Package 'geostats'

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Title An Introduction to Statistics for Geoscientists

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Description
Provides example datasets and code for the introductory statistics module for geoscientists at University College London (UCL). Includes functionality for compositional data, fractals and chaos.

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Depends R (>= 3.5.0)

Imports MASS

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LazyData true

RoxygenNote 7.1.1

Encoding UTF-8

R topics documented:

ACNK *A-CN-K compositions*

Description

Synthetic A (Al2O3), CN (CaO+Na2O), K (K2O) data table

Examples

```
data(ACNK,package='geostats')
ternary(ACNK,type='p',labels=c(expression('Al'[2]*'O'[3]),
                               expression('CaO+Na'[2]*'O'),
                               expression('K'[2]*'O')))
```

AFM *A-F-M data*

Description

(Na2O + K2O) - FeO - MgO compositions of 630 calc-alkali basalts from the Cascade Mountains and 474 tholeiitic basalts from Iceland.

Examples

```
data(AFM,package='geostats')
ternary(AFM[,-1])
```

alr *additive logratio transformation*

Description

maps compositional data from an n-dimensional simplex to an (n-1)-dimensional Euclidean space with Aitchison's additive logratio transformation

Usage

```
alr(dat, inverse = FALSE)
```

Arguments

dat	an n x m matrix
inverse	if TRUE, applies the inverse alr tranformation

Value

if `inverse=FALSE`, returns an `(n-1) x m` matrix of logratios; otherwise returns an `(n+1) x m` matrix of compositional data whose columns add up to 1.

Examples

```
xyz <- rbind(c(0.03,99.88,0.09),
             c(70.54,25.95,3.51),
             c(72.14,26.54,1.32))
colnames(xyz) <- c('a','b','c')
rownames(xyz) <- 1:3
pc <- prcomp(alr(xyz))
biplot(pc)
```

---

boxcount *box counting*

Description

count the number of boxes needed to cover all the 1s in a matrix of 0s and 1s.

Usage

```
boxcount(mat, size)
```

Arguments

`mat`	a square square matrix of 0s and 1s. Must be a power of 2.
`size`	the size (pixels per side) of the boxes. Should be a power of 2.

Examples

```
g <- sierpinski(n=5)
boxcount(mat=g,size=16)
```

Britain *British coast*

Description

a 512 x 512 pixel image of the British coast line

Examples

```
data(Britain,package='geostats')
p <- par(mfrow=c(1,2))
image(Britain)
fractaldim(Britain)
```

cantor *Cantor set*

Description

Calculates or plots a Cantor set of fractal lines.

Usage

```
cantor(n = 5, plot = FALSE, add = FALSE, Y = 0, lty = 1, col = "black", ...)
```

Arguments

n	an integer value controling the number of recursive levels.
plot	logical. If TRUE, the Cantor set is plotted, otherwise a list of breaks and counts is returned.
add	logical (only used if plot=TRUE). If add=FALSE, then a brand new figure is created; otherwise the Cantor set is added to an existing plot.
Y	y-value for the plot (only used if plot=TRUE).
lty	line type (see pars() for details)
col	colour of the Cantor lines.
...	optional arguments to be passed on to matplot or matlines.

Details

The Cantor set is generated using a recursive algorithm that is built on a line segment whose middle third is removed. Each level of recursion replaces each black line by the same pattern.

Value

a square matrix with 0s and 1s.

Examples

```
g <- sierpinski(n=5)
image(g,col=c('white','black'),axes=FALSE,asp=1)
```

`CartToSph` *Convert Cartesian to spherical coordinates based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011. returns the trend (trd) and plunge (plg) of a line for input north (cn), east (ce), and down (cd) direction cosines*

Description

Convert Cartesian to spherical coordinates based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011. returns the trend (trd) and plunge (plg) of a line for input north (cn), east (ce), and down (cd) direction cosines

Usage

```
CartToSph(cn, ce, cd)
```

`circle.plot` *plot circular data*

Description

Plots directional data as ticks on a circle

Usage

```
circle.plot(angles, degrees = FALSE, tl = 0.1, ...)
```

Arguments

`angles`	scalar or vector
`degrees`	`TRUE` for degrees, `FALSE` for radians
`tl`	tick length (value between 0 and 1)
`...`	optional arguments to be passed on to the generic `matlines` function

Details

Produces a circle with angles plotting in a clockwise direction from the top

Examples

```
data(striations,package='geostats')
circle.plot(striations,degrees=TRUE)
```

circle.points *add points to a circular plot*

Description

adds directional data as points on an existing circle plot

Usage

```
circle.points(angles, degrees = FALSE, ...)
```

Arguments

angles	scalar or vector
degrees	TRUE for degrees, FALSE for radians
...	optional arguments to be passed on to the generic points function

Details

adds points to a circle with angles plotting in a clockwise direction from the top

Examples

```
data(striations,package='geostats')
circle.plot(striations,degrees=TRUE)
md <- meanangle(striations,degrees=TRUE)
circle.points(md,pch=22,bg='black')
```

clasts *clast size data*

Description

20 clast size measurements, in cm

Examples

```
data(clasts,package='geostats')
d <- density(log(clasts))
plot(d)
```

clr *centred logratio transformation*

Description

maps compositional data from an n-dimensional simplex to an n-dimensional Euclidean space with Aitchison's centred logratio transformation

Usage

```
clr(dat, inverse = FALSE)
```

Arguments

dat	an n x m matrix
inverse	if TRUE, applies the inverse clr tranformation

Value

an n x m matrix

Examples

```
xyz <- rbind(c(0.03,99.88,0.09),
             c(70.54,25.95,3.51),
             c(72.14,26.54,1.32))
colnames(xyz) <- c('a','b','c')
rownames(xyz) <- 1:3
pc <- prcomp(clr(xyz))
biplot(pc)
```

Corsica *rivers on Corsica*

Description

a 512 x 512 pixel image of the river network on Corsica

Examples

```
data(Corsica,package='geostats')
p <- par(mfrow=c(1,2))
image(Corsica)
fractaldim(Corsica)
```

countQuakes *count the number of earthquakes per year*

Description

counts the number of earthquakes per year that fall between two magnitude limits

Usage

```
countQuakes(qdat, minmag, from, to)
```

Arguments

qdat	a data frame containing columns named mag and year.
minmag	minimum magnitude
from	first year
to	last year

Examples

```
data(declustered,package='geostats')
quakesperyear <- countQuakes(declustered,minmag=5.0,from=1917,to=2016)
table(quakesperyear)
```

declustered *declustered earthquake data*

Description

dataset of 28267 earthquakes between 1769 and 2016, with aftershocks and precursor events removed

References

Mueller, C.S., 2019. Earthquake catalogs for the USGS national seismic hazard maps. Seismological Research Letters, 90(1), pp.251-261.

Examples

```
data(declustered,package='geostats')
quakesperyear <- countQuakes(declustered,minmag=5.0,from=1917,to=2016)
table(quakesperyear)
```

DZ *detrital zircon U-Pb data*

Description

detrital zircon U-Pb data of 5 sand samples from China

Examples

```
data(DZ,package='geostats')
qqplot(DZ[['Y']],DZ[['5']])
```

earthquakes *earthquake data*

Description

dataset of 20000 earthquakes between 2017 and 2000, downloaded from the USGS earthquake database (https://earthquake.usgs.gov/earthquakes/search/).

Examples

```
data(earthquakes,package='geostats')
gutenberg(earthquakes$mag)
```

ellipse *ellipse*

Description

compute the x-y coordinates of an error ellipse

Usage

```
ellipse(mean, cov, alpha = 0.05, n = 50)
```

Arguments

mean	two-element vector with the centre of the ellipse
cov	the 2 x 2 covariance matrix of x and y
alpha	confidence level of the confidence ellipse
n	the number of points at which the ellipse is evaluated

Examples

```
X <- rnorm(100,mean=100,sd=1)
Y <- rnorm(100,mean=100,sd=1)
Z <- rnorm(100,mean=100,sd=5)
dat <- cbind(X/Z,Y/Z)
plot(dat)
ell <- ellipse(mean=colMeans(dat),cov=cov(dat))
polygon(ell)
```

---

exp *exponential transformation*

Description

Map the input from $[-\infty, +\infty]$ to $[0, \infty]$ by taking exponents

Usage

```
## S3 method for class 'density'
exp(x)
```

Arguments

x	an object of class density

Value

an object of class density

Examples

```
data(clasts,package='geostats')
lc <- log(clasts)
ld <- density(lc)
d <- exp(ld)
plot(d)
```

---

fault *fault orientation data*

Description

Ten paired strike and dip measurements (in degrees), drawn from a von Mises - Fisher distribution with mean vector $\mu = \{1, 1, 1\}/\sqrt{3}$ and concentration parameter $\kappa = 200$.

Examples

```
data(fault,package='geostats')
stereoplot(fault,option=2,degrees=TRUE,show.grid=FALSE)
```

Finland *Finnish lake data*

Description

Table of 2327 Finnish lakes, extracted from a hydroLAKES database.

References

Lehner, B., and Doll, P. (2004), Development and validation of a global database of lakes, reservoirs and wetlands, Journal of Hydrology, 296(1), 1-22, doi: 10.1016/j.jhydrol.2004.03.028.

Examples

```
data(Finland,package='geostats')
sf <- sizefrequency(Finland$area)
size <- sf[,'size']
freq <- sf[,'frequency']
plot(size,freq,log='xy')
fit <- lm(log(freq) ~ log(size))
lines(exp(predict(fit)))
```

Forams *foram count data*

Description

Planktic foraminifera counts in surface sediments in the Atlantic ocean.

Examples

```
data(forams,package='geostats')
abundant <- forams[,c('quinqueloba','pachyderma','incompta',
                      'glutinata','bulloides')]
other <- rowSums(forams[,c('uvula','scitula')])
dat <- cbind(abundant,other)
chisq.test(dat)
```

fractaldim *calculate the fractal dimension*

Description

performs box counting on a matrix of 0s and 1s.

Usage

```
fractaldim(mat, plot = TRUE, ...)
```

Arguments

mat	a square matrix of 0s and 1s. Size must be a power of 2.
plot	logical. If TRUE, plots the results on a log-log scale.
...	optional arguments to the generic points function.

Examples

```
g <- sierpinski(n=5)
fractaldim(g)
```

fractures *fractures*

Description

a 512 x 512 pixel image of a fracture network

Examples

```
data(fractures,package='geostats')
p <- par(mfrow=c(1,2))
image(fractures)
fractaldim(fractures)
```

geostats *library(geostats)*

Description

A list of documented functions may be viewed by typing help(package='geostats'). Detailed instructions are provided at https://github.com/pvermees/geostats/.

Author(s)

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GreatCircle *computes the great circle path of a plane in an equal angle or equal area stereonet of unit radius. Basedon the MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011.*

Description

computes the great circle path of a plane in an equal angle or equal area stereonet of unit radius. Basedon the MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011.

Usage

```
GreatCircle(strike, dip, wulff = TRUE)
```

gutenberg *create a Gutenberg-Richter plot*

Description

calculate a semi-log plot with earthquake magnitude on the horizontal axis,and the cumulative number of earthquakes exceeding any given magnitude on the vertical axis.

Usage

```
gutenberg(m, n = 10, ...)
```

Arguments

m	a vector of earthquake magnitudes
n	the number of magnitudes to evaluate
...	optional arguments to the generic points function.

Value

the output of lm with earthquake magnitude as the independent variable (mag) and the logarithm (base 10) of the frequency as the dependent variable (lfreq).

Examples

```
data(declustered,package='geostats')
gutenberg(declustered$mag)
```

koch *Koch snowflake*

Description

Calculates or plots a Koch set of fractal lines.

Usage

```
koch(n = 4, plot = TRUE, res = 512)
```

Arguments

n	an integer value controling the number of recursive levels.
plot	logical. If TRUE, the Koch flake is plotted.
res	the number of pixels in each side of the output matrix

Details

The Koch set is generated using a recursive algorithm that is built on a triangular hat shaped line segment. Each level of recursion replaces each linear segment by the same pattern.

Value

a res x res matrix with 0s and 1s

Examples

```
k <- koch(n=5)
d <- fractaldim(k,plot=FALSE)
print(d)
```

ksdist *Kolmogorov-Smirnov distance matrix*

Description

fills a square matrix with Kolmogorov-Smirnov statistics

Usage

```
ksdist(dat)
```

Arguments

dat	a list of numerical data vectors

Examples

```
data(DZ,package='geostats')
d <- ksdist(DZ)
plot(cmdscale(d))
```

---

logit *logistic transformation*

Description

maps numbers from [0,1] to $[-\infty, +\infty]$ and back

Usage

```
logit(x, ...)

## Default S3 method:
logit(x, inverse = FALSE, ...)

## S3 method for class 'density'
logit(x, inverse = TRUE, ...)
```

Arguments

x	a vector of real numbers (strictly positive if inverse=FALSE)
...	optional arguments to the log function.
inverse	logical. If inverse=FALSE, returns $\ln\left[\frac{x}{1-x}\right]$; otherwise returns $\frac{\exp[x]}{\exp[x]+1}$.

Value

a vector with the same length of x

Examples

```
data(porosity,package='geostats')
lp <- logit(porosity,inverse=FALSE)
ld <- density(lp)
d <- logit(ld,inverse=TRUE)
plot(d)
```

major *composition of Namib dune sand*

Description

major element compositions of 16 Namib sand samples

Examples

```
data(major,package='geostats')
comp <- clr(major)
pc <- prcomp(comp)
biplot(pc)
```

meanangle *von Mises distribution*

Description

returns the probability density of a von Mises distribution

Usage

```
meanangle(angles, degrees = FALSE)
```

Arguments

angles	scalar or vector
degrees	TRUE for degrees, FALSE for radians

Details

the von Mises distribution describes probability distributions on a circle using the following density function:
$\frac{\exp(\kappa \cos(x-\mu))}{2\pi I_0(\kappa)}$
where $I_0(\kappa)$ is a zero order Bessel function

Value

the mean angle, either in radians (if degrees=FALSE), or in degrees.

Examples

```
data(striations,package='geostats')
circle.plot(angles=striations,degrees=TRUE)
circle.points(meanangle(striations,degrees=TRUE),pch=19)
```

Mode *get the mode of a dataset*

Description

compute the most frequently occuring value in a sampling distribution.

Usage

```
Mode(x, categorical = FALSE)
```

Arguments

x	a vector
categorical	logical. If TRUE, returns the most frequently occuring value for categorical variables. If FALSE, returns the value corresponding to the maximimum kernel density for continuous variables

Value

a scalar

Examples

```
data(clasts,package='geostats')
m1 <- Mode(clasts,categorical=TRUE)

m2 <- 1:50
for (i in m2){
   m2[i] <- Mode(rnorm(100),categorical=FALSE)
}
hist(m2)
```

palaeomag *palaeomagnetic data*

Description

Ten paired magnetic declination (azimuth) and inclination (dip) measurements, drawn from a von Mises - Fisher distribution with mean vector $\mu = \{2, 2, 1\}/3$ and concentration parameter $\kappa = 200$.

Examples

```
data(palaeomag,package='geostats')
stereoplot(palaeomag,degrees=TRUE,show.grid=FALSE)
```

PCA2D *Principal Component Analysis of 2D data*

Description

produces a 4-panel summary plot for two dimensional PCA for didactical purposes

Usage

```
PCA2D(X)
```

Arguments

X	a matrix with two columns

Examples

```
X <- rbind(c(-1,7),c(3,2),c(4,3))
colnames(X) <- c('a','b')
PCA2D(X)
```

pendulum *3-magnet pendulum experiment*

Description

simulate the 3-magnet pendulum experiment

Usage

```
pendulum(
  startpos = c(-2, 2),
  startvel = c(0, 0),
  src = rbind(c(0, 0), c(0.5, sqrt(0.75)), c(1, 0)),
  plot = TRUE
)
```

Arguments

startpos	2-element vecotor with the initial position
startvel	2-element vector with the initial velocity
src	n x 2 matrix with the positions of the magnets
plot	logical. If TRUE, generates a plot with the trajectory of the pendulum.

Details

start a pendulumn at a specified position and with a start velocity.

Value

the end position of the pendulum

Examples

```
par(mfrow=c(1,2))
pendulum(startpos=c(2,2))
pendulum(startpos=c(1.9,2))
```

---

pH *pH data*

Description

pH measurements in 20 samples of rain water

Examples

```
data(pH,package='geostats')
hist(pH)
```

---

pole *returns the pole to a plane or the plane which correspond to a pole based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011. trd and plg are in radians*

Description

returns the pole to a plane or the plane which correspond to a pole based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011. trd and plg are in radians

Usage

```
pole(trd, plg, option = 1)
```

porosity *porosity data*

Description

20 porosity measurements, as fractions

Examples

```
data(porosity,package='geostats')
plot(density(logit(porosity)))
```

randy *generate bivariate random data*

Description

returns bivariate datasets from four synthetic distributions that have the shape of a circle, arrow, square and ellipse.

Usage

```
randy(pop = 1, n = 250)
```

Arguments

pop	an integer from 1 to 4 marking the population of choice: 1 = circle, 2 = arrow, 3 = solid square, 4 = ellipse.
n	the number of random draws to be drawn from population pop

Value

a [2xn] matrix of random numbers

Examples

```
p <- par(mfrow=c(1,4))
for (i in 1:4){
   plot(randy(pop=i))
}
par(p)
```

Rbar *calculate $\bar{R}$*

Description

returns $\bar{R}$, a measure of directional concentration

Usage

```
Rbar(angles, degrees = FALSE)
```

Arguments

angles	scalar or vector
degrees	TRUE for degrees, FALSE for radians

Details

Given n directional measurements θ_i,

$\bar{R} = \sqrt{\frac{\sum_{i=1}^{n}(\sin(\theta_i)^2 + cos(\theta_i)^2))}{n}}$

Value

a value between 0 and 1

Examples

```
data(striations,package='geostats')
Rbar(angles=striations,degrees=TRUE)
```

Rbar2kappa *$\bar{R}$ to κ conversion*

Description

converts concentration parameter $\bar{R}$ to κ

Usage

```
Rbar2kappa(R)
```

Arguments

R	a scalar or vector of values between 0 and 1

Details

$\bar{R}$ and κ are two types of concentration parameter that are commonly used in directional data analysis. κ is one of the parameters of the parametric von Mises distribution, which is difficult to estimate from the data. $\bar{R}$ is easier to calculate from data. R2kappa converts $\bar{R}$ to $\bar{\kappa}$ using a lookup table.

Value

value(s) between 0 and $+\infty$

Examples

```
data(striations,package='geostats')
Rbar2kappa(Rbar(striations,degrees=TRUE))
```

---

rbsr *Rb-Sr data*

Description

synthetic dataset of 8 Rb-Sr analysis that form a 1Ga isochron

Examples

```
data(rbsr,package='geostats')
plot(rbsr[,'RbSr'],rbsr[,'SrSr'])
fit <- lm(SrSr ~ RbSr,data=rbsr)
abline(fit)
```

Rotate *Rotate a line by performing a coordinate transformation on vectors. The algorithm was originally written by Randall A. Marrett and implemented in MATLAB by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011. raz = trend of rotation axis rdip = plunge of rotation axis rot = magnitude of rotation trd = trend of the vector to be rotated plg = plunge of the vector to be rotated ans0 = a character indicating whether the line to be rotated is an axis (ans0 = 'a') or a vector (ans0 = 'v')*

Description

Rotate a line by performing a coordinate transformation on vectors. The algorithm was originally written by Randall A. Marrett and implemented in MATLAB by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011. raz = trend of rotation axis rdip = plunge of rotation axis rot = magnitude of rotation trd = trend of the vector to be rotated plg = plunge of the vector to be rotated ans0 = a character indicating whether the line to be rotated is an axis (ans0 = 'a') or a vector (ans0 = 'v')

Usage

```
Rotate(raz, rdip, rot, trd, plg, ans0)
```

`rwyxz` *Spurious correlation*

Description

Calculate the 'null correlation' of ratios

Usage

```
rwyxz(
  mw,
  mx,
  my,
  mz,
  sw,
  sx,
  sy,
  sz,
  rwx = 0,
  rwy = 0,
  rwz = 0,
  rxy = 0,
  rxz = 0,
  ryz = 0
)

ryxy(mx, my, sx, sy, rxy = 0)

rxzyz(mx, my, mz, sx, sy, sz, rxy = 0, rxz = 0, ryz = 0)
```

Arguments

`mw`	the mean of variable `w`
`mx`	the mean of variable `x`
`my`	the mean of variable `y`
`mz`	the mean of variable `z`
`sw`	the standard deviation of variable `w`
`sx`	the standard deviation of variable `x`
`sy`	the standard deviation of variable `y`
`sz`	the standard deviation of variable `z`
`rwx`	the correlation coefficient between `w` and `x`

rwy	the correlation coefficient between w and y
rwz	the correlation coefficient between w and z
rxy	the correlation coefficient between x and y
rxz	the correlation coefficient between x and z
ryz	the correlation coefficient between y and z

Details

Implements the spurious correlation formula of Pearson (1897)

Value

the null correlation coefficient

Examples

```
rxzyz(mx=100,my=100,mz=100,sx=1,sy=1,sz=10)
```

---

sierpinski *Sierpinski carpet*

Description

returns a matrix of 0s and 1s that form a Sierpinski fractal.

Usage

```
sierpinski(n = 5)
```

Arguments

n	an integer value controling the number of recursive levels.

Details

The Sierpinski carpet is two dimensional fractal, which is generated using a recursive algorithm that is built on a grid of eight black squares surrounding a white square. Each level of recursion replaces each black square by the same pattern.

Value

a square matrix with 0s and 1s.

Examples

```
g <- sierpinski(n=5)
image(g,col=c('white','black'),axes=FALSE,asp=1)
```

sizefrequency *calculate the size-frequency distribution of things*

Description

calculate the number of items exceeding a certain size

Usage

```
sizefrequency(dat, n = 10, log = TRUE)
```

Arguments

dat	a numerical vector
n	the number of sizes to evaluate
log	logical. If TRUE, uses a log spacing for the sizes at which the frequencies are evaluated

Value

a data frame with two columns size and frequency

Examples

```
data(Finland,package='geostats')
sf <- sizefrequency(Finland$area)
plot(frequency~size,data=sf,log='xy')
fit <- lm(log(frequency) ~ log(size),data=sf)
lines(x=sf$size,y=exp(predict(fit)))
```

skew *calculate the skewness of a dataset*

Description

compute the third moment of a sampling distribution.

Usage

```
skew(x)
```

Arguments

x	a vector

Value

a scalar

Examples

```
data(porosity,package='geostats')
skew(porosity)
```

`SmallCircle` *Compute the paths of a small circle defined by its axis and cone angle, for an equal angle or equal area stereonet of unit radius. Based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011.*

Description

Compute the paths of a small circle defined by its axis and cone angle, for an equal angle or equal area stereonet of unit radius. Based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011.

Usage

```
SmallCircle(trda, plga, coneAngle, wulff = TRUE)
```

`StCoordLine` *Computes the coordinates of a line on a stereonet. Based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011.*

Description

Computes the coordinates of a line on a stereonet. Based on a MATLAB script written by Nestor Cardozo for the book Structural Geology Algorithms by Allmendinger, Cardozo, & Fisher, 2011.

Usage

```
StCoordLine(trd, plg, wulff = TRUE)
```

stereonet *stereonet*

Description

Plots directional data on a Schmidt equal area or Wulff equal angle stereonet.

Usage

```
stereonet(
  trd,
  plg,
  coneAngle = 0,
  option = 1,
  wulff = TRUE,
  add = FALSE,
  degrees = FALSE,
  show.grid = TRUE,
  grid.col = "grey50",
  tl = 0.05,
  type = "p",
  labels = 1:length(trd),
  ...
)
```

Arguments

trd	trend angle, in degrees, between 0 and 360 (if degrees=TRUE) or between 0 and 2π (if degrees=FALSE).
plg	plunge angle, in degrees, between 0 and 90 (if degrees=TRUE) or between 0 and 2π (if degrees=FALSE).
wulff	logical. If FALSE, produces a Schmidt net.
add	logical. If TRUE, adds to an existing stereonet.
degrees	logical. If FALSE, assumes that azimuth and dip are in radians.
show.grid	logical. If TRUE, decorates the plot with a grid of great and small circles.
grid.col	colour of the grid.
tl	tick length for the N, E, S, W markers (value between 0 and 1). Set to 0 to omit the markers.
type	if option=1 or 3, coordinates can be visualsed as points (type='p'), lines (type='l') or decorated with text labels (type='t').
labels	if option=1 or 3 and type='t', specifies the text labels to be used to mark the measurements on the stereonet.
...	optional arguments to be passed on to the generic points function

Details

The Wulff equal angle polar Lambert projection preserves the shape of objects and is often used to visualise structural data. The Schmidt equal area polar Lambert projection preserves the size of objects and is more popular in mineralogy.

Author(s)

based on the Matlab script by Gerry Middleton

Examples

```
stereonet(azimuth=c(120,80),dip=c(10,30),degrees=TRUE)
```

---

striations *directions of glacial striations*

Description

directions (in degrees) of 30 glacial striation measurements from Madagascar.

Examples

```
data(striations,package='geostats')
circle.plot(striations,degrees=TRUE)
```

---

ternary *ternary diagrams*

Description

plot points, lines or text on a ternary diagram

Usage

```
ternary(xyz = NULL, f = rep(1, 3), labels, add = FALSE, type = "p", ...)
```

Arguments

xyz	an n x 3 matrix or data frame
f	a three-element vector of multipliers for xyz
labels	the text labels for the corners of the ternary diagram
add	if TRUE, adds information to an existing ternary diagram
type	one of 'n' (empty plot), 'p' (points), 'l' (lines) or 't' (text).
...	optional arguments to the points, lines or text functions.

Examples

```
data(ACNK,package='geostats')
ternary(ACNK,type='p',labels=c(expression('Al'[2]*'O'[3]),
                               expression('CaO+Na'[2]*'O'),
                               expression('K'[2]*'O')))
```

`test` *composition of oceanic basalts*

Description

major element compositions of 64 island arc basalts (IAB), 23 mid oceanic ridge basalts (MORB) and 60 ocean island basalts (OIB). This dataset can be used to test supervised learning algorithms.

Examples

```
library(MASS)
data(training,package='geostats')
data(test,package='geostats')
qd <- qda(affinity ~ ., data=training)
pr <- predict(qd,newdata=test[,-1])
table(test$affinity,pr$class)
```

`training` *composition of oceanic basalts*

Description

major element compositions of 227 island arc basalts (IAB), 221 mid oceanic ridge basalts (MORB) and 198 ocean island basalts (OIB). This dataset can be used to train supervised learning algorithms.

Examples

```
library(MASS)
data(training,package='geostats')
qd <- qda(affinity ~ ., data=training)
pr <- predict(qd)
table(training$affinity,pr$class)
```

vonMises *von Mises distribution*

Description

returns the probability density of a von Mises distribution

Usage

```
vonMises(angle, mu = 0, kappa = 1, degrees = FALSE)
```

Arguments

mu	scalar containing the mean direction
kappa	scalar containing the concentration parameter
degrees	TRUE for degrees, FALSE for radians
angles	scalar or vector

Details

the von Mises distribution describes probability distributions on a circle using the following density function:

$\frac{\exp(\kappa \cos(x-\mu))}{2\pi I_0(\kappa)}$

where $I_0(\kappa)$ is a zero order Bessel function

Value

a scalar or vector of the same length as angles

Examples

```
plot(x=c(-1.2,1.2),y=c(-1.2,1.2),type='n',
     axes=FALSE,ann=FALSE,bty='n',asp=1)
a <- seq(from=-pi,to=pi,length.out=200)
d <- vonMises(angle=a,mu=pi/2,kappa=5)
symbols(x=0,y=0,circles=1,add=TRUE,inches=FALSE,xpd=NA,fg='grey50')
lines(x=x0+(1+d)*cos(a),y=(1+d)*sin(a),xpd=NA)
```

worldpop *world population*

Description

The world population from 1750 until 2014

Examples

```
data(worldpop,package='geostats')
plot(worldpop)
```

xyz2xy *get x,y plot coordinates of ternary data*

Description

helper function to generate bivariate plot coordinates for ternary data

Usage

```
xyz2xy(xyz)
```

Arguments

xyz	an n x 3 matrix or data frame

Value

an n x 2 numerical matrix

Examples

```
xyz <- rbind(c(1,0,0),c(0,1,0),c(0,0,1),c(1,0,0))
xy <- xyz2xy(xyz)
plot(xy,type='l',bty='n')
```

york *Linear regression of X,Y-variables with correlated errors*

Description

Implements the unified regression algorithm of York et al. (2004) which, although based on least squares, yields results that are consistent with maximum likelihood estimates of Titterington and Halliday (1979).

Usage

```
york(dat, alpha = 0.05, plot = TRUE, fill = NA, ...)
```

Arguments

dat	a 4 or 5-column matrix with the X-values, the analytical uncertainties of the X-values, the Y-values, the analytical uncertainties of the Y-values, and (optionally) the correlation coefficients of the X- and Y-values.
alpha	cutoff value for confidence intervals.
plot	logical. If true, creates a scatter plot of the data with the best fit line shown on it.
fill	the fill colour of the error ellipses. For additional plot options, use the IsoplotR package.
...	optional arguments for the scatter plot.

Details

Given n pairs of (approximately) collinear measurements X_i and Y_i (for $1 \leq i \leq n$), their uncertainties $s[X_i]$ and $s[Y_i]$, and their covariances cov$[X_i, Y_i]$, the york function finds the best fitting straight line using the least-squares algorithm of York et al. (2004). This algorithm is modified from an earlier method developed by York (1968) to be consistent with the maximum likelihood approach of Titterington and Halliday (1979).

Value

A two-element list of vectors containing:

coef the intercept and slope of the straight line fit

cov the covariance matrix of the coefficients

References

Titterington, D.M. and Halliday, A.N., 1979. On the fitting of parallel isochrons and the method of maximum likelihood. Chemical Geology, 26(3), pp.183-195.

York, Derek, et al., 2004. Unified equations for the slope, intercept, and standard errors of the best straight line. American Journal of Physics 72.3, pp.367-375.

Examples

```
X <- c(1.550,12.395,20.445,20.435,20.610,24.900,
       28.530,50.540,51.595,86.51,106.40,157.35)
Y <- c(.7268,.7849,.8200,.8156,.8160,.8322,
       .8642,.9584,.9617,1.135,1.230,1.490)
n <- length(X)
sX <- X*0.01
sY <- Y*0.005
rXY <- rep(0.8,n)
dat <- cbind(X,sX,Y,sY,rXY)
fit <- york(dat)
```

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