Package 'rPAex'

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Type Package

Title Automatic Detection of Experimental Unit in Precision Agriculture

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Imports raster, agricolae

Description A part of precision agriculture is linked to the spectral image obtained from the cameras. With the image information of the agricultural experiment, the included functions facilitate the collection of spectral data associated with the experimental units. Some designs generated in R are linked to the images, which allows the use of the information of each pixel of the image in the experimental unit and the treatment. Tables and images are generated for the analysis of the precision agriculture experiment during the entire vegetative period of the crop.

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NeedsCompilation no

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R topics documented:

`borderPoint` *Build the Edge Equations the Experimental Plot*

Description

With 4 points and their x and y coordinates of a Raster image, the function constructs the equations of the edge of the experimental plot. Its usefulness is to discriminate the unused area and also to study the responses of the spectrum electromagnetic radiation of the external environment of the area under study.

Usage

```
borderPoint(Q)
```

Arguments

`Q`	list, Matrix, data.frame or arrays with coordinates x,y

Details

The four points can be obtained from a plot with locator(4) function. If the input data is a matrix, its size will be 4 rows and 2 columns.

Value

`models`	list regression linear models

Author(s)

Felipe de Mendiburu

See Also

`externalPoint`, `fixedPoint`, `fourPoint`, `imageField`, `designRaster`, `movePlot`

Examples

```
# use corn crop information
library(rPAex)
crop <- system.file("external/corn.csv", package="rPAex")
s<-read.csv(crop,header = TRUE)
r <- raster::rasterFromXYZ(s)
raster::image(r,useRaster=FALSE,main="Area outside the experimental plot")
#P<-locator(3)
# simulated area
P<-list(x=c(287705.9, 287711.8, 287712.8),y=c(8664203.15, 8664204.8, 8664193.67))
Q<-fourPoint(P)
models<-borderPoint(Q)
```

```
abline(models$m1)
abline(models$m2)
abline(models$m3)
abline(models$m4)
text(Q,cex=2)
```

`designRaster` *Experimental Design on a Raster Image*

Description

It uses a design generated by the agricolae package in a raster image.

Usage

```
designRaster(R,book)
```

Arguments

`R`	output object imageField
`book`	function output field book design.* agricolae

Details

The R object contains the following information: pixel coordinates and image layer information.

The outDesign object is generated by the design functions of the agricolae package

Value

`design`	The matrix R of the image with the experimental design information
`rasterField`	the R matrix of the image with the information of the bands and the characteristics of the experimental design

Author(s)

Felipe de Mendiburu

References

Felipe de Mendiburu (2019). agricolae: Statistical Procedures for Agricultural Research. R package version 1.3-1. http://tarwi.lamolina.edu.pe/~fmendiburu\

Kwanchai A. Gomez, Arturo A. Gomez (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons, new York.

See Also

`externalPoint`, `fixedPoint`, `fourPoint`, `imageField`, `borderPoint`, `movePlot`

Examples

```
library(rPAex)
oldpar<-par(mar=c(2,2,3,2),cex=0.8)
# r = simulated raster image data
prg1 <- system.file("examples/Ex-01.R", package="rPAex")
source(prg1)
r<-data1()

# Alpha design, r-raster image
trt<-1:12
t <- length(trt)
# size block k
k<-3
# Blocks s
s<-t/k
# replications r =2
outdesign<- agricolae::design.alpha(trt,k=3,r=2,serie=1)
r1<-subset(outdesign$book, replication==1)
r2<-subset(outdesign$book, replication==2)
#--------
raster::image(r,main="alpha design in the image\n
with the distribution of treatments",col=col2rgb(10))
#P<-locator(3)
p1<-list(x=c(4.27, 35.42, 47.49),y=c(68.12, 70.82, 23.63))
q1<-fourPoint(p1)
p2<-list(x=c(50.27, 81.42, 93.49),y=c(68.12, 70.82, 23.63))
q2<-fourPoint(p2)
polygon(q1,lwd=3,lty=2,border=colors()[51])
polygon(q2,lwd=3,lty=2,border=colors()[51])
R1<-imageField(r, P=q1, nPl=4, nPw=3, long=10, wide=9,col=colors()[18])
R2<-imageField(r, P=q2, nPl=4, nPw=3, long=10, wide=9,col=colors()[18])
q1<-designRaster(R=R1$Qbase,book=r1)$design
q2<-designRaster(R=R2$Qbase,book=r2)$design
text(q1[,6],q1[,7],q1[,4])
text(q2[,6],q2[,7],q2[,4])
par(oldpar)
```

`externalPoint` *Information Outside the Experimental Plot*

Description

Pixels with information outside the experimental plot under study. The environment outside the study area is important for its explanation of the experimental response.

Usage

```
externalPoint(models,R)
```

Arguments

models	list regression linear models, output borderPoint function
R	Raster image

Details

out points

Value

outpoints	coordenate matrix

Author(s)

Felipe de Mendiburu

See Also

borderPoint, fixedPoint, fourPoint, imageField, designRaster, movePlot

Examples

```
library(rPAex)
#
# for image "tiff" format, see rPAex document
# r <- fileRaster(tiff)
#
crop <- system.file("external/corn.csv", package="rPAex")
s<-read.csv(crop,header = TRUE)
r <- raster::rasterFromXYZ(s)
raster::image(r,useRaster=FALSE,main="Corn crop\nArea outside the experimental plot")
#P<-locator(3)
P<-list(x=c(287705.9, 287711.8, 287712.8),y=c(8664203.15, 8664204.8, 8664193.67))
Q<-fourPoint(P)
polygon(Q,border = "blue")
text(Q)
models<-borderPoint(Q)
out<-externalPoint(models,r)
points(out[,1],out[,2],pch=".")
```

---

fixedPoint *Orientation, Position and Length of the Experimental Unit*

Description

Generates a number of equidistant spatial points in an area. Fixed a couple of points in the image and the number of segments included, the function determines the position of the segments according to the length of the segment. The function relates the real dimension of the segment measurement to the image dimension. The function is useful for sizing plot sizes in the field, it also facilitates the generation of experimental units in the field.

Usage

```
fixedPoint(start, end, npoints, long)
```

Arguments

start	Starting point
end	Point at the end
npoints	Number of points
long	Segment length

Details

This function is used by imageField.

Value

xy	Data vector with the coordinate of the points

See Also

borderPoint, externalPoint, fourPoint, imageField, designRaster, movePlot

Examples

```
library(rPAex)
prg1 <- system.file("examples/Ex-01.R", package="rPAex")
source(prg1)
r<-data1()
oldpar<-par(mar=c(2,2,4,2),cex=0.8)
raster::image(r,col=col2rgb(10),main="Orientation, position and length of the experimental unit")
# P<-locator(2)
P<-list(x=c(20,80),y=c(40,80))
P<-cbind(x=P$x,y=P$y)
Q<-fixedPoint(start = P[1,],end = P[2,],4,long = 10)
x <- Q[,1]; y <- Q[,2]
s <- seq(length(x)-1)  # one shorter than data
segments(x[s], y[s], x[s+1], y[s+1], col= c(1,0),lwd=2)
text(Q,cex=1.5)
text(20,80,"Total length   = 72.11 units")
text(20,70,"total segments = 4")
text(60,40,"   Free space  = 10.7037 units")
text(60,30,"Segment length = 10 units")
text(50,10,"fixedPoint(start ,end ,npoints = 4,long = 10)")
text(20,35,"start",cex=1.5)
text(80,75,"end",cex=1.5)
par(oldpar)
```

fourPoint *Generating the Fourth Point of the Study Plot*

Description

Generate the fourth reference point of the plot according to three defined geo-referential points. This function is important for the correct use of all the functions of the rPAex package. In the image the plot is a parallelogram, the first assigned point must be located in the upper left and continue the second point in the upper right side and the third point in the lower right, always in a clockwise direction.

Usage

```
fourPoint(P)
```

Arguments

P	the three points list

Value

P	matrix, four points

See Also

borderPoint, externalPoint, fixedPoint, imageField, designRaster, movePlot

Examples

```
library(rPAex)
prg1 <- system.file("examples/Ex-01.R", package="rPAex")
source(prg1)
r<-data1()
oldpar<-par(mar=c(2,2,4,2),cex=0.8)
raster::image(r,main="Generating the fourth point of the study plot",col=col2rgb(10))
#P<-locator(3)
P<-list(x=c(20,80,80),y=c(70,80,30))
Q<-fourPoint(P)
polygon(Q,lty=2,density=8)
text(Q,cex=2)
points(Q[4,1],Q[4,2],cex=6,col=2,lwd=2)
par(oldpar)
```

imageField *Matching Pixels With Field Book*

Description

The function uses the raster image of all bands. It generates the limits of the unit and extracts the values of each pixel of the plot n x m units (n, m = 1,2, ...). The function requires the dimensions of the unit observed and the number of units per row (width) and column (length). The result is a table with image information and the characteristics of the experimental unit.

Usage

```
imageField(r, P, nPl, nPw, long, wide,  ploting = TRUE, ...)
```

Arguments

r	raster image
P	References points of de area
nPl	Number of experimental units along the plot (X axis)
nPw	Number of experimental units across the plot (Y axis)
wide	Wide of unit plots
long	Long of unit plots
ploting	Overlap the units in the area, TRUE or FALSE
...	Other parameters the plot

Value

parameters	Parameters of experimental design in precision agriculture
Qbase	Image data frame with location in field

See Also

borderPoint, externalPoint, fixedPoint, fourPoint, designRaster, movePlot

Examples

```
library(rPAex)
crop <- system.file("external/cassava.csv", package="rPAex")
s<-read.csv(crop,header = TRUE)
r <- raster::rasterFromXYZ(s)
#-----
# P<-locator(3)
P<-list(x=c(287698.21, 287700.99, 287702.39), y=c(8664200.68, 8664201.57,8664190.63))
Q<-fourPoint(P)
#-----
nPl<-11; nPw<-3; long=1; wide=0.9
```

```
raster::image(r,useRaster=FALSE,main="Cassava crop\nnear infrared image")
img<-imageField(r, P=Q, nPl, nPw, long, wide, ploting = TRUE, border="blue",lwd=1)
R<-img$Qbase
head(R)
q<-agricolae::tapply.stat(R[,2:3],R[,1],mean)
text(q[,2],q[,3],q[,1],cex=1)
```

---

movePlot *Rotation and Translation of the Plot Position*

Description

The coordinates of the plot generated with the locate() and fourPoint() functions define the experimental units with the field dimensions, In the successive images in time, these may have some difference in position and it is necessary to adapt the experimental units to obtain exactly the information within the unit.

Usage

```
movePlot(Q,q)
```

Arguments

Q	matrix. Four points of the plot as described by the fourPoint function
q	matrix or list. Two points, the first one sets the position and the second the orientation

Details

The matrix Q has the points organized according to the fourPoint function. To know the numbering in the plane, execute text(Q). The first must be the upper left and numbered clockwise.

Value

q	matrix. Four points of the new plot as described by the fourPoint function

Author(s)

Felipe de Mendiburu

See Also

borderPoint, fixedPoint, fourPoint, imageField, designRaster

Examples

```
library(rPAex)
#
prg1 <- system.file("examples/Ex-01.R", package="rPAex")
source(prg1)
r<-data1()
oldpar<-par(mar=c(2,2,4,2),cex=0.8)
raster::image(r,col=col2rgb(10),main="Orientation, position and length of the experimental unit")
P<-list(x=c(23, 68, 78),y=c(77, 85, 45))
Q<-fourPoint(P)
polygon(Q)
R<-imageField(r,Q,3,2,13,22,ploting = TRUE,col=colors()[20])
points(Q[1,1],Q[1,2],cex=3)
q<-list(x=c(30, 60),y=c(70, 80))
arrows(q$x[1],q$y[1],q$x[2],q$y[2],lwd=2,length=0.1)
Qnew<-movePlot(Q,q)
polygon(Qnew,border="brown")
R1<-imageField(r,Qnew,3,2,13,22,ploting = TRUE,col="red",density=20)
points(q$x[1],q$y[1],cex=3)
```

---

rPAex *Automatic Detection of Experimental Unit in Precision Agriculture*

Description

The package contains functions to manage images obtained by remote sensing of the experimental fields. In the field the characteristics of the plot are defined (number of units per row and column and dimensions in meters or other dimension measures). The program uses the information to generate the limits and record the content of the different layers, as well as the coordinates of the pixels and the identification of the observation units in the field. It also allows to extract the experimental designs generated in agricolae package and distribute the treatments in the image according to the distribution of the generated plan. The images used in the examples were obtained from the repository url: https://doi.org/10.21223/P3/UVWVLA, International Potato Center, V1.

Details

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Note

The fileRaster() function converts a TIFF image to raster. You need to install rgdal first then activite. see example.

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References

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F. de Mendiburu. A statistical analisys tool for agricultural research. Masters thesis, Universidad Nacional de Ingenieria. Lima-Peru, 8 2009. Degree in systems engineering.

Richards, J. A. Remote sensing digital image analysis: An introduction. 2012

See Also

externalPoint, fixedPoint, fourPoint, imageField, borderPoint, designRaster, movePlot

Examples

```
# activate fileRaster() function.
# fraster <- system.file("script/fileRaster.R", package="rPAex")
```

```
# source(fraster)
# r<- fileRaster(tiff)
#
# Simple examples of the most important functions
library(rPAex)
# Graeco - latin square design
T1<-c("a","b","c","d")
T2<-c("v","w","x","y")
outdesign <- agricolae::design.graeco(T1,T2,serie=1)
book<-outdesign$book
prg1 <- system.file("examples/Ex-01.R", package="rPAex")
source(prg1)
r<-data1()
oldpar<-par(mar=c(2,2,4,2),cex=0.9)
raster::image(r,main="Graeco - latin square design\n
Treatments T1 (a, b, c, d) and T2 (v, w, x, y)",col=col2rgb(2))
#P<-locator(3)
P<-list(x=c(20,90,80),y=c(80,90,20))
Q<-fourPoint(P)
polygon(Q,lwd=3)
R<-imageField(r, P=Q, nPl=4, nPw=4, long=12, wide=12,col=colors()[18])
q<-designRaster(R$Qbase,book)$design
text(q[,6],q[,7]+2,q[,1])
text(q[,6],q[,7]-2,paste(q[,4],q[,5],sep=" - "))
par(oldpar)
```

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