

# Package ‘shapeR’

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**Type** Package

**Title** Collection and Analysis of Otolith Shape Data

**Version** 1.0-2

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**Depends** R (>= 3.0.2)

**Imports** plotrix, jpeg, pixmap, wavethresh, methods, vegan, MASS

**Description** Studies otolith shape variation among fish populations.

Otoliths are calcified structures found in the inner ear of teleost fish and their shape has been known to vary among several fish populations and stocks, making them very useful in taxonomy,

species identification and to study geographic variations. The package extends previously described

software used for otolith shape analysis by allowing the user to automatically extract closed contour outlines from a large number of images, perform smoothing to eliminate pixel noise described in Haines and Crampton (2000) <doi:10.1111/1475-4983.00148>,

choose from conducting either a Fourier or wavelet see Gençay et al (2001) <doi:10.1016/S0378-4371(00)00463-5> transform to the outlines and visualize

the mean shape. The output of the package are independent Fourier or wavelet coefficients which can be directly imported into a wide range of statistical packages in R. The package might prove useful in studies of any two dimensional objects.

**License** GPL (>= 2)

**URL** <https://github.com/lisalibungan/shapeR>,

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121102>

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---

cluster.plot	<i>Plot data clusters</i>
--------------	---------------------------

---

### Description

Plots data clusters

### Usage

```
cluster.plot( ddata, classes, main="", col.stock=NULL,
              plotCI = FALSE, conf.level = 0.68, ...)
```

**Arguments**

ddata	Matrix of points
classes	A factor including the cluster values
main	Title for the plot
col.stock	Colors for the plotted classes
plotCI	Plot means with confidence intervals
conf.level	The confidence interval for the standard error of the mean
...	Additional parameters to be passed to 'plot' or 'ldahist' if one dimension

**Value**

None

**Author(s)**

Lisa Anne Libungan

**References**

Oksanen, J., Blanchet, F.G., Kindt, R., Legendre, P., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H. and Wagner, H. (2013). [vegan](#): Community Ecology Package. R package version 2.0-10.

**Examples**

```
data(shape)
library(vegan)
cap.res = capscale(getStdWavelet(shape) ~ getMasterlist(shape)$pop)

eig=eigenvals(cap.res,constrained=TRUE)
eig.ratio = eig/sum(eig)

cluster.plot(scores(cap.res)$sites[,1:2],getMasterlist(shape)$pop
,plotCI=TRUE
,xlab=paste("CAP1 (",round(eig.ratio[1]*100,1),"%)",sep="")
,ylab=paste("CAP2 (",round(eig.ratio[2]*100,1),"%)",sep="")
,main="Canonical clustering"
)
```

---

detect.outline	<i>Detect otolith outline</i>
----------------	-------------------------------

---

### Description

Determine the outline of otolith images in jpeg format which have been stored in the Fixed folder.

### Usage

```
detect.outline(object, threshold=0.2, mouse.click=FALSE,  
              display.images=FALSE, write.outline.w.org=FALSE)
```

### Arguments

object	<a href="#">shapeR</a> object
threshold	Grayscale threshold. Value between 0 and 1.
mouse.click	If TRUE, the user clicks where the starting point for the otolith contour extraction algorithm should start. Default is the center of the image. Could be good to set as TRUE if the otolith detection produces an error.
display.images	If TRUE, each image is displayed and the user can visualize how the outline is captured
write.outline.w.org	If TRUE, the outline is written on top of the original image using the function <a href="#">write.image.with.outline</a> , and can be seen in the Original_with_outline folder

### Details

Based on the Conte function (Claude 2008)

### Value

A [shapeR](#) object with otolith outlines in the slot outline.list

### Author(s)

Lisa Anne Libungan & Snaebjorn Palsson

### References

- Claude, J. (2008). Morphometrics with R. Springer. 316 p.
- Urbanek, S. (2014). [jpeg](#): Read and write JPEG images. R package version 0.1-8.
- Bivand, R., Leisch, F. & Maechler, M. (2011) [pixmap](#): Bitmap Images ("Pixel Maps"). R package version 0.4-11.
- Libungan LA and Palsson S (2015) ShapeR: An R Package to Study Otolith Shape Variation among Fish Populations. PLoS ONE 10(3): e0121102. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121102>

## Examples

```
## Not run:
#Use test data from Libungan and Palsson (2015):
shape = shapeR("ShapeAnalysis/", "FISH.csv")
shape = detect.outline(shape, threshold=0.2, write.outline.w.org = TRUE)
## End(Not run)
```

---

enrich.master.list      *Link information in the info.file to the coefficients obtained from the otolith images*

---

## Description

Link the original info file to the otolith coefficients

## Usage

```
enrich.master.list(object, folder_name = "folder", pic_name = "picname",
  calibration = "cal", include.wavelet = TRUE, include.fourier = TRUE,
  n.wavelet.levels = 5, n.fourier.freq = 12,...)
```

## Arguments

object	A <a href="#">shapeR</a> object
folder_name	Should contain the first letters of the area and the serie or station number of the sample, for example: "IC"
pic_name	Should contain the serie number of a given sample and fish number, for example "403_2" (not including the .jpg extension)
calibration	The name of the column where the pixels to measurement calibration is located
include.wavelet	If TRUE, the wavelet coefficient are included in the master.list
include.fourier	If TRUE then the Normalized Elliptic Fourier coefficients are included in the master.list
n.wavelet.levels	Integer saying how many levels of wavelet levels should be included
n.fourier.freq	Integer saying how many Fourier frequency levels should be included
...	Additional parameter for read.csv for reading the info.file

## Value

A [shapeR](#) object with values in slots:

- wavelet.coef
- fourier.coef
- shape
- filter
- master.list

**Author(s)**

Lisa Anne Libungan

**Examples**

```
data(shape)
shape = generateShapeCoefficients(shape)

shape = enrich.master.list(shape)
```

---

estimate.outline.reconstruction

*Estimate the outline reconstruction based on Fourier/wavelet compared to the outlines that have not been transformed*

---

**Description**

Estimate outline reconstruction using a different number of coefficients of wavelet and Fourier compared to the original otolith

**Usage**

```
estimate.outline.reconstruction(object, ...)
```

**Arguments**

object            [shapeR](#) object  
...                Additional parameters to be passed to 'plot' and 'points'

**Value**

A list containing values

- w.dev.m a list for number of coefficients for mean error of wavelet reconstruction
- w.dev.sd a list for number of coefficients for standard deviation of wavelet reconstruction
- f.power.total Fourier power for number of Fourier harmonics

**Author(s)**

Lisa Anne Libungan

**References**

Claude, J. (2008) Morphometrics with R. Springer. 316 p.

**Examples**

```
## Not run:  
data(shape)  
estimate.outline.reconstruction(shape)  
## End(Not run)
```

---

FISH

*An example data file*

---

**Description**

The file's columns are:

- country
- station
- pop
- stockID
- day
- month
- year
- lat
- lon
- fishno
- length\_cm
- weight\_g
- age
- sex
- maturity
- folder
- picname
- cal

**Usage**

```
data(FISH)
```

**Format**

An example data file

**Source**

<https://github.com/lisalibungan/shapeR>

---

generateShapeCoefficients

*Get wavelet/Fourier coefficients and basic shape variables*

---

### Description

Generates shape variables based on Fourier/wavelet reconstruction. Wavelet coefficients for wavelet. Basic shape parameters are also collected (area, length, width, perimeter).

### Usage

```
generateShapeCoefficients(object,...)
```

### Arguments

object	<a href="#">shapeR</a>
...	Additional parameters to be passed to the [wavethresh::wd()] function package for the wavelet decomposition of the otolith outlines

### Value

A [shapeR](#) object with values in slots:

- wavelet.coef.raw
- fourier.coef.raw
- shape.coef.raw

### Author(s)

Lisa Anne Libungan & Snaebjorn Palsson

### References

Nason, G. (2012). [wavethresh::wd()]: Wavelets statistics and transforms. R package, version 4.5.  
Claude, J. (2008). Morphometrics with R. Springer. 316 p.

### See Also

[wavethresh::wd()]

### Examples

```
data(shape)  
shape = generateShapeCoefficients(shape)
```

---

getFourier	<i>Get Fourier coefficients, filtered according to filter</i>
------------	---

---

**Description**

Returns the Fourier coefficients determined in `stdCoefs`. Returns only values as set in `setFilter`

**Usage**

```
getFourier(object)
```

**Arguments**

object            [shapeR](#) object

**Value**

The Fourier coefficients for all fish as determined by `setFilter`

**Author(s)**

Lisa Anne Libungan

---

getMasterlist	<i>Get filtered master.list values</i>
---------------	--

---

**Description**

Returns selected values from `master.list`

**Usage**

```
getMasterlist(object, useFilter = TRUE)
```

**Arguments**

object            [shapeR](#) object  
useFilter        If TRUE, the master.list values are filtered by the slot filter. FALSE = no filtering.

**Value**

The `master.list` is filtered by the slot filter if the `useFilter` is TRUE, else no filtering is done.

**Author(s)**

Lisa Anne Libungan

---

`getMeasurements`*Get simple shape variables, filtered according to filter*

---

### Description

Returns shape variables length, width, perimeter and area determined in [generateShapeCoefficients](#). Returns only values as set in the slot `filter`. These variables can only be obtained if the calibration measurements in pixels have been registered in the csv data file in a column labelled 'cal' (see example data file). To get the calibration measurements, use an image manipulation program and measure 1mm on the calibration measurement stick (that was taken for that particular dataset) and register how many pixels 1mm is into the column 'cal'.

### Usage

```
getMeasurements(object)
```

### Arguments

`object`            [shapeR](#) object

### Value

A data frame with all valid fish as determined by the slot `filter` and with columns:

- `otolith.area`
- `otolith.length`
- `otolith.width`
- `otolith.perimeter`

### Author(s)

Lisa Anne Libungan

### Examples

```
data(shape)
# Calculate the mean otolith area for each fish population
# The results are in square mm since the calibration ('cal') column
# in the data file is in pixels (1 mm/pixel).
tapply(getMeasurements(shape)$otolith.area, getMasterlist(shape)$pop, mean)
```

---

getStdFourier	<i>Get standardized Fourier coefficients, filtered according to filter</i>
---------------	--

---

**Description**

Returns the standardized Fourier coefficients determined in `stdCoefs`. Returns only values as set in the slot `filter`

**Usage**

```
getStdFourier(object)
```

**Arguments**

object            [shapeR](#) object

**Value**

The standardized Fourier coefficients for all valid fish as determined by the slot `filter`

**Author(s)**

Lisa Anne Libungan

---

getStdMeasurements	<i>Get simple shape variables after standardization, filtered according to filter</i>
--------------------	---

---

**Description**

Returns the simple shape variables determined in `stdCoefs`. Returns only values as set in the slot `filter`

**Usage**

```
getStdMeasurements(object)
```

**Arguments**

object            [shapeR](#) object

**Value**

A data frame with all valid fish as determined by the slot `filter`. Returns only variables that have not been removed after standardization.

**Author(s)**

Lisa Anne Libungan

**Examples**

```
data(shape)
#Calculate the mean standardized otolith length for each fish population
tapply(getStdMeasurements(shape)$otolith.length,
getMasterlist(shape)$pop,mean)
```

---

getStdWavelet

*Get standardized wavelet coefficients, filtered according to filter*

---

**Description**

Returns the standardized wavelet coefficients determined in `stdCoefs`. Returns only values as set in the slot `filter`

**Usage**

```
getStdWavelet(object)
```

**Arguments**

object            [shapeR](#) object

**Value**

The standardized wavelet coefficients for all valid fish as determined by the slot `filter`

**Author(s)**

Lisa Anne Libungan

---

getWavelet

*Get wavelet coefficients, filtered according to filter*

---

**Description**

Returns the wavelet coefficients determined in [generateShapeCoefficients](#). Returns only values as set in the slot `filter`

**Usage**

```
getWavelet(object)
```

**Arguments**

object            [shapeR](#) object

**Value**

The wavelet coefficients for all valid fish as determined by the slot filter

**Author(s)**

Lisa Anne Libungan

---

outline.reconstruction.plot  
*Plot outline reconstruction*

---

**Description**

Show graphs of the reconstruction using different number of levels of wavelet reconstruction and Fourier power using different number of Fourier harmonics. Uses the output from [estimate.outline.reconstruction](#)

**Usage**

```
outline.reconstruction.plot(outline.rec.list,ref.w.level=5,
                             ref.f.harmonics=12,max.num.harmonics=32,...)
```

**Arguments**

outline.rec.list            The output from [estimate.outline.reconstruction](#)

ref.w.level            Reference level for graphical purposes. The default is 5 as is the default of [shapeR](#).

ref.f.harmonics            Reference Fourier harmonize. The default is 12 as is the default in [shapeR](#).

max.num.harmonics            Maximum number of Fourier harmonics to be shown

...            Additional parameters to be passed to 'plot'

**Value**

None

**Author(s)**

Lisa Anne Libungan

**Examples**

```
## Not run: data(shape)
est.list = estimate.outline.reconstruction(shape)
outline.reconstruction.plot(est.list,panel.first = grid())
## End(Not run)
```

---

plotFourier

*Mean and standard deviation of the Fourier coefficients*


---

**Description**

The mean and standard deviation of the Fourier coefficients

**Usage**

```
plotFourier(object, coef.index=NULL,class.name=NULL,useStdcoef=FALSE, ...)
```

**Arguments**

object	<a href="#">shapeR</a> object
coef.index	An index vector for which fourier coefficients to be shown. Default is NULL and all coefficients are shown.
class.name	Column name in master list for partitioning the data into groups and showing the ratio of variance among to the sum of variance among and variance within.
useStdcoef	Boolean saying if to use the standardized coefficients or not
...	Additional parameters to be passed to 'plot'

**Value**

None

**Author(s)**

Lisa Anne Libungan

**Examples**

```
data(shape)
shape = stdCoefs(shape,classes="pop","length_cm")
plotFourier(shape,class.name= "pop",useStdcoef=TRUE)
```

---

plotFourierShape	<i>Mean otolith shape based on Fourier reconstruction</i>
------------------	---

---

**Description**

A function for showing the mean otolith shape based on Fourier reconstruction

**Usage**

```
plotFourierShape(object, class.name, show.angle = FALSE, lty=1:5, col=1:6, ...)
```

**Arguments**

object	A <a href="#">shapeR</a> object
class.name	A string as the column name in the master list
show.angle	If TRUE angles are shown on the plot
lty, col	Vector of line types and colors. Values are used cyclically.
...	Additional parameters to be passed to 'plot'

**Value**

None

**Author(s)**

Lisa Anne Libungan

**References**

Libungan LA and Palsson S (2015) ShapeR: An R Package to Study Otolith Shape Variation among Fish Populations. PLoS ONE 10(3): e0121102. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121102>

**Examples**

```
data(shape)
plotFourierShape(shape, "pop", show.angle = TRUE, lwd=2, lty=1)
```

---

plotWavelet	<i>Mean and standard deviation of the wavelet coefficients</i>
-------------	--

---

**Description**

The mean and standard deviation of the wavelet coefficients

**Usage**

```
plotWavelet(object, level, start.angle = 0, class.name=NULL, useStdcoef=FALSE, ...)
```

**Arguments**

object	A <a href="#">shapeR</a> object
level	The wavelet level to be shown
start.angle	The angle in degrees, the x-axis should start on
class.name	Column name in master list for partitioning the data into groups and showing the ratio of variation among groups.
useStdcoef	Choose "TRUE" or "FALSE" if coefficients should be standardized or not
...	Additional parameters to be passed to 'plot'

**Value**

None

**Author(s)**

Lisa Anne Libungan

**Examples**

```
data(shape)
shape = stdCoefs(shape, classes="pop", "length_cm")
plotWavelet(shape, level=5, class.name= "pop", useStdcoef=TRUE)
```

---

plotWaveletShape	<i>Mean otolith shape based on wavelet reconstruction</i>
------------------	---

---

**Description**

A function for showing the mean otolith shape based on wavelet reconstruction

**Usage**

```
plotWaveletShape(object, class.name, show.angle=FALSE, lty=1:5, col=1:6, ...)
```

**Arguments**

object	A <a href="#">shapeR</a> object
class.name	A string as the column name in the master list
show.angle	If TRUE angles are shown on the plot
lty, col	Vector of line types and colors. Values are used cyclically.
...	Additional parameters to be passed to 'plot'

**Value**

None

**Author(s)**

Lisa Anne Libungan

**References**

Nason, G. (2012) [wavethresh::wd()]: Wavelets statistics and transforms, version 4.5. R package.

**Examples**

```
data(shape)
plotWaveletShape(shape, "pop", show.angle = TRUE, lwd=2, lty=1)
```

---

read.master.list	<i>Read updated master list</i>
------------------	---------------------------------

---

### Description

Reads an updated master list. This is important to run if you want to ensure that a updated master list is used in the analysis.

### Usage

```
read.master.list(object, ...)
```

### Arguments

object	A <a href="#">shapeR</a> object
...	Additional parameter for read.csv for reading the info.file

### Value

[shapeR](#) object with values in slots:

- master.list.org

### Author(s)

Lisa Anne Libungan

---

remove.outline	<i>Remove otolith outline</i>
----------------	-------------------------------

---

### Description

A function for removing an otolith outline from the file 'outline.list'. Typically done if the image is of bad quality and needs to be enhanced in a image processing software

### Usage

```
remove.outline(object, folder = "", fname = "")
```

### Arguments

object	A <a href="#">shapeR</a> object
folder	The folder name where the outline that needs to be removed is stored
fname	The file name of the outline to be removed

**Value**

shapeR object

**Author(s)**

Lisa Anne Libungan

**References**

Libungan LA and Palsson S (2015) ShapeR: An R Package to Study Otolith Shape Variation among Fish Populations. PLoS ONE 10(3): e0121102. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121102>

**Examples**

```
## Not run:  
#Use test data from example in Libungan and Palsson (2015):  
shape = shapeR("ShapeAnalysis/", "FISH.csv")  
shape = detect.outline(shape)  
#If otolith outline in folder IC named 403_1 needs to be removed  
shape = remove.outline(shape, "IC", "403_1")  
## End(Not run)
```

---

setFilter

*Set a filter to analyze the shape data*

---

**Description**

Sets a filter on `master.list`. Here it is possible to filter the `master.list` by specific ages, maturity stages, areas, etc. If no value is set, all data with shape parameters are used

**Usage**

```
setFilter(object, filter)
```

**Arguments**

object	A shapeR object
filter	A vector restricting the new filter value. Only otoliths having shape parameters are selected.

**Value**

A shapeR object with the slot `filter` set.

**Author(s)**

Lisa Anne Libungan

**Examples**

```

data(shape)
#Filter only Icelandic and Norwegian samples
shape = setFilter(shape,
getMasterlist(shape, useFilter = FALSE)$pop %in% c("NO", "IC"))
table(getMasterlist(shape)$pop)
#Reset filter
shape = setFilter(shape)
table(getMasterlist(shape)$pop)

```

---

shape	<i>An example shapeR instance including 160 images.</i>
-------	---

---

**Description**

The shape coefficients have been generated. The wavelet coefficients have been standardized using pop and length\_cm.

**Usage**

```
data(shape)
```

**Format**

A shapeR class including 160 images

**Details**

The class slot's are as follows:

- project.path. A path as "ShapeAnalysis/"
- info.file. A file as FISH.csv. The information is stored in the data frame master.list
- outline.list. A list with three elements (IC, NO, SC) which give a list of the otolith outlines
- filter. A logical vector showing which elements of the master list have valid otoliths
- fourier.coef. A matrix of the Normalized Elliptic Fourier coefficients
- wavelet.coef. A matrix of the wavelet coefficients
- shape. A matrix of shape variables after scaling according to calibration otolith.area, otolith.length, otolith.width, otolith.perimeter.
- fourier.coef.std. A matrix which will contain standardized Fourier coefficients
- wavelet.coef.std. A matrix which will contain standardized wavelet coefficients
- shape.coef.raw. A matrix of shape variables before scaling according to calibration otolith.area, otolith.length, otolith.width, otolith.perimeter.
- master.list. The contents of the info.file

**Source**

<https://github.com/lisalibungan/shapeR>

---

shapeR	<i>shapeR</i>
--------	---------------

---

**Description**

Collection and analysis of otolith shape data  
a shapeR class

**Usage**

```
shapeR(project.path, info.file, ...)
```

**Arguments**

project.path	The base project path where the images are stored
info.file	The information file which store the information on the fish and otoliths. This is the base for the master.list
...	Additional parameters to be passed to 'read.csv' for reading the info.file

**Value**

a [shapeR](#) object

**Slots**

project.path	Path to the project where the images are stored
info.file	Info file containing fish and otolith information
master.list.org	The contents of the info.file
master.list	The contents of the info.file with added shape parameters and descriptors
outline.list.org	A list of all the original otolith outlines
outline.list	A list of all the otolith outlines. It returns a list of smoothed if contour smoothing (usingsmoothout) has been conducted.
filter	A logical vector selecting the otoliths used for analysis
wavelet.coef.raw	The wavelet coefficients for all the otolith outlines
wavelet.coef	The wavelet coefficients after aligning with the info.file. The data is generated when <a href="#">enrich.master.list</a> is run
wavelet.coef.std	The standardized wavelet coefficients. The data is generated when <a href="#">stdCoefs</a> is run
wavelet.coef.std.removed	The index of the removed wavelet coefficients after standardization. The data is generated when <a href="#">stdCoefs</a> is run
fourier.coef.raw	The Fourier coefficients for all the otolith outlines
fourier.coef	The Fourier coefficients for after aligning with the info file. The data is generated when <a href="#">enrich.master.list</a> is run

`fourier.coef.std` The standardized Fourier coefficients. The data is generated when `stdCoefs` is run

`fourier.coef.std.removed` The index of the removed Fourier coefficients after standardization. The data is generated when `stdCoefs` is run

`shape.coef.raw` The uncalibrated shape measurements for all the otoliths. The shape parameters are: `otolith.area`, `otolith.length`, `otolith.width`, `otolith.perimeter`

`shape.coef` The shape measurements for after aligning with the info file. The shape parameters have been calibrated using the calibration parameter as registered in the datafile as the column 'cal'.

`shape.std` The standardized shape measurements. The data is generated when `stdCoefs` is run

`shape.std.removed` The index of the removed shape measurements after standardization. The data is generated when `stdCoefs` is run

### Author(s)

Lisa Anne Libungan & Snaebjorn Palsson

### References

Libungan LA and Palsson S (2015) ShapeR: An R Package to Study Otolith Shape Variation among Fish Populations. PLoS ONE 10(3): e0121102. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121102>

### See Also

<https://github.com/lisalibungan/shapeR>

`plotWavelet`

`plotFourier`

`plotWaveletShape`

`plotFourierShape`

`capscale`

`cluster.plot`

`setFilter`

`lda`

`detect.outline`

`generateShapeCoefficients`

`enrich.master.list`

### Examples

```
## Not run:  
  
# This example has two sections: (1) Demonstration of how a shapeR object  
# is analyzed and (2) How to create a shapeR object from an archive of  
# image files.
```

```

#-----
# Section 1: Analyzing a shapeR object

data(shape)

#Standardize coefficients
shape = stdCoefs(shape,"pop","length_cm")

#Visualize Wavelet and Fourier coefficients
plotWavelet(shape,level=5,class.name= "pop",useStdcoef=TRUE)
plotFourier(shape,class.name= "pop",useStdcoef=TRUE)

#Examine the mean shapes
plotWaveletShape(shape, "pop",show.angle = TRUE,lwd=2,lty=1)
plotFourierShape(shape, "pop",show.angle = TRUE,lwd=2,lty=1)

#Canonical analysis
library(vegan)
cap.res = capscale(getStdWavelet(shape) ~ getMasterlist(shape)$pop)
anova(cap.res)

#Visualize the canonical scores
eig=eigenvals(cap.res,constrained=TRUE)
eig.ratio = eig/sum(eig)

cluster.plot(scores(cap.res)$sites[,1:2],getMasterlist(shape)$pop
,plotCI=TRUE
,xlab=paste("CAP1 (",round(eig.ratio[1]*100,1),"%)",sep="")
,ylab=paste("CAP2 (",round(eig.ratio[2]*100,1),"%)",sep="")
,main="Canonical clustering"
)

#Only analyze Icelandic and Norwegian samples
shape = setFilter(shape, getMasterlist(shape, useFilter = FALSE)$pop %in% c("NO","IC"))

#Classifier on standardized wavelet
lda.res.w = lda(getStdWavelet(shape),getMasterlist(shape)$pop,CV=TRUE)
ct.w = table(getMasterlist(shape)$pop,lda.res.w$class)

diag(prop.table(ct.w, 1))

# Total percent correct
sum(diag(prop.table(ct.w)))

cap.res = capscale(getStdWavelet(shape) ~ getMasterlist(shape)$pop)
anova(cap.res)

#Classifier on canonical values
lda.res.w = lda(scores(cap.res)$sites,getMasterlist(shape)$pop,CV=TRUE)
ct.w = table(getMasterlist(shape)$pop,lda.res.w$class)

diag(prop.table(ct.w, 1))

```

```
# Total percent correct
sum(diag(prop.table(ct.w)))

#-----
# Section 2: Creating a shapeR object from image files

# The following example requires the user to download an archive of JPEG
# files from https://github.com/lisalibungan/shapeR/
# place the ShapeAnalysis directory inside the working directory.

shape = shapeR("~/ShapeAnalysis/", "FISH.csv")
shape = detect.outline(shape, write.outline.w.org = TRUE)

shape = generateShapeCoefficients(shape)
shape = enrich.master.list(shape)

## End(Not run)
```

---

show,shapeR-method      *Show a shapeR object*

---

### Description

Show the project.path and info.file, the number of outlines that have been read and which fundamental methods have been run.

### Usage

```
## S4 method for signature 'shapeR'
show(object)
```

### Arguments

object                  a shapeR object

### Value

None

---

`show.original.with.outline`*Show the extracted outline on top of the original image*

---

## Description

A function which displays the outlines which were extracted from the image in the "Fixed" folder on top of the corresponding image in the "Original" folder.

## Usage

```
show.original.with.outline(object, folder, fname)
```

## Arguments

object	A <a href="#">shapeR</a> object
folder	The folder name where the image is stored
fname	Image file name. Not including the extension ".jpg"

## Value

None

## Author(s)

Lisa Anne Libungan

## References

Libungan LA and Palsson S (2015) ShapeR: An R Package to Study Otolith Shape Variation among Fish Populations. PLoS ONE 10(3): e0121102. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121102>

## Examples

```
## Not run:  
#Follow the example in Libungan and Palsson (2015) and run the following lines:  
show.original.with.outline(shape,"IC","403_2")  
## End(Not run)
```

---

 smoothout

*Contour smoothing*


---

**Description**

Remove high frequency pixel noise around the otolith outline

**Usage**

```
smoothout(object, n)
```

**Arguments**

object	A <a href="#">shapeR</a> object
n	The number of iterations. The default value is 100.

**Value**

A [shapeR](#) object with smoothed otolith outlines in the slot `outline.list`

**Author(s)**

Lisa Anne Libungan

**References**

Haines, A.J., Crampton, J.S. (2000). Improvements to the method of Fourier shape analysis as applied in morphometric studies. *Palaeontology* 43: 765-783.

Claude, J. (2008) *Morphometrics with R*. Springer. 316 p.

**Examples**

```
data(shape)
shape = smoothout(shape,n=100)

# Plot smoothed outline on top of original outline for comparison
outline.org=shape@outline.list.org[["IC"]][["403_2"]]
outline=shape@outline.list[["IC"]][["403_2"]]
plot(outline.org$X,outline.org$Y,type='l',xlab="",ylab="",lwd=2,axes=FALSE)
lines(outline$X,outline$Y,col="red",lwd=2)
legend("bottomleft",c('Original', 'Smoothed'),lty=1,col=c('black', 'red'),lwd=2)
```

---

stdCoefs                      *Standardize coefficients*

---

### Description

Function to standardized the wavelet and Fourier coefficients for a specific parameter such as the fish length. For each country/population a regression coefficient is calculated as a function of fish length. If the slope is significantly different from zero, a correction is made according to Leonart et al 2000. First ANCOVA is performed:  $\text{variable} \sim \text{pop} * \text{length\_cm}$ , following a method by Longmore et al 2010. If there is a significant interaction between population and length\_cm, then the coefficients are not used and automatically discarded. If there is no interaction, the coefficients are kept and standardized with regards to fish length.

### Usage

```
stdCoefs(object, classes=NA, std.by, std.type = "mean", p.crit = 0.05, bonferroni= FALSE)
```

### Arguments

object	A <a href="#">shapeR</a> object
classes	The classes to be grouped for standardization. Should be the same as used for the statistical tests
std.by	The parameter to be used for standardization. Typically the length of the fish from the master.list.
std.type	The tuning of the standardization. The standardization can be sensitive to what value all the fishes are standardized to. Possible values are: <ul style="list-style-type: none"> <li>• min Standardized as the minimum value of std.by</li> <li>• mean Standardized as the mean value of std.by</li> <li>• max Standardized as the maximum value of std.by</li> </ul>
p.crit	An argument used to select the threshold criteria for omitting coefficients which show interaction with fish length. If p.crit = 0.05, all coefficients which have $p < 0.05$ are omitted. If p.crit = 0.01, only coefficients with $p < 0.01$ are omitted.
bonferroni	A logical parameter for performing Bonferroni for multiple testing

### Value

A [shapeR](#) object with standardized shape coefficients in the slot shape.std

### Author(s)

Lisa Anne Libungan

## References

- Lleonart, J., Salat, J. & Torres, G.J. (2000) Removing allometric effects of body size in morphological analysis. *Journal of Theoretical Biology*, 205, 85-93.
- Longmore, C., Fogarty, K., Neat, F., Brophy, D., Trueman, C., Milton, A. & Mariani, S. (2010) A comparison of otolith microchemistry and otolith shape analysis for the study of spatial variation in a deep-sea teleost, *Coryphaenoides rupestris*. *Environmental Biology of Fishes*, 89, 591-605.
- Reist, J.D. (1985) An Empirical-Evaluation of Several Univariate Methods That Adjust for Size Variation in Morphometric Data. *Canadian Journal of Zoology-Revue Canadienne De Zoologie*, 63, 1429-1439.

## Examples

```
data(shape)
shape = stdCoefs(shape, classes="pop", "length_cm")
```

---

```
write.image.with.outline
```

*Write outlines on top of the original images for quality checking*

---

## Description

A function which writes the outlines which were extracted from the images in the folder "Fixed" on top of the corresponding images in the "Original" folder. Viewing the resulted images in the folder "Original\_with\_outlines" is a good quality check to ensure the correct outline has been extracted. If the outline is not correct, then the image can be fixed in an image software, such as GIMP ([www.gimp.org](http://www.gimp.org)), placed in the "Fixed" folder and then the `detect.outline` step is repeated. The function `detect.outline` calls this function if the parameter `write.outline.w.org` is set to TRUE.

## Usage

```
write.image.with.outline(object, folder = NA, fname = NA, doProgress = TRUE)
```

## Arguments

object	A <a href="#">shapeR</a> object
folder	The folder name where the image is stored
fname	Image file name. Not including the extension ".jpg"
doProgress	If TRUE, a progressbar is shown

## Value

None

## Author(s)

Lisa Anne Libungan

## References

Libungan LA and Palsson S (2015) ShapeR: An R Package to Study Otolith Shape Variation among Fish Populations. PLoS ONE 10(3): e0121102. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121102>

## Examples

```
## Not run:  
#Use test data from Libungan and Palsson (2015) and run the following lines:  
shape = shapeR("ShapeAnalysis/", "FISH.csv")  
shape = detect.outline(shape, write.outline.w.org = FALSE)  
write.image.with.outline(shape)  
## End(Not run)
```

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