penalty regularization.
n.trials	number of repeated trials used to avoid shallow local minima during optimization
method	optimization method for optim function; must be chosen from c("BFGS", "Nelder-Mead").
boot.method	bootstrap method; must be chosen from c("residual", "parametric").
init.from.prev	logical value indicating whether or not optimization runs should be initialized from the final weights of the previous run.
max.fails	maximum number of repeated exceptions allowed during optimization
probs	vector of cumulative probabilities for which quantile confidence intervals are desired.
...	additional arguments passed to the control list of optim function

Details

Note: the [boot](#) package provides a more comprehensive suit of methods for estimating bootstrap-based confidence intervals.

Value

a list consisting of

`weights.bootstrap`

a list of length `n.bootstrap` consisting of weights following the format returned by [gevcdn.fit](#)

`parms.bootstrap`

a list of length `n.bootstrap` consisting of GEV parameters following the format returned by [gevcdn.evaluate](#)

`location.bootstrap`

a matrix of GEV location parameters with number of rows equal to that of `x` and number of columns equal to `n.bootstrap`

`scale.bootstrap`

a matrix of GEV scale parameters with number of rows equal to that of `x` and number of columns equal to `n.bootstrap`

`shape.bootstrap`

a matrix of GEV shape parameters with number of rows equal to that of `x` and number of columns equal to `n.bootstrap`

`quantiles.bootstrap`

a list of length `n.bootstrap` with each consisting of a matrix with number of rows equal to that of `x` and columns corresponding to `probs`

References

Cannon, A.J., 2010. A flexible nonlinear modelling framework for nonstationary generalized extreme value analysis in hydroclimatology. *Hydrological Processes*, 24: 673-685. DOI: 10.1002/hyp.7506

See Also

[gevcdn.cost](#), [gevcdn.evaluate](#), [gevcdn.fit](#), [gevcdn.bag](#), [dgev](#), [optim](#)

Examples

```
## Generate synthetic data

x <- as.matrix(seq(0.1, 1, length = 50))

loc <- x^2
scl <- x/2
shp <- seq(-0.1, 0.3, length = length(x))

set.seed(100)
y <- as.matrix(rgev(length(x), location = loc, scale = scl,
                    shape = shp))
```

```

## Not run:
## Fit 30 bootstrapped models

CI <- gevcdn.bootstrap(n.bootstrap = 30, x = x, y = y,
                      iter.max = 100, n.hidden = 2,
                      Th = gevcdn.logistic, n.trials = 1,
                      boot.method = "residual",
                      probs = c(0.1, 0.5, 0.9))

## Plot data and percentile confidence intervals for GEV parameters

par(mfrow = c(2, 2))
matplot(x, y, type = "b", pch = 19, col = "red", xlab = "x",
        ylab = "y", main = "gevcdn.bootstrap")
matplot(x, cbind(loc, t(apply(CI$location.bootstrap, 1, quantile,
                             p = c(0.025, 0.975))))), type = c("l", "b", "b"), pch = 20,
        lwd = 3, col = c("black", rep("green", 2)), xlab = "x",
        ylab = "location", main = "location CI")
matplot(x, cbind(scl, t(apply(CI$scale.bootstrap, 1, quantile,
                             p = c(0.025, 0.975))))), type = c("l", "b", "b"), pch = 20,
        lwd = 3, col = c("black", rep("orange", 2)), xlab = "x",
        ylab = "scale", main = "scale CI")
matplot(x, cbind(shp, t(apply(CI$shape.bootstrap, 1, quantile,
                             p = c(0.025, 0.975))))), type = c("l", "b", "b"), pch = 20,
        lwd = 3, col = c("black", rep("brown", 2)), xlab = "x",
        ylab = "shape", main = "shape CI")

## End(Not run)

```

gevcdn.cost

Cost function for GEV CDN model fitting

Description

The generalized maximum likelihood (GML) cost function used for GEV CDN model fitting (Martins and Stedinger, 2000). Calculates the negative of the logarithm of the GML, which includes a shifted beta distribution prior for the GEV shape parameter. A normal distribution prior can also be set for the magnitude of the input-hidden layer weights, thus leading to weight penalty regularization.

Usage

```
gevcdn.cost(weights, x, y, n.hidden, Th, fixed, scale.min, beta.p,
           beta.q, sd.norm)
```

Arguments

`weights` weight vector of length returned by [gevcdn.initialize](#).

x	covariate matrix with number of rows equal to the number of samples and number of columns equal to the number of variables.
y	column matrix of target values with number of rows equal to the number of samples.
n.hidden	number of hidden nodes in the GEV CDN model.
Th	hidden layer transfer function; defaults to gevcdn.logistic .
fixed	vector indicating GEV parameters to be held constant; elements chosen from <code>c("location", "scale", "shape")</code>
scale.min	minimum allowable value for the GEV scale parameter.
beta.p	shape1 parameter for shifted beta distribution prior for GEV shape parameter.
beta.q	shape2 parameter for shifted beta distribution prior for GEV shape parameter.
sd.norm	sd parameter for normal distribution prior for the magnitude of input-hidden layer weights; equivalent to weight penalty regularization.

References

Martins, E.S. and J.R. Stedinger, 2000. Generalized maximum-likelihood generalized extreme-value quantile estimators for hydrologic data. *Water Resources Research*, 36: 737-744. DOI: 10.1029/1999WR900330

See Also

[gevcdn.fit](#), [gevcdn.bag](#), [dgev](#), [optim](#)

gevcdn.evaluate	<i>Evaluate parameters from trained GEV CDN model</i>
-----------------	---

Description

Evaluate a trained GEV CDN model, resulting in a matrix with columns corresponding to the location, scale, and shape parameters of the GEV distribution.

Usage

```
gevcdn.evaluate(x, weights)
```

Arguments

x	covariate matrix with number of rows equal to the number of samples and number of columns equal to the number of variables.
weights	list containing GEV CDN input-hidden and hidden-output layer weight matrices from gevcdn.fit or gevcdn.bag .

Value

a matrix with number of rows equal to that of `x` and columns corresponding to the GEV location, scale, and shape parameters.

References

Cannon, A.J., 2010. A flexible nonlinear modelling framework for nonstationary generalized extreme value analysis in hydroclimatology. *Hydrological Processes*, 24: 673-685. DOI: 10.1002/hyp.7506

See Also

[gevcdn.fit](#), [gevcdn.bag](#), [dgev](#)

Examples

```
# Generate synthetic data

x <- as.matrix(1:50)
y <- as.matrix(rgev(length(x), location = 0, scale = 1, shape = 0.2))

## Fit stationary model

weights <- gevcdn.fit(x = x, y = y, Th = gevcdn.identity,
                     fixed = c("location", "scale", "shape"))

## Evaluate GEV parameters

parms <- gevcdn.evaluate(x, weights)
cat("GEV parameters", parms[1,], "\n")
```

gevcdn.fit

Fit a GEV CDN model

Description

Fit a GEV CDN model via nonlinear optimization of the generalized maximum likelihood cost function.

Usage

```
gevcdn.fit(x, y, iter.max = 1000, n.hidden = 2,
           Th = gevcdn.logistic, fixed = NULL,
           init.range = c(-0.25, 0.25),
           scale.min = .Machine$double.eps, beta.p = 3.3,
           beta.q = 2, sd.norm = Inf, n.trials = 5,
           method = c("BFGS", "Nelder-Mead"), max.fails = 100, ...)
```

Arguments

<code>x</code>	covariate matrix with number of rows equal to the number of samples and number of columns equal to the number of variables.
<code>y</code>	column matrix of target values with number of rows equal to the number of samples.
<code>iter.max</code>	maximum number of iterations of optimization algorithm.
<code>n.hidden</code>	number of hidden nodes in the GEV CDN model.
<code>Th</code>	hidden layer transfer function; defaults to <code>gevcdn.logistic</code> .
<code>fixed</code>	vector indicating GEV parameters to be held constant; elements chosen from <code>c("location", "scale", "shape")</code>
<code>init.range</code>	range for random weights on <code>[min(init.range), max(init.range)]</code>
<code>scale.min</code>	minimum allowable value for the GEV scale parameter.
<code>beta.p</code>	shape1 parameter for shifted beta distribution prior for GEV shape parameter.
<code>beta.q</code>	shape2 parameter for shifted beta distribution prior for GEV shape parameter.
<code>sd.norm</code>	sd parameter for normal distribution prior for the magnitude of input-hidden layer weights; equivalent to weight penalty regularization.
<code>n.trials</code>	number of repeated trials used to avoid shallow local minima during optimization
<code>method</code>	optimization method for <code>optim</code> function; must be chosen from <code>c("BFGS", "Nelder-Mead")</code> .
<code>max.fail</code>	maximum number of repeated exceptions allowed during optimization
<code>...</code>	additional arguments passed to the control list of <code>optim</code> function

Details

Fit a nonstationary GEV CDN model (Cannon, 2010) by minimizing a cost function based on the generalized maximum likelihood of Martins and Stedinger (2000). The hidden layer transfer function `Th` should be set to `gevcdn.logistic` for a nonlinear model and to `gevcdn.identity` for a linear model. In the nonlinear case, the number of hidden nodes `n.hidden` controls the overall complexity of the model. GEV parameters can be held constant (i.e., stationary) via the `fixed` argument. The form of the shifted beta distribution prior for the GEV shape parameter is controlled by the `beta.p` and `beta.q` arguments. By default, these are set to values used in Cannon (2010). Other alternatives include values recommended by Martins and Stedinger (2000) (`beta.p = 9` and `beta.q = 6`) or values following from the normal distribution reported by Papalexioiu and Koutsoyiannis (2013) (`beta.p = 71.1` and `beta.q = 44.7`). Weight penalty regularization for the magnitude of the input-hidden layer weights can be applied by setting `sd.norm` to a value less than `Inf`.

Values of the Akaike information criterion (AIC), Akaike information criterion with small sample size correction (AICc), and Bayesian information criterion (BIC) are calculated to assist in model selection. It is possible for such criteria to fail in the face of overfitting, for example with a nonlinear model and `n.hidden` set too high, as the GEV distribution may converge on one or more samples. This can usually be diagnosed by inspecting the scale parameter for near zero values. In this case, one can apply a weight penalty (via `sd.norm`), although this rules out the use of AIC/AICc/BIC for model selection as the effective number of model parameters will no longer equal the number of

weights in the GEV CDN model. Alternatively, a lower threshold (as a proportion of the range of y) for the scale parameter can be set via `scale.min`. Finally, bootstrap aggregation is available via `gevcdn.bag` as a second method for fitting GEV CDN models.

Note: values of x and y need not be standardized or rescaled by the user. All variables are automatically scaled to range between 0 and 1 prior to fitting and parameters are automatically rescaled by `gevcdn.evaluate`.

Value

a list consisting of

W1	input-hidden layer weights
W2	hidden-output layer weights

Attributes indicating the minimum/maximum values of x and y ; the values of `Th`, `fixed`, `scale.min`; the negative of the logarithm of the generalized maximum likelihood GML, the negative of the logarithm of the likelihood NLL, the value of the penalty term `penalty`, the Bayesian information criterion BIC, the Akaike information criterion with (AICc) and without (AIC) small sample size correction; and the number of model parameters k are also returned.

References

Cannon, A.J., 2010. A flexible nonlinear modelling framework for nonstationary generalized extreme value analysis in hydroclimatology. *Hydrological Processes*, 24: 673-685. DOI: 10.1002/hyp.7506

Martins, E.S. and J.R. Stedinger, 2000. Generalized maximum-likelihood generalized extreme-value quantile estimators for hydrologic data. *Water Resources Research*, 36:737-744. DOI: 10.1029/1999WR900330

Papalexiou, S.M. and Koutsoyiannis, D., 2013. Battle of extreme value distributions: A global survey on extreme daily rainfall. *Water Resources Research*, 49(1), 187-201. DOI: 10.1029/2012WR012557

See Also

[gevcdn.cost](#), [gevcdn.evaluate](#), [gevcdn.bag](#), [gevcdn.bootstrap](#), [dgev](#), [optim](#)

Examples

```
## Generate synthetic data, quantiles
x <- as.matrix(seq(0.1, 1, length = 50))

loc <- x^2
scl <- x/2
shp <- seq(-0.1, 0.3, length = length(x))

set.seed(100)
y <- as.matrix(rgev(length(x), location = loc, scale = scl,
                    shape = shp))
q <- sapply(c(0.1, 0.5, 0.9), qgev, location = loc, scale = scl,
            shape = shp)

## Define a hierarchy of models of increasing complexity
```

```

models <- vector("list", 4)
# Stationary model
models[[1]] <- list(Th = gevcdn.identity,
                  fixed = c("location", "scale", "shape"))
# Linear model
models[[2]] <- list(Th = gevcdn.identity)
# Nonlinear, 1 hidden node
models[[3]] <- list(n.hidden = 1, Th = gevcdn.logistic)
# Nonlinear, 2 hidden nodes
models[[4]] <- list(n.hidden = 2, Th = gevcdn.logistic)

## Fit models

weights.models <- vector("list", length(models))
for(i in seq_along(models)){
  weights.models[[i]] <- gevcdn.fit(x = x, y = y, n.trials = 1,
                                  n.hidden = models[[i]]$n.hidden,
                                  Th = models[[i]]$Th,
                                  fixed = models[[i]]$fixed)
}

## Select model with minimum AICc

models.AICc <- sapply(weights.models, attr, which = "AICc")
weights.best <- weights.models[[which.min(models.AICc)]]
parms.best <- gevcdn.evaluate(x, weights.best)

## 10th, 50th, and 90th percentiles

q.best <- sapply(c(0.1, 0.5, 0.9), qgev,
                location = parms.best[, "location"],
                scale = parms.best[, "scale"],
                shape = parms.best[, "shape"])

## Plot data and quantiles

matplot(x, cbind(y, q, q.best), type = c("b", rep("l", 6)),
        lty = c(1, rep(c(1, 2, 1), 2)),
        lwd = c(1, rep(c(3, 2, 3), 2)),
        col = c("red", rep("orange", 3), rep("blue", 3)),
        pch = 19, xlab = "x", ylab = "y", main = "gevcdn.fit")

```

gevcdn.identity

Identity function

Description

gevcdn.identity computes a trivial identity function. Used as the hidden layer transfer function for linear GEV CDN models.

Usage

```
gevcdn.identity(x)
```

Arguments

x a numeric vector

See Also

[gevcdn.logistic](#)

gevcdn.initialize *Initialize GEV CDN weight vector*

Description

Random initialization of the weight vector used during fitting of the GEV CDN model.

Usage

```
gevcdn.initialize(x, n.hidden, init.range)
```

Arguments

x covariate matrix with number of rows equal to the number of samples and number of columns equal to the number of variables.

n.hidden number of hidden nodes in the GEV CDN model.

init.range range for random weights on $[\min(\text{init.range}), \max(\text{init.range})]$

See Also

[gevcdn.reshape](#)

gevcdn.logistic *Logistic sigmoid function*

Description

gevcdn.logistic computes the logistic sigmoid (S-shaped) function. Used as the hidden layer transfer function for nonlinear GEV CDN models.

Usage

```
gevcdn.logistic(x)
```

Arguments

x a numeric vector

See Also

[gevcdn.identity](#)

gevcdn.reshape *Reshape a GEV CDN weight vector*

Description

Reshapes a weight vector used during fitting of the GEV CDN model into input-hidden and hidden-output layer weight matrices.

Usage

```
gevcdn.reshape(x, weights, n.hidden)
```

Arguments

x covariate matrix with number of rows equal to the number of samples and number of columns equal to the number of variables.

weights weight vector of length returned by [gevcdn.initialize](#).

n.hidden number of hidden nodes in the GEV CDN model.

See Also

[gevcdn.initialize](#)

Index

*Topic **package**

GEVcdn-package, [2](#)

boot, [7](#)

dgev, [4](#), [7](#), [9](#), [10](#), [12](#)

GEVcdn (GEVcdn-package), [2](#)

GEVcdn-package, [2](#)

gevcdn.bag, [2](#), [2](#), [7](#), [9](#), [10](#), [12](#)

gevcdn.bootstrap, [2](#), [4](#), [5](#), [12](#)

gevcdn.cost, [4](#), [7](#), [8](#), [12](#)

gevcdn.evaluate, [2](#), [4](#), [7](#), [9](#), [12](#)

gevcdn.fit, [2-4](#), [7](#), [9](#), [10](#), [10](#)

gevcdn.identity, [11](#), [13](#), [15](#)

gevcdn.initialize, [8](#), [14](#), [15](#)

gevcdn.logistic, [3](#), [6](#), [9](#), [11](#), [14](#), [14](#)

gevcdn.reshape, [14](#), [15](#)

optim, [3](#), [4](#), [6](#), [7](#), [9](#), [11](#), [12](#)

VGAM, [2](#)