

Package ‘measuRing’

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Type Package

Title Detection and Control of Tree-Ring Widths on Scanned Image
Sections

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Description Identification of ring borders on scanned image sections from dendrochronological samples. Processing of image reflectances to produce gray matrices and time series of smoothed gray values. Luminance data is plotted on segmented images for users to perform both: visual identification of ring borders or control of automatic detection. Routines to visually include/exclude ring borders on the R graphical devices, or automatically detect ring borders using a linear detection algorithm. This algorithm detects ring borders according to positive/negative extreme values in the smoothed time-series of gray values. Most of the in-package routines can be recursively implemented using the multiDetect() function.

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measuRing-package	<i>Detection and Control of Tree-Ring Widths on Scanned Image Sections</i>
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Description

Identification of ring borders on scanned image sections from dendrochronological samples. Processing of image reflectances to produce gray matrices and time series of smoothed gray values. Luminance data is plotted on segmented images for users to perform both: visual identification of ring borders or control of automatic detection. Routines to visually include/exclude ring borders on the R graphical devices, or automatically detect ring borders using a linear detection algorithm. This algorithm detects ring borders according to positive/negative extreme values in the smoothed time-series of gray values. Most of the in-package routines can be recursively implemented using the multiDetect() function.

Details

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Author(s)

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colNarrow

Narrow rings

Description

This function can detect narrow rings in a sequence of tree-ring widths in wood (TRWs). This and other in-package functions are recursively implemented by [multiDetect](#).

Usage

```
colNarrow(rwidths, marker = 5)
```

Arguments

rwidths	a dataframe with the ring widths such as that produced by ringWidths .
marker	a number from 1 to 10. Those rings with scaled averages greater than or equal to this argument will be identified as narrow rings.

Details

Each ring is averaged with those rings on either side of it (t-1,t,t+1), and averages are divided by the highest computed average in the sample; such quotients are scaled from 10 (the narrowest possible ring) to one (the broadest ring).

Value

character vector with the columns in gray matrix corresponding to the narrow rings (see [ringDetect](#), [multiDetect](#), and [plotSegments](#)).

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Examples

```
## (not run) Read one image section in package measuRing:
image1 <- system.file("P105_a.png", package="measuRing")
## (not run) compute a gray matrix from RGB in the image:
gray <- imageTogray(image = image1,ppi=1000)
## (not run) Columns in gray matrix to be included/excluded:
Toinc <- c(196,202,387,1564)
Toexc <- c(21,130,197,207,1444,1484)
## (not run) tree-ring widths:
rwidths <- ringWidths(gray,inclu = Toinc,exclu = Toexc,last.yr=2012)
##(not run) narrow rings:
narrows <- colNarrow(rwidths,marker = 8)
```

crossRings

dplR crossdating

Description

This function implements routines to crossdate TRWs.

Usage

```
crossRings(mdr, smp = 1,
           ncol = 1:length(mdr),
           fun = "corr", ...)
```

Arguments

mdr	list. Set of detected TRWs such as that produced by multiDetect .
smp	numeric or character. Position or name in the set of the sample being cross-dated.
ncol	numeric or character. Positions or names in the set of the TRWs used to crossdate the sample.
fun	character. Function to be implemented. Three functions can be used: corr.rwl.seg ('corr'), ccf.series.rwl ('ccf'), and spag.plot ('spag').
...	arguments to be passed to the function.

Value

output of selected function.

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Examples

```
## Paths to three image sections in the package:
img <- system.file(c("P105_a.tif",
                    "P105_b.tif",
                    "P105_d.tif"),
                  package="measuRing")

## Recursive detection:
mrings <- multiDetect(img,
                      last.yr = 2013,
                      auto.det = TRUE,
                      plot = FALSE)

## corr analysis
crossRings(mrings,
           fun = 'corr',
           seg.length = 10,
           bin.floor = 0,
           lag.max = 2,
           make.plot = FALSE)
```

dataSegments

Data segments

Description

Segmented data sets required by function [plotSegments](#).

Usage

```
dataSegments(image, segs = 1,
             ...)
```

Arguments

image	Either path of an image section or an array representing a gray matrix.
segs	number of image segments.
...	arguments to be passed to three functions: ringWidths , ringBorders , and/or imageTogray .

Value

a list with segmented sets of the gray matrix, the ring borders, and the ring widths (see [plotSegments](#)).

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Examples

```
## (not run) Read one image section in package measuRing:
image1 <- system.file("P105_a.tif", package="measuRing")
## (not run) compute a gray matrix from its RGB:
gray <- imageToGray(image1)
## (not run) Columns in gray matrix to be included/excluded:
Toinc <- c(196,202,387,1564)
Toexc <- c(21,130,197,207,1444,1484)
## (not run) segmented data:
segm <- dataSegments(image1,segs = 3)
lapply(segm,str)
attributes(segm)
```

grayDarker

Gray extremes

Description

This function can detect the extremes of the smoothed gray.

Usage

```
grayDarker(smoothed,
           origin = 0, darker = TRUE)
```

Arguments

smoothed	a data frame with the smoothed gray such as that produced by graySmoothed .
origin	an origin to find the extremes.
darker	logical. If TRUE the function finds the negative extremes. If FALSE the possible extremes are detected.

Value

vector with the columns in gray matrix corresponding to the extremes (see [graySmoothed](#) and [linearDetect](#)).

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Examples

```
## (not run) read one image section:
image1 <- system.file("P105_a.png", package="measuRing")
## (not run) gray matrix from RGB in image:
gray <- imageTogray(image = image1,ppi = 1000)
## (not run) smoothed gray:
smoothed <- graySmoothed(gray)
## (not run) column numbers of possitive and negative extremes:
posit <- grayDarker(smoothed,darker=FALSE)
nega <- grayDarker(smoothed,darker=TRUE)
str(nega)
```

graySmoothed	<i>Smoothed gray</i>
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Description

Averaging, detrending, and smoothing of the columns in a gray matrix.

Usage

```
graySmoothed(image, all = FALSE,
  ...)
```

Arguments

image	character or matrix. Either path of an image section or an array representing a gray matrix.
all	logical. If TRUE the column numbers and moving averages are added to the output.
...	arguments to be passed to imageTogray .

Value

data frame with the smoothed grays. If all is TRUE then the output is extended with the columns in gray matrix, and moving averages.

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Examples

```
## (not run) Read one image section in package measuRing:
image1 <- system.file("P105_a.png", package="measuRing")
## (not run) the smoothed gray:
smoothed <- graySmoothed(image1,ppi=1000)
## (not run) Plot of the smoothed gray:
Smooth <- ts(smoothed)
main. <- 'Smoothed gray'
plot(Smooth,xlab = 'Column', main=main.,
      ylab = 'Smoothed gray',col = 'gray')
```

imageTogray

Gray matrix

Description

This function can compute a gray matrix from the RGB in an image section. Such an image section can be compressed in either portable network graphics format (png) or tagged image file format (tif).

Usage

```
imageTogray(image, ppi = NULL,
             rgb = c(0.3, 0.6,
                    0.1), p.row = 1)
```

Arguments

image	character. path of an image section.
ppi	NULL or integer. If NULL the image resolution in points per inch is extracted from attributes in image. If this attribute is not embedded then users should provide it
rgb	vector with three fractions, all of them adding to one, to combine RGB channels into gray matrix.
p.row	proportion of rows of gray matrix to be processed.

Value

a gray matrix containing the image reflectances.

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Examples

```
## (not run) Read two image sections in package measuRing:
image1 <- system.file("P105_a.tif", package="measuRing")
image2 <- system.file("P105_a.png", package="measuRing")
## (not run) compute a gray matrix:
gray <- imageTogray(image1)
## (not run) - the ppi is embedded in the image:
attributes(gray)
## (not run) but, the ppi is not embedded in image2:
## - imageTogray will return an error:
## (uncomment and run):
## gray2 <- imageTogray(image2)
## attributes(gray2)
## - the ppi should be provided (i.e. ppi = 1200):
gray3 <- imageTogray(image2, ppi = 1200)
attributes(gray3)
##(not run) a plot of the gray matrix
xrange <- range(0:ncol(gray)) + c(-1,1)
yrange <- range(0:nrow(gray)) + c(-1,1)
{plot(xrange, yrange, xlim=xrange, ylim=yrange, xlab='',
      ylab='', type='n', asp=0)
 rasterImage(gray, xrange[1], yrange[1], xrange[2], yrange[2])}
```

lagIngray

First-local lag

Description

This function can compute the lag of the first local on the auto-correlation function (acf) of smoothed grays.

Usage

```
lagIngray(image, acf = FALSE,
          ...)
```

Arguments

image	character or matrix. Either path of an image section or an array representing a gray matrix.
acf	logical. If TRUE the output is extended with the acf.
...	arguments to be passed to imageTogray .

Value

constant value of the first local on the acf of the smoothed gray. If acf is TRUE then the computed acf is added to the output (see [linearDetect](#), and [graySmoothed](#)).

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Examples

```
## (not run) Read one image sample in folder of package measuRing:
image1 <- system.file("P105_a.tif", package="measuRing")
##(not run) First local in the acf of smoothed grays:
local1 <- lagIngray(image1,acf = TRUE)
##(not run) Plot of first local over the acf:
Flocal <- local1[['local']]
Clocal <- ts(local1[['acf']][Flocal,],start=Flocal)
acf <- ts(local1[['acf']],start=1)
{plot(acf,type='h',col='gray',xlab='Lag',main='First local lag')
points(Clocal,pch=19,cex=0.5)}
```

linearDetect

*Linear detection***Description**

Function for developing linear detection of ring borders.

Usage

```
linearDetect(smoothed,
             origin = 0, darker = TRUE)
```

Arguments

smoothed	a data frame with smoothed grays such as that produced by graySmoothed .
origin	numeric. an origin in smoothed gray to find the ring borders.
darker	logical. If TRUE the algorithm uses the negative extremes on smoothed grays to detect the ring borders. If FALSE the possitive extremes are used.

Value

vector with column numbers in gray matrix of the detected ring borders (see [grayDarker](#), and [graySmoothed](#)).

Author(s)

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```

                                auto.det = c(FALSE,TRUE,FALSE),
                                plot = FALSE)

str(mrings)

## Updating the call in mrings using new arguments:
mrings1 <- update(mrings,
                  exclu = list(c(1:4),c(1:4),c(1:4)),
                  last.yr = 2016)

```

plotSegments	<i>Image segments</i>
--------------	-----------------------

Description

One or several plots of consecutive segments of gray matrix and smoothed grays.

Usage

```

plotSegments(image, ratio = NULL,
             marker = NULL, col.marker = "red",
             tit = TRUE, plot = TRUE,
             ...)

```

Arguments

image	character or matrix. Either path of an image section or an array representing a gray matrix.
ratio	NULL or vector with two values representing the aspect of the plots (height, and width). If NULL the default aspect in <code>par()</code> is used.
marker	NULL or a number from 1 to 10 as explained in colNarrow . If numeric then three kind of markers are indicated: those narrow rings with averages major than marker, chronological markers (decades, centuries, and millenia), and the column numbers in gray matrix of the ring borders. The markers are highlighted with the color in <code>col.marker</code> . If NULL no markers are highlighted.
col.marker	color of the markers.
tit	logical or character. A title for the plots. If TRUE the main title is the image name. For more than 1 segment the main title ends with the segment number.
plot	logical. If TRUE the image segments are plotted.
...	arguments to be passed to four functions: dataSegments , ringWidths , ringBorders , and/or imageToGray .

Value

the image segments and a list such as that produced by [dataSegments](#).

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Examples

```
## (not run) Read one image sample in folder of package measuRing:
image1 <- system.file("P105_a.tif", package="measuRing")
## column numbers to be included/avoided:
Toinc <- c(196,202,387,1564)
Toexc <- c(21,130,197,207,1444,1484)
##(not run) Plotting of five image segments:
plots <- plotSegments(image1,rgb=c(0.5,0,0.5),last.yr=2011,
  marker=8,segs=3,inclu = Toinc,exclu = Toexc)
## plots <- plotSegments(rwidths,segs = 4,marker=8)
## (not run) kill all the image segments:
graphics.off()
```

reduceList

ring-width object reduction

Description

ring-width objects are reduced to dplR chronologies.

Usage

```
reducelist(mls, name.ls = "ringWidths",
  empty.rm = TRUE)
```

Arguments

mls	List. Object from <code>multiDetect</code>
name.ls	Character. name of the list to be reduced.
empty.rm	Logical. Remove empty lists.

Value

data frame in wide format with the ring widths.

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Examples

```
## Paths to three image sections in the package:
img <- system.file(c("P105_a.tif",
                    "P105_b.tif",
                    "P105_d.tif"),
                  package="measuRing")

## Recursive detection (arbitrary ring borders and formation years
## are included):
mrings <- multiDetect(img,
                      inclu = list(c(1:40),c(1:30),c(1:41)),
                      last.yr = list(2014, 2013, 2012),
                      auto.det = c(FALSE,TRUE,FALSE),
                      plot = FALSE)

## Reducing the processed ring withs
wide <- reduceList(mrings)
tail(wide)
```

ringBorders

Ring borders

Description

This function can find the ring borders in a gray matrix.

Usage

```
ringBorders(image, auto.det = TRUE,
            darker = TRUE, origin = 0,
            inclu = NULL, exclu = NULL,
            ...)
```

Arguments

image	character or matrix. Either path of an image section or an array ##representing a gray matrix.
auto.det	logical. If TRUE the linear detection is implemented (see linearDetect).
darker	logical. If TRUE the algorithm uses the negative extremes on smoothed grays to detect the ring borders. If FALSE the possitive extremes are used.
origin	numeric. an origin in smoothed gray to find the ring borders.
inclu	NULL or vector with column numbers in gray matrix, other than those automatically detected, to be considered as ring borders.If NULL no column numbers are included.
exclu	NULL or vector with column numbers in gray
...	arguments to be passed to imageTogray .

Value

a data frame with the smoothed grays and the identified ring borders (see [grayDarker](#), [graySmoothed](#), and [linearDetect](#)).

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Examples

```
## (not run) Read one image sample in folder of package
## measuRing:
image1 <- system.file("P105_a.tif", package="measuRing")
## column numbers in gray matrix to be included/avoided:
Toinc <- c(196,202,387,1564)
Toexc <- c(21,130,197,207,1444,1484)
##(not run) the ring borders:
borders <- ringBorders(image1,inclu = Toinc,exclu = Toexc)
str(borders)
##(not run) Plot of smoothed grays with the ring borders:
Smooth <- ts(borders[,1])
includpix <- subset(borders,borders%in%TRUE)
includcol <- as.numeric(rownames(includpix))
xyborders <- data.frame(column=includcol,smooth=includpix[,1])
y.lim <- c(-0.05,0.05)
main. <- 'Ring borders'
{plot(Smooth,xlab = 'Column',ylab = 'Smoothed gray',
      main=main.,col = 'darkgoldenrod1')
  points(xyborders[,1],xyborders[,2],pch=19,cex=0.5,col='orangered')}
```

ringDetect

Single Detection of TRWs

Description

This function assists in the detection of TRW (mm) in a scanned image (.tif or .png) or gray matrix, evaluating other required functions and plotting the outputs in graphics devices. The function can be combined with [ringSelect](#) to visually detected TRWs. Nevertheless, the complete measurement procedure of TRW with the package can be performed by [multiDetect](#).

Usage

```
ringDetect(image, ...)
```

Arguments

image	character or matrix. Vector of path to the image section or a gray matrix such as that produced by imageToGray .
...	arguments to be passed to other functions, see section of Details.

Details

The scanned sample should correspond to a horizontal window of wood with the bark side located towards the left area of the image, and the pit side towards the right. The image section may not necessarily contain both bark and pit, see images of the Examples. The image should contain Red, Gren, and Blue channels (rgb) and be compressed in any of two file formats: tif or png. These are easily obtained by scanning wood samples with a conventional scanner and extracting a horizontal image section. Five functions are internally implemented: [plotSegments](#), [dataSegments](#), [ringWidths](#), [ringBorders](#), and [orimageToGray](#). These are controlled using the following arguments:

- `ppi = NULL`: image resolution in points per inch. If `NULL` the `ppi` is extracted from the image attributes. If the `ppi` is not embedded in the image, then thos argument should be provided;
- `rgb = c(0.3, 0.6, 0.1)`: vector of three fractions, all of them adding to one, to combine the rgb into a gray matrix. Defaults correspond to the rgb-standard in the luminosity function (Russ, 2006): green light contributes the most to the intensity perceived by humans, and blue light the least;
- `p.row = 1`: Proportion of rows in the central portion of the gray matrix to be processed;
- `last.yr = NULL`: `NULL` or integer. Year of formation of the newest ring. If `NULL` then the rings are numbered from one (right) to the number of detected rings (left);
- `auto.det = TRUE`: logical. If `TRUE` then an algorithm for automatic detection is implemented, see [linearDetect](#);
- `darker = TRUE`: logical. If `TRUE` then the algorithm uses the negative extremes on smoothed grays to detect the ring borders. If `FALSE` the positive extremes are used instead;
- `origin = 0`: An origin along central portion of the smoothed gray to find the ring borders. This value could help to avoid noisy areas during the visual detection process;
- `inclu = NULL`: `NULL` or vector with column numbers in the gray matrix, other than those automatically detected, to be considered as ring borders. If `NULL` no column numbers are included;
- `exclu = NULL`: `NULL` or vector with column numbers in gray matrix of those ring borders to be excluded from the analysis. If `NULL`, no ring borders are excluded;
- `plot = TRUE`: logical. If `TRUE` then a plot is produced;
- `segs = 1`: Number of image segments to be plotted;
- `ratio = NULL`: `NULL` or numeric vector of two values representing the aspect ratio of the plots (height, and width). If `NULL` default in [par](#) is used;
- `marker = NULL`: `NULL` or integer vector with any value from 1 to 10. The rings are averaged with those rings on either side of it and the averages are scaled from ten (the narrowest possible ring) to one (the broadest ring). The narrow rings with averages larger than `marker` as well as other chronological markers (decades, centuries, and millennia), are highlighted with red pinpricks;

- `col.marker = 'red'`: color of the markers;
- `tit = TRUE`: logical or character. A title for the plots. If TRUE the main title is the image name. For more than 1 segment the main title ends with the segment number. This argument does not work in `multiDetect`.

If users run R from Interactive Development Environments (IDE) aiming to segment the image section (`segs > 1`), they should be sure that such environments support multiple graphics devices. If the argument `image` is a gray matrix, then other arguments passed to `imageTogray` will be ignored. The function can be combined with `ringSelect` to visually include/exclude ring borders in the plot output, see examples in the `ringSelect` function. See `multiDetect` for recursive implementation of this function.

references«

- Lara W., F. Bravo, and S. Carlos. 2015. `measuRing`: An R package to measure tree-ring widths from scanned images. *Dendrochronologia*, 34: 43-50;
- Russ, J.C., 2006. *The Image Processing Handbook*, Fifth Edition. CRC Press, Boca Raton, 817 pp.

Value

list of data frames with ring widths and ring borders such as these produced by `ringWidths`, and `ringBorders`.

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Examples

```
image1 <- system.file("P105_a.tif", package="measuRing")
## (not run) Initial diagnostic:
detect1 <- ringDetect(image1,segs=3)
## (not run) Updating ringDetect to chage arguments;
## and flagged rings
detect1 <- update(detect1,marker=8)
## (not run) Some noise in smoothed gray can be avoided
## by moving the origin:
detect1 <- update(detect1,origin = -0.03)
## (not run) columns 21 and 130 are not considered now.
##
## (not run) Choose other columns in gray matrix (see ringSelect);
## (not run) graphical devices from ringDetect should be active!
## (not run) Including columns:
## (uncomment and run):
## detect1 <- update(detect1)
## Toinc <- ringSelect(detect1)
## detect1 <- update(detect1, inclu = Toinc)
## or, include the next columns:
Toinc <- c(202,387,1564)
```

```

detect1 <- update(detect1,inclu = Toinc)
## (not run) Object detect1 is updated with Toinc;
##
## (not run) ring borders to be excluded:
## (uncomment and run):
## detect1 <- update(detect1)
## Toexc <- ringSelect(detect1,any.col = FALSE)
## detect1 <- update(detect1,exclu=Toexc)
## or, exclude the nex columns:
Toexc <- c(208,1444,1484)
detect1 <- update(detect1,exclu = Toexc)
##
## (not run) Final arguments:
detect2 <- update(detect1,last.yr=2011,marker = 8)
str(detect2)
##
## (not run) kill previous plot:
graphics.off()
##
## (not run) Tree-ring widths and attributes:
rings <- detect2$'ringWidths'
##
## (not run) Plot of the tree-ring widths:
maint <- 'Hello ring widths!'
plot(rings,ylab = 'width (mm)',type='l',col = 'red',main=maint)

```

ringSelect

Visual selection

Description

This function can include and exclude ring borders in plot outputs from [ringDetect](#) or [plotSegments](#). The function is mapped by [multiDetect](#) for recursive processing of image sections.

Usage

```
ringSelect(rdetect, any.col = TRUE)
```

Arguments

<code>rdetect</code>	a list containing data frames of ring widths and ring borders such as that produced by ringDetect .
<code>any.col</code>	logical. If FALSE only those column numbers in gray matrix previously identified as ring borders can be selected.

Details

Columns in gray matrix are either identified and stored by left-clicking the mouse over the central axis of a gray image in the plot output; pixel numbers of just added ring borders are highlighted on the gray raster. The raphics devices are sequentially closed by right-clicking the mouse. After a graphics device has been closed, the graphics device of the following segment is activated, and visual selection on such a new segment can be performed. Closing the graphics devices with other procedures will stop the selection of ring borders. This detection process can be recursively developed on several image section using `multiDetect`.

Value

vector with column numbers in gray matrix of the identified ring borders.

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References

Lara W., F. Bravo, and S. Carlos. 2015. `measuRing`: An R package to measure tree-ring widths from scanned images *Dendrochronologia*, 34: 43-50.

Examples

```
## Read one image in package folder:
image1 <- system.file("P105_a.tif", package="measuRing")
## (not run) Initial diagnostic:
detect1 <- ringDetect(image1, segs=2, marker=7)
##
## (not run) Choose other columns in gray matrix (see ringSelect);
## (not run) graphical devices from ringDetect should be active!
## (not run) Including columns:
##
## (uncomment and run):
## Toinc <- ringSelect(detect1)
## detect1 <- update(detect1, inclu = Toinc)
##
## (not run) ring borders to be excluded:
## (uncomment and run):
## Toexc <- ringSelect(detect1, any.col = FALSE)
## detect1 <- update(detect1, exclu=Toexc)
## (not run) kill previous plot:
graphics.off()
```

ringWidths

*Ring widths***Description**

This function can compute the ring widths (mm) from the ring borders detected on an image section.

Usage

```
ringWidths(image, last.yr = NULL,
  ...)
```

Arguments

image	character or matrix. Either path of an image section or an array representing a gray matrix.
last.yr	year of formation of the newest ring. If NULL then the rings are numbered from one (right) to the number of detected rings (left).
...	arguments to be passed to two functions: ringBorders , and/or imageTogray .

Value

data frame with the ring widths.

Author(s)

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Examples

```
## (not run) Read one image section:
image1 <- system.file("P105_a.tif", package="measuRing")
## (not run) columns in gray matrix to be included/excluded:
Toinc <- c(196,202,387,1564)
Toexc <- c(21,130,197,207,1444,1484)
## (not run) tree-ring widths
rwidths <- ringWidths(image1,inclu = Toinc,exclu = Toexc,last.yr=NULL)
str(rwidths)
##plot of computed tree-ring widths:
maint <- 'Hello ring widths!'
plot(rwidths,type='l',col = 'red',main = maint,
  xlab = 'Year',ylab = 'Width (mm)')
```

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