

Package ‘rPAex’

October 14, 2022

Type Package

Title Automatic Detection of Experimental Unit in Precision
Agriculture

Version 1.0.2

Date 2022-08-18

Maintainer Felipe de Mendiburu <fmendiburu@lamolina.edu.pe>

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.

License GPL

NeedsCompilation no

Author Felipe de Mendiburu [aut, cre],
David Mauricio [aut],
Rodrigo Morales [aut],
Roberto Quiroz [aut]

Repository CRAN

Date/Publication 2022-08-21 02:20:02 UTC

R topics documented:

borderPoint	2
designRaster	3
EUsPoint	5
fixedPoint	6
fourPoint	7
imageField	8
movePlot	9
rPAex	10

borderPoint	<i>Border in the experimental units</i>
-------------	---

Description

Generates the spectral information of the edge of the UEs for analysis of the border effect, it requires the spectral image, the distance of the border and the segmentation of the UEs generated by imageField.

Usage

```
borderPoint(r,Rbook,distance,plotting=TRUE,...)
```

Arguments

r	spectral image
Rbook	Object generated by imageField
distance	distance defining the border of the exterior to the experimental plot
plotting	Logic value to display the image of the border effect around the UEs
...	plot parameter to document the image as main, axis, etc

Details

Set the border in terms of distance in units measured in the field

Value

Qborder	Border bounds matrix
border	dataframe spectral border and that is expressed in the image.

Author(s)

Felipe de Mendiburu

See Also

[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)
# simulated area
P<-list(x=c(287705.9, 287711.8, 287712.8),y=c(8664203.15, 8664204.8, 8664193.67))
Q<-fourPoint(P)
Rbook<-imageField(r,Q,1,1,0,0,plotting=FALSE)
op<-par(mfrow=c(1,2))
out<-borderPoint(r,Rbook,distance=1, main="Border effect")
par(op)
# NDVI in border
ndvi<-with(out$Border, (L1-L2)/(L1+L2))
plt<-out$Border[ndvi>0.5,1:2]
op<-par(mfrow=c(1,1))
w<-raster::rasterFromXYZ(out$Border)
raster::image(w,useRaster=FALSE)
points(plt,cex=0.8,col=colors()[51],pch=20)
par(op)

```

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

[EUsPoint](#), [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, Q=q1, ny=4, nx=3, dy=10, dx=9,col=colors()[18])
R2<-imageField(r, Q=q2, ny=4, nx=3, dy=10, dx=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)
```

EUsPoint*Generates the matrix Q of a particular experimental unit*

Description

The Q matrix is formed by 4 points that limits the Experimental unit, this matrix is used by the imageField function to generate the units, by obtaining the Q matrix of an unit, it is possible to generate subplots of the units.

Usage

```
EUsPoint(Rbook, unit)
```

Arguments

Rbook	object imagenField
unit	constant. number of experimental unit

Value

Q	matrix, four points
---	---------------------

See Also

[imageField](#), [designRaster](#)

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)
#-----
ny<-11; nx<-3; dy=1; dx=0.9
raster::image(r,useRaster=FALSE,main="Cassava crop\nnear infrared image")
Rbook<-imageField(r, Q, ny, nx, dy, dx, plotting = TRUE, border="blue",lwd=1)
# See experimental unit number 12
Q<-EUsPoint(Rbook,unit=12)
polygon(Q,lty=2,density=8)
```

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, segments, length)
```

Arguments

start	Starting point
end	Point at the end
segments	Number of segments
length	Segment length

Details

This function is used by imageField.

Value

xy	Data vector with the coordinate of the points
----	---

See Also

[borderPoint](#), [EUsPoint](#), [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,length = 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 ,segments = 4,length = 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](#), [EUSPoint](#), [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 $n \times m$ units ($n, m = 1, 2, \dots$). 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, Q, ny, nx, dy, dx, start=1, plotting = TRUE, ...)
```

Arguments

r	raster image
Q	References points of de area
ny	Number of experimental units along the plot (y axis)
nx	Number of experimental units across the plot (x axis)
dy	Wide of unit plots
dx	Length of unit plots
start	Number of the first experimental unit
plotting	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
coordinates.unit	The limits of each experimental unit

See Also

[borderPoint](#), [EUSPoint](#), [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)
P1<-list(x=c(287698.21, 287700.99, 287702.39),
         y=c(8664200.68, 8664201.57,8664190.63))
P2<-list(x=c(287701.59, 287704.3, 287705.25),y=c(8664198.5, 8664199.3, 8664191.6))
Q1<-fourPoint(P1)
Q2<-fourPoint(P2)
#-----
dy=1; dx=0.9
raster::image(r,useRaster=FALSE,main="Cassava crop\nnear infrared image")
img1<-imageField(r, Q1, ny=11, nx=3, dy, dx, plotting = TRUE, border="blue",lwd=1)
img2<-imageField(r, Q2, ny=6, nx=3, dy, dx, start=34,plotting = TRUE, border="blue",lwd=1)
R<-rbind(img1$Qbase,img2$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

Package: rPAex
Type: Package
Version: 1.0.2
Date: 2022-08-20
License: GPL

Note

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

Author(s)

Professor Felipe de Mendiburu
Systems Engineer.
Universidad Nacional de Ingenieria Lima-Peru.
Professor Applied Statistics
Universidad Nacional Agraria La Molina, Lima-Peru.

Professor David Mauricio.
Department of Computer Science.
Universidad Nacional Mayor de San Marcos, Lima-Peru

Rodrigo A. Morales A. PhD
Phytopathologist-Sustainable Agriculture
Agricultural Research Institute of Panama (IDIAP)

Professor Roberto Quiroz.
Centro Agronomico Tropical de Investigacion.
CATIE.

References

- Loayza, Hildo; Silva, Luis; Palacios, Susan; Balcazar, Mario; Quiroz, Roberto, 2018, "Dataset for: Modelling crops using high resolution multispectral images", url: <https://doi.org/10.21223/P3/UVWVLA>, International Potato Center, V1.
- M. Montalvo, G. Pajares, J. M. Guerrero, J. Romeo, M. Guijarro, A. Ribeiro, J. J. Ruz, and J. Cruz. Automatic detection of crop rows in maize fields with high weeds pressure. *Expert Systems with Applications*, 39(15):11889-11897, 2012.
- X. Zhang, X. Li, B. Zhang, J. Zhou, G. Tian, Y. Xiong, and B. Gu. Automated robust crop-row detection in maize fields based on position clustering algorithm and shortest path method. *Computers and electronics in agriculture*, 154:165-175, 2018.
- F. de Mendiburu. A statistical analysis 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

[EUsPoint](#), [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$book
prg1 <- system.file("examples/Ex-01.R", package="rPAex")
source(prg1)
r<-data1()
oldpar<-par(mar=c(2,2,4,2),cex=0.9)
raster::image(r,main="Graeco - latin square design\n
Treatments T1 (a, b, c, d) and T2 (v, w, x, y)",col=col2rgb(2))
#P<-locator(3)
P<-list(x=c(20,90,80),y=c(80,90,20))
Q<-fourPoint(P)
polygon(Q,lwd=3)
R<-imageField(r, Q, ny=4, nx=4, dy=12, dx=12,col=colors()[18])
q<-designRaster(R$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)
```

Index

* **design**

- borderPoint, 2
- designRaster, 3
- fixedPoint, 6
- imageField, 8

* **dplot**

- borderPoint, 2
- EUsPoint, 5
- fourPoint, 7
- movePlot, 9

* **package**

- rPAex, 10

borderPoint, 2, 4, 6–8, 10, 12

designRaster, 2, 3, 5–8, 10, 12

EUsPoint, 4, 5, 6–8, 12

fixedPoint, 2, 4, 6, 7, 8, 10, 12

fourPoint, 2, 4, 6, 7, 8, 10, 12

imageField, 2, 4–7, 8, 10, 12

movePlot, 2, 4, 6–8, 9, 12

rPAex, 10

rPAex-package (rPAex), 10