

# Package ‘tourr’

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anchored\_orthogonal\_distance  
*Calculate orthogonal distances*

**Description**

For each datapoint this function calculates the orthogonal distance from the anchored projection plane.

**Usage**

anchored\_orthogonal\_distance(plane, data, anchor = NULL)

**Arguments**

- plane           matrix specifying the projection plane
- data           data frame or matrix
- anchor         A vector specifying the reference point to anchor the plane If NULL (default) the slice will be anchored at the origin.

**Value**

distance vector

---

andrews	<i>Compute Andrews' curves</i>
---------	--------------------------------

---

**Description**

This function takes a numeric vector of input, and returns a function which allows you to compute the value of the Andrew's curve at every point along its path from  $-\pi$  to  $\pi$ .

**Usage**

```
andrews(x)
```

**Arguments**

x	input a new parameter
---	-----------------------

**Value**

a function with single argument, theta

**Examples**

```
a <- andrews(1:2)
a(0)
a(-pi)
grid <- seq(-pi, pi, length = 50)
a(grid)

plot(grid, andrews(1:2)(grid), type = "l")
plot(grid, andrews(runif(5))(grid), type = "l")
```

---

angular_breaks	<i>Returns n equidistant bins between -pi and pi</i>
----------------	--

---

**Description**

Returns n equidistant bins between  $-\pi$  and  $\pi$

**Usage**

```
angular_breaks(n)
```

**Arguments**

n	number of bins
---	----------------

---

animate	<i>Animate a tour path.</i>
---------	-----------------------------

---

### Description

This is the function that powers all of the tour animations. If you want to write your own tour animation method, the best place to start is by looking at the code for animation methods that have already implemented in the package.

### Usage

```
animate(  
  data,  
  tour_path = grand_tour(),  
  display = display_xy(),  
  start = NULL,  
  aps = 1,  
  fps = 10,  
  max_frames = Inf,  
  rescale = TRUE,  
  sphere = FALSE,  
  ...  
)
```

### Arguments

data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour
display	takes the display that is suppose to be used, defaults to the xy display
start	projection to start at, if not specified, uses default associated with tour path
aps	target angular velocity (in radians per second)
fps	target frames per second (defaults to 15, to accommodate RStudio graphics device)
max_frames	the maximum number of bases to generate. Defaults to Inf for interactive use (must use Ctrl + C to terminate), and 1 for non-interactive use.
rescale	if true, rescale all variables to range [0,1]?
sphere	if true, sphere all variables
...	ignored

### Details

See [render](#) to render animations to disk.

**Value**

an (invisible) list of bases visited during this tour

**Examples**

```
f <- flea[, 1:6]
animate(f, grand_tour(), display_xy())
# or in short
animate(f)
animate(f, max_frames = 30)
## Not run:
animate(f, max_frames = 10, fps = 1, aps = 0.1)

## End(Not run)
```

---

areColors	<i>Test if all entries are colors</i>
-----------	---------------------------------------

---

**Description**

Test if all entries are colors

**Usage**

```
areColors(x)
```

**Arguments**

x	vector
---	--------

---

center	<i>Center a numeric vector by subtracting off its mean.</i>
--------	---

---

**Description**

Center a numeric vector by subtracting off its mean.

**Usage**

```
center(x)
```

**Arguments**

x	numeric vector
---	----------------

---

cmass	<i>Central mass index.</i>
-------	----------------------------

---

**Description**

Calculates the central mass index. See Cook and Swayne (2007) Interactive and Dynamic Graphics for Data Analysis for equations.

**Usage**

```
cmass()
```

---

dcor2d	<i>Distance correlation index.</i>
--------	------------------------------------

---

**Description**

Computes the distance correlation based index on 2D projections of the data.

**Usage**

```
dcor2d()
```

---

dependence_tour	<i>A dependence tour path.</i>
-----------------	--------------------------------

---

**Description**

The dependence tour combines a set of independent 1d tours to produce a nd tour. For the special case of 2d, this is known as a correlation tour. This tour corresponds to the multivariate method known as generalised canonical correlation, and is used to investigate dependence between groups of variables.

**Usage**

```
dependence_tour(pos)
```

**Arguments**

pos	a numeric vector describing which variables are mapped to which dimensions: 1 corresponds to first, 2 to second etc.
-----	--

**Details**

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

**Examples**

```
animate_xy(flea[, 1:3], dependence_tour(c(1, 2, 2)))
animate_xy(flea[, 1:4], dependence_tour(c(1, 2, 1, 2)))
animate_pcp(flea[, 1:6], dependence_tour(c(1, 2, 3, 2, 1, 3)))
```

---

display_andrews	<i>Andrews' curves tour path animation.</i>
-----------------	---

---

**Description**

Animate a nD tour path with Andrews' curves. For more details about Andrew's curves, see [andrews](#)

**Usage**

```
display_andrews(col = "black", ...)

animate_andrews(data, tour_path = grand_tour(3), col = "black", ...)
```

**Arguments**

col	color to be plotted. Defaults to "black"
...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**See Also**

[animate](#) for options that apply to all animations

**Examples**

```
animate_andrews(flea[, 1:6])
animate_andrews(flea[, 1:6], grand_tour(d = 3))
animate_andrews(flea[, 1:6], grand_tour(d = 6))

# It's easy to experiment with different tour paths:
animate_andrews(flea[, 1:6], guided_tour(cmass()))
```



---

display\_density2d      *Display tour path with a density and scatterplot*

---

## Description

Animate a 2D tour path with density contour(s) and a scatterplot.

## Usage

```
display_density2d(
  center = TRUE,
  axes = "center",
  half_range = NULL,
  col = "black",
  pch = 20,
  cex = 1,
  contour_quartile = c(0.25, 0.5, 0.75),
  edges = NULL,
  ...
)

animate_density2d(data, tour_path = grand_tour(), ...)
```

## Arguments

center	if TRUE, centers projected data to (0,0). This pins the center of data cloud and make it easier to focus on the changing shape rather than position.
axes	position of the axes: center, bottomleft or off
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
col	color to be plotted. Defaults to "black"
pch	shape of the point to be plotted. Defaults to 20.
cex	size of the point to be plotted. Defaults to 1.
contour_quartile	Vector of quartiles to plot the contours at. Defaults to 5.
edges	A two column integer matrix giving indices of ends of lines.
...	other arguments passed on to <a href="#">animate</a> and <a href="#">display_density2d</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**Examples**

```

animate_density2d(flea[, 1:6])
animate(flea[, 1:6], tour_path = grand_tour(), display = display_density2d())
animate(flea[, 1:6],
  tour_path = grand_tour(),
  display = display_density2d(axes = "bottomleft")
)
animate(flea[, 1:6],
  tour_path = grand_tour(),
  display = display_density2d(half_range = 0.5)
)
animate_density2d(flea[, 1:6], tour_path = little_tour())

animate_density2d(flea[, 1:3], tour_path = guided_tour(holes()), sphere = TRUE)
animate_density2d(flea[, 1:6], center = FALSE)

# The default axes are centered, like a biplot, but there are other options
animate_density2d(flea[, 1:6], axes = "bottomleft")
animate_density2d(flea[, 1:6], axes = "off")
animate_density2d(flea[, 1:6], dependence_tour(c(1, 2, 1, 2, 1, 2)),
  axes = "bottomleft"
)

animate_density2d(flea[, -7], col = flea$species)

# You can also draw lines
edges <- matrix(c(1:5, 2:6), ncol = 2)
animate(
  flea[, 1:6], grand_tour(),
  display_density2d(axes = "bottomleft", edges = edges)
)

```

---

display\_depth

*Display 3d projection with depth cues*


---

**Description**

Suggestion to use gray background and colour saturation (instead of gray shading) by Graham Wills.

**Usage**

```

display_depth(center = TRUE, half_range = NULL, ...)

animate_depth(data, tour_path = grand_tour(3), ...)

```

**Arguments**

center	should projected data be centered to have mean zero (default: TRUE). This pins the centre of the data to the same place, and makes it easier to focus on the shape.
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**See Also**

[animate](#) for options that apply to all animations

**Examples**

```
animate_depth(flea[, 1:6])
```

---

display\_dist

*1d distribution tour path animation.*

---

**Description**

Animate a 1d tour path with a density plot or histogram.

**Usage**

```
display_dist(
  method = "density",
  center = TRUE,
  half_range = NULL,
  rug = FALSE,
  ...
)
```

```
animate_dist(data, tour_path = grand_tour(1), ...)
```

**Arguments**

method	display method, histogram or density plot
center	should 1d projection be centered to have mean zero (default: TRUE). This pins the centre of distribution to the same place, and makes it easier to focus on the shape of the distribution.
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.

rug	draw rug plot showing position of actual data points?
...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**See Also**

[animate](#) for options that apply to all animations

**Examples**

```
animate_dist(flea[, 1:6])

# When the distribution is not centred, it tends to wander around in a
# distracting manner
animate_dist(flea[, 1:6], center = FALSE)

# Alternatively, you can display the distribution with a histogram
animate_dist(flea[, 1:6], method = "hist")
```

---

display\_faces

*Chernoff faces tour path animation.*


---

**Description**

Animate a nD tour path with Chernoff's faces. Can display up to 18 dimensions.

**Usage**

```
display_faces(...)

animate_faces(data, tour_path = grand_tour(3), ...)
```

**Arguments**

...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**Details**

This function requires the TeachingDemos package to draw the Chernoff faces. See [faces2](#) for more details.

**See Also**

[animate](#) for options that apply to all animations

**Examples**

```
# The drawing code is fairly slow, so this animation works best with a
# limited number of cases
animate_faces(flea[1:2, 1:6])
animate_faces(flea[1:4, 1:6])

animate_faces(flea[1:2, 1:6], grand_tour(5))
```

---

display\_groupxy

*Display 2D tour projections displayed separately by groups*


---

**Description**

This function is designed to allow comparisons across multiple groups, especially for examining things like two (or more) different models on the same data. The primary display is a scatterplot, with lines or contours overlaid.

**Usage**

```
display_groupxy(
  centr = TRUE,
  axes = "center",
  half_range = NULL,
  col = "black",
  pch = 20,
  cex = 1,
  edges = NULL,
  group_by = NULL,
  plot_xgp = TRUE,
  ...
)

animate_groupxy(data, tour_path = grand_tour(), ...)
```

**Arguments**

centr	if TRUE, centers projected data to (0,0). This pins the center of data cloud and make it easier to focus on the changing shape rather than position.
axes	position of the axes: center, bottomleft or off
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
col	color to be plotted. Defaults to "black"
pch	shape of the point to be plotted. Defaults to 20.
cex	size of the point to be plotted. Defaults to 1.
edges	A two column integer matrix giving indices of ends of lines.

group_by	variable to group by. Must have less than 25 unique values.
plot_xgp	if TRUE, plots points from other groups in light grey
...	other arguments passed on to <a href="#">animate</a> and <a href="#">display_groupxy</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

### Examples

```
f <- flea[, 1:6]
col <- rainbow(length(unique(flea$species)))[as.numeric(as.factor(flea$species))]
pch <- as.numeric(flea$species) + 14

animate_groupxy(f, col = col, pch = pch, group_by = flea$species)
animate_groupxy(f, col = col, pch = pch, group_by = flea$species, plot_xgp = FALSE)
```

---

display_image	<i>Image tour path animation.</i>
---------------	-----------------------------------

---

### Description

Animate a 1d tour path with an image plot. This animation requires a different input data structure, a 3d array. The first two dimensions are locations on a grid, and the 3rd dimension gives the observations to be mixed with the tour.

### Usage

```
display_image(xs, ys, ...)

animate_image(data, tour_path = grand_tour(1), ...)
```

### Arguments

xs	x limit that is used in making the size of the plot
ys	y limit that is used in making the size of the plot
...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

### See Also

[animate](#) for options that apply to all animations

### Examples

```
str(ozone)
animate_image(ozone)
```

---

display_pca	<i>Display tour path with principal component scores with original axes</i>
-------------	---

---

### Description

Animate a 2D tour path on data that has been transformed into principal components, and also show the original variable axes.

### Usage

```
display_pca(
  center = TRUE,
  axes = "center",
  half_range = NULL,
  col = "black",
  pch = 20,
  cex = 1,
  pc_coefs = NULL,
  edges = NULL,
  edges.col = "black",
  ...
)
```

```
animate_pca(data, tour_path = grand_tour(), rescale = TRUE, ...)
```

### Arguments

center	if TRUE, centers projected data to (0,0). This pins the center of data cloud and make it easier to focus on the changing shape rather than position.
axes	position of the axes: center, bottomleft or off
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
col	color to be plotted. Defaults to "black".
pch	shape of the point to be plotted. Defaults to 20.
cex	size of the point to be plotted. Defaults to 1.
pc_coefs	coefficients relating the original variables to principal components. This is required.
edges	A two column integer matrix giving indices of ends of lines.
edges.col	colour of edges to be plotted, Defaults to "black".
...	other arguments passed on to <a href="#">animate</a> and <a href="#">display_slice</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour
rescale	if true, rescale all variables to range [0,1].

## Examples

```
flea_std <- scale(flea[, 1:6])
flea_pca <- prcomp(flea_std, center = FALSE, )
flea_coefs <- flea_pca$rotation[, 1:3]
flea_scores <- flea_pca$x[, 1:3]
animate_pca(flea_scores, pc_coefs = flea_coefs)
```

---

display\_pcp

*Parallel coordinates tour path animation.*

---

## Description

Animate a nD tour path with a parallel coordinates plot.

## Usage

```
display_pcp(...)

animate_pcp(data, tour_path = grand_tour(3), ...)
```

## Arguments

...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

## Details

The lines show the observations, and the points, the values of the projection matrix.

## See Also

[animate](#) for options that apply to all animations

## Examples

```
animate_pcp(flea[, 1:6], grand_tour(3))
animate_pcp(flea[, 1:6], grand_tour(5))
```



display\_sage

*Display tour path with a sage scatterplot***Description**

Animate a 2D tour path with a sage scatterplot that uses a radial transformation on the projected points to re-allocate the volume projected across the 2D plane.

**Usage**

```
display_sage(
  axes = "center",
  half_range = NULL,
  col = "black",
  pch = 20,
  gam = 1,
  R = NULL,
  ...
)

animate_sage(data, tour_path = grand_tour(), ...)
```

**Arguments**

axes	position of the axes: center, bottomleft or off
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
col	color to be plotted. Defaults to "black"
pch	marker for points. Defaults to 20.
gam	scaling of the effective dimensionality for rescaling. Defaults to 1.
R	scale for the radial transformation. If not set, defaults to maximum distance from origin to each row of data.
...	other arguments passed on to <a href="#">animate</a> and <a href="#">display_sage</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**Examples**

```
# Generate uniform samples in a 10d sphere using the geozoo package
sphere10 <- geozoo::sphere.solid.random(10)$points
# Columns need to be named before launching the tour
colnames(sphere10) <- paste0("x", 1:10)
# Standard grand tour display, points cluster near center
animate_xy(sphere10)
# Sage display, points are uniformly distributed across the disk
animate_sage(sphere10)
```

---

display_scattermat	<i>Scatterplot matrix tour path animation.</i>
--------------------	--

---

### Description

Animate a nD tour path with a scatterplot matrix.

### Usage

```
display_scattermat(...)

animate_scattermat(data, tour_path = grand_tour(3), ...)
```

### Arguments

...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

### Details

The lines show the observations, and the points, the values of the projection matrix.

### See Also

[animate](#) for options that apply to all animations

### Examples

```
animate_scattermat(flea[, 1:6], grand_tour(2))
animate_scattermat(flea[, 1:6], grand_tour(6))
```

---

display_slice	<i>Display tour path with a sliced scatterplot</i>
---------------	--

---

### Description

Animate a 2D tour path with a sliced scatterplot.

**Usage**

```

display_slice(
  center = TRUE,
  axes = "center",
  half_range = NULL,
  col = "black",
  pch_slice = 20,
  pch_other = 46,
  cex_slice = 2,
  cex_other = 1,
  v_rel = NULL,
  anchor = NULL,
  edges = NULL,
  edges.col = "black",
  ...
)

animate_slice(data, tour_path = grand_tour(), rescale = TRUE, ...)

```

**Arguments**

center	if TRUE, centers projected data to (0,0). This pins the center of data cloud and make it easier to focus on the changing shape rather than position.
axes	position of the axes: center, bottomleft or off
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
col	color to be plotted. Defaults to "black"
pch_slice	marker for plotting points inside the slice. Defaults to 20.
pch_other	marker for plotting points outside the slice. Defaults to 46.
cex_slice	size of the points inside the slice. Defaults to 2.
cex_other	size if the points outside the slice. Defaults to 1.
v_rel	relative volume of the slice. If not set, suggested value is calculated and printed to the screen.
anchor	A vector specifying the reference point to anchor the slice. If NULL (default) the slice will be anchored at the data center.
edges	A two column integer matrix giving indices of ends of lines.
edges.col	colour of edges to be plotted, Defaults to "black."
...	other arguments passed on to <a href="#">animate</a> and <a href="#">display_slice</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour
rescale	if true, rescale all variables to range [0,1].

**Examples**

```
# Generate samples on a 3d and 5d hollow sphere using the geozoo package
sphere3 <- geozoo::sphere.hollow(3)$points
sphere5 <- geozoo::sphere.hollow(5)$points

# Columns need to be named before launching the tour
colnames(sphere3) <- c("x1", "x2", "x3")
colnames(sphere5) <- c("x1", "x2", "x3", "x4", "x5")

# Animate with the slice display using the default parameters
animate_slice(sphere3)
animate_slice(sphere5)

# Animate with off-center anchoring
anchor3 <- rep(0.7, 3)
anchor5 <- rep(0.3, 5)
animate_slice(sphere3, anchor = anchor3)
# Animate with thicker slice to capture more points in each view
animate_slice(sphere5, anchor = anchor5, v_rel = 0.02)
```

---

display\_stars

*Star glyph tour path animation.*


---

**Description**

Animate a nD tour path with star glyphs.

**Usage**

```
display_stars(...)
```

```
animate_stars(data, tour_path = grand_tour(3), ...)
```

**Arguments**

...	other arguments passed on to <a href="#">stars</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**Details**

Currently, scaling doesn't seem to be computed absolutely correctly, as centres move around as well as outside points.

**See Also**

[animate](#) for options that apply to all animations

**Examples**

```

animate_stars(flea[1:10, 1:6])
animate_stars(flea[1:10, 1:6], grand_tour(5))
animate_stars(flea[, 1:6], grand_tour(5))
animate_stars(flea[1:10, 1:6], grand_tour(5),
  col.stars = rep("grey50", 10), radius = FALSE
)

```

---

display\_stereo      *Anaglyph tour path animation.*

---

**Description**

Uses red-blue anaglyphs to display a 3d tour path. You'll need some red- blue glasses to get much out of this displays!

**Usage**

```
display_stereo(blue, red, cex = 1, ...)
```

```

animate_stereo(
  data,
  tour_path = grand_tour(3),
  blue = rgb(0, 0.91, 0.89),
  red = rgb(0.98, 0.052, 0),
  ...
)

```

**Arguments**

blue	blue colour (for right eye)
red	red colour (for left eye)
cex	size of the point to be plotted. Defaults to 1.
...	other arguments passed on to <a href="#">animate</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**Examples**

```
animate_stereo(flea[, 1:6])
```

---

display\_trails      *Display tour path with trails*

---

### Description

Animate a 2D tour path with a point trails

### Usage

```
display_trails(
  center = TRUE,
  axes = "center",
  half_range = NULL,
  col = "black",
  pch = 20,
  cex = 1,
  past = 3,
  ...
)
```

```
animate_trails(data, tour_path = grand_tour(), ...)
```

### Arguments

center	if TRUE, centers projected data to (0,0). This pins the center of data cloud and make it easier to focus on the changing shape rather than position.
axes	position of the axes: center, bottomleft or off
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
col	color to be plotted. Defaults to "black"
pch	shape of the point to be plotted. Defaults to 20.
cex	magnification of plotting text relative to default. Defaults to 1.
past	draw line between current projection and projection past steps ago
...	other arguments passed on to <a href="#">animate</a> and <a href="#">display_xy</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

---

display_xy	<i>Display tour path with a scatterplot</i>
------------	---

---

### Description

Animate a 2D tour path with a scatterplot.

### Usage

```
display_xy(
  center = TRUE,
  axes = "center",
  half_range = NULL,
  col = "black",
  pch = 20,
  cex = 1,
  edges = NULL,
  edges.col = "black",
  ...
)
```

```
animate_xy(data, tour_path = grand_tour(), ...)
```

### Arguments

center	if TRUE, centers projected data to (0,0). This pins the center of data cloud and make it easier to focus on the changing shape rather than position.
axes	position of the axes: center, bottomleft or off
half_range	half range to use when calculating limits of projected. If not set, defaults to maximum distance from origin to each row of data.
col	color to be plotted. Defaults to "black"
pch	shape of the point to be plotted. Defaults to 20.
cex	size of the point to be plotted. Defaults to 1.
edges	A two column integer matrix giving indices of ends of lines.
edges.col	colour of edges to be plotted, Defaults to "black"
...	other arguments passed on to <a href="#">animate</a> and <a href="#">display_xy</a>
data	matrix, or data frame containing numeric columns
tour_path	tour path generator, defaults to 2d grand tour

**Examples**

```

animate_xy(flea[, 1:6])
animate(flea[, 1:6], tour_path = grand_tour(), display = display_xy())
animate(flea[, 1:6],
  tour_path = grand_tour(),
  display = display_xy(axes = "bottomleft")
)
animate(flea[, 1:6],
  tour_path = grand_tour(),
  display = display_xy(half_range = 0.5)
)
animate_xy(flea[, 1:6], tour_path = little_tour())
animate_xy(flea[, 1:3], tour_path = guided_tour(holes()), sphere = TRUE)
animate_xy(flea[, 1:6], center = FALSE)

# The default axes are centered, like a biplot, but there are other options
animate_xy(flea[, 1:6], axes = "bottomleft")
animate_xy(flea[, 1:6], axes = "off")
animate_xy(flea[, 1:6], dependence_tour(c(1, 2, 1, 2, 1, 2)),
  axes = "bottomleft"
)

animate_xy(flea[, -7], col = flea$species)

# You can also draw lines
edges <- matrix(c(1:5, 2:6), ncol = 2)
animate(
  flea[, 1:6], grand_tour(),
  display_xy(axes = "bottomleft", edges = edges)
)

```

---

estimate\_eps

*Estimate cutoff eps for section pursuit.*


---

**Description**

Estimate cutoff eps for section pursuit.

**Usage**

```
estimate_eps(N, p, res, K, K_theta, r_breaks)
```

**Arguments**

N	total number of points in the input data.
p	number of dimensions of the input data.
res	resolution, (slice radius)/(data radius)
K	total number of bins



K\_theta            number of angular bins  
r\_breaks           boundaries of the radial bins

---

Flea measurements            *Flea beetle measurements*

---

### Description

This data is from a paper by A. A. Lubischew, "On the Use of Discriminant Functions in Taxonomy", Biometrics, Dec 1962, pp.455-477.

### Format

A 74 x 7 numeric array

### Details

- tars1, width of the first joint of the first tarsus in microns (the sum of measurements for both tarsi)
- tars2, the same for the second joint
- head, the maximal width of the head between the external edges of the eyes in 0.01 mm
- ade1, the maximal width of the aedeagus in the fore-part in microns
- ade2, the front angle of the aedeagus ( 1 unit = 7.5 degrees)
- ade3, the aedeagus width from the side in microns
- species, which species is being examined - concinna, heptapotamica, heikertingeri

### Examples

```
head(flea)
animate_xy(flea[, -7])
animate_xy(flea[, -7], col = flea[, 7])
```

---

frozen\_guided\_tour            *The frozen guided tour*

---

### Description

The frozen guided tour

### Usage

```
frozen_guided_tour(frozen, index_f, d = 2, max.tries = 25)
```

**Arguments**

frozen	matrix of frozen variables, as described in <a href="#">freeze</a>
index_f	the index function to optimise.
d	target dimensionality
max.tries	the maximum number of unsuccessful attempts to find a better projection before giving up

**See Also**

[cmass](#), [holes](#) and [lda\\_pp](#) for examples of index functions. The function should take a numeric matrix and return a single number, preferably between 0 and 1.

**Examples**

```
frozen <- matrix(NA, nrow = 4, ncol = 2)
frozen[3, ] <- .5
animate_xy(flea[, 1:4], frozen_guided_tour(frozen, holes()))
```

---

frozen_tour	<i>A frozen tour path.</i>
-------------	----------------------------

---

**Description**

A frozen tour fixes some of the values of the orthonormal projection matrix and allows the others to vary freely according to any of the other tour methods. This frozen tour is a frozen grand tour. See [frozen\\_guided\\_tour](#) for a frozen guided tour.

**Usage**

```
frozen_tour(d = 2, frozen)
```

**Arguments**

d	target dimensionality
frozen	matrix of frozen variables, as described in <a href="#">freeze</a>

**Details**

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

**Examples**

```
frozen <- matrix(NA, nrow = 4, ncol = 2)
frozen[3, ] <- .5
animate_xy(flea[, 1:4], frozen_tour(2, frozen))

frozen <- matrix(NA, nrow = 4, ncol = 2)
frozen[1, 1] <- 0.5
animate_xy(flea[, 1:4], frozen_tour(2, frozen))

# Doesn't work - a bug?
frozen <- matrix(NA, nrow = 4, ncol = 2)
frozen[1:2, 1] <- 1 / 4
animate_xy(flea[, 1:4], frozen_tour(2, frozen))

## Not run:
# This freezes one entire direction which causes a problem,
# and is caught by error handling.
# If you want to do this it would be best with a dependence
# tour, with one variable set one axis, eg 3rd variable to
# x axis would be indicated from the code below
frozen <- matrix(NA, nrow = 4, ncol = 2)
frozen[3, ] <- c(0, 1)
animate_xy(flea[, 1:4], frozen_tour(2, frozen))

## End(Not run)

# Two frozen variables in five.
frozen <- matrix(NA, nrow = 5, ncol = 2)
frozen[3, ] <- .5
frozen[4, ] <- c(-.2, .2)
animate_xy(flea[, 1:5], frozen_tour(2, frozen))
```

---

grand\_tour

*A grand tour path.*


---

**Description**

This method generates target bases by randomly sampling on the space of all d-dimensional planes in p-space.

**Usage**

```
grand_tour(d = 2, ...)
```

**Arguments**

d	target dimensionality
...	arguments sent to the generator

**Details**

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

**Examples**

```
# All animation methods use the grand tour path by default
animate_dist(flea[, 1:6])
animate_xy(flea[, 1:6])
animate_pcp(flea[, 1:6])
animate_pcp(flea[, 1:6], grand_tour(4))

# The grand tour is a function:
tour2d <- grand_tour(2)
is.function(tour2d)

# with two parameters, the previous projection and the data set
args(tour2d)
# if the previous projection is null, it will generate a starting
# basis, otherwise the argument is ignored
tour2d(NULL, mtcars)
# the data argument is just used to determine the correct dimensionality
# of the output matrix
tour2d(NULL, mtcars[, 1:2])
```

---

guided\_section\_tour    *A guided section tour path.*

---

**Description**

The guided section tour is a variation of the guided tour that is using a section pursuit index for the selection of target planes.

**Usage**

```
guided_section_tour(
  index_f,
  d = 2,
  alpha = 0.5,
  cooling = 0.99,
  max.tries = 25,
  max.i = Inf,
  v_rel = NULL,
  anchor = NULL,
  search_f = search_geodesic,
  ...
)
```

**Arguments**

<code>index_f</code>	the section pursuit index function to optimise. The function needs to take three arguments, the projected data, the vector of distances from the current projection plane, and the slice thickness <code>h</code> .
<code>d</code>	target dimensionality
<code>alpha</code>	the initial size of the search window, in radians
<code>cooling</code>	the amount the size of the search window should be adjusted by after each step
<code>max.tries</code>	the maximum number of unsuccessful attempts to find a better projection before giving up
<code>max.i</code>	the maximum index value, stop search if a larger value is found
<code>v_rel</code>	relative volume of the slice. If not set, suggested value is calculated and printed to the screen.
<code>anchor</code>	A vector specifying the reference point to anchor the slice. If NULL (default) the slice will be anchored at the data center.
<code>search_f</code>	the search strategy to use
<code>...</code>	arguments sent to the <code>search_f</code>

**Details**

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate\\_slice](#), [save\\_history](#) or [render](#).

**See Also**

[slice\\_index](#) for an example of an index functions. [search\\_geodesic](#), [search\\_better](#), [search\\_better\\_random](#) for different search strategies

**Examples**

```
# Generate samples on a 3d hollow sphere using the geozoo package
set.seed(12345)
sphere3 <- geozoo::sphere.hollow(3)$points
# Columns need to be named before launching the tour
colnames(sphere3) <- c("x1", "x2", "x3")
# Off-center anchoring
anchor3 <- rep(0.75, 3)
# Index setup
r_breaks <- linear_breaks(5, 0, 1)
a_breaks <- angular_breaks(10)
eps <- estimate_eps(nrow(sphere3), ncol(sphere3), 0.1 / 1, 5 * 10, 10, r_breaks)
idx <- slice_index(r_breaks, a_breaks, eps, bintype = "polar", power = 1, reweight = TRUE, p = 3)
# Running the guided section tour select sections showing a big hole in the center
animate_slice(sphere3, guided_section_tour(idx, v_rel = 0.1, anchor = anchor3, max.tries = 5),
  v_rel = 0.1, anchor = anchor3
)
```

---

 guided\_tour

*A guided tour path.*


---

### Description

Instead of choosing new projections at random like the grand tour, the guided tour always tries to find a projection that is more interesting than the current projection.

### Usage

```
guided_tour(
  index_f,
  d = 2,
  alpha = 0.5,
  cooling = 0.99,
  max.tries = 25,
  max.i = Inf,
  search_f = search_geodesic,
  n_sample = 100,
  ...
)
```

### Arguments

<code>index_f</code>	the index function to optimise.
<code>d</code>	target dimensionality
<code>alpha</code>	the initial size of the search window, in radians
<code>cooling</code>	the amount the size of the search window should be adjusted by after each step
<code>max.tries</code>	the maximum number of unsuccessful attempts to find a better projection before giving up
<code>max.i</code>	the maximum index value, stop search if a larger value is found
<code>search_f</code>	the search strategy to use: <a href="#">search_geodesic</a> , <a href="#">search_better</a> , <a href="#">search_better_random</a> , <a href="#">search_polish</a> . Default is <a href="#">search_geodesic</a> .
<code>n_sample</code>	number of samples to generate if <code>search_f</code> is <a href="#">search_polish</a>
<code>...</code>	arguments sent to the <code>search_f</code>

### Details

Currently the index functions only work in 2d.

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

**See Also**

[cmass](#), [holes](#) and [lda\\_pp](#) for examples of index functions. The function should take a numeric matrix and return a single number, preferably between 0 and 1. [search\\_geodesic](#), [search\\_better](#), [search\\_better\\_random](#) for different search strategies

**Examples**

```
## Not run:
animate_xy(flea[, 1:6], guided_tour(holes()), sphere = TRUE)
animate_xy(flea[, 1:6], guided_tour(holes(), search_f = search_better_random), sphere = TRUE)
animate_dist(flea[, 1:6], guided_tour(holes(), 1), sphere = TRUE)
animate_xy(flea[, 1:6], guided_tour(lda_pp(flea$species)), sphere = TRUE, col = flea$species)

# save_history is particularly useful in conjunction with the
# guided tour as it allows us to look at the tour path in many different
# ways
f <- flea[, 1:3]
tries <- replicate(5, save_history(f, guided_tour(holes()))), simplify = FALSE)

## End(Not run)
```

---

holes

*Holes index.*


---

**Description**

Calculates the holes index. See Cook and Swayne (2007) Interactive and Dynamic Graphics for Data Analysis for equations.

**Usage**

```
holes()
```

---

interpolate

*Interpolate geodesically between bases.*


---

**Description**

This function takes a set of bases and produces a tour by geodesically interpolating between each basis

**Usage**

```
interpolate(basis_set, angle = 0.05, cycle = FALSE)
```

**Arguments**

basis_set	input basis set
angle	target distance (in radians) between bases
cycle	For <code>planned_tour</code> cycle through continuously (TRUE) or stop after first pass (FALSE)

**Examples**

```
t1 <- save_history(flea[, 1:6], grand_tour(1), max = 10)
dim(t1)
dim(interpolate(t1, 0.01))
dim(interpolate(t1, 0.05))
dim(interpolate(t1, 0.1))
```

---

Laser measurements      *Turnable laser measurements from Bellcore*

---

**Description**

This data came from an investigation of an experimental laser at Bellcore. It was a tunable laser, in the sense that both its wavelength and power output were controllable.

**Format**

A 64 x 4 numeric array

**Details**

Rotation helped the experimental physicists to characterize the laser, which turned out not to be a very good one, due to its unstable operating region.

This data initially came to the statistics research group when Janette Cooper asked Paul Tukey to help her analyze the data she had collected to describe the laser.

- ifront, current applied to the front of the laser
- iback, current applied to the back of the laser
- power, output power
- lambda, output wavelength

**Examples**

```
head(laser)
animate_xy(laser[, -4])
```



---

lda_pp	<i>LDA projection pursuit index.</i>
--------	--------------------------------------

---

**Description**

Calculate the LDA projection pursuit index. See Cook and Swayne (2007) Interactive and Dynamic Graphics for Data Analysis for equations.

**Usage**

```
lda_pp(c1)
```

**Arguments**

c1	class to be used. Such as "color"
----	-----------------------------------

---

linear_breaks	<i>Returns n equidistant bins between a and b</i>
---------------	---

---

**Description**

Returns n equidistant bins between a and b

**Usage**

```
linear_breaks(n, a, b)
```

**Arguments**

n	number of bins
a	lower bound
b	upper bound

---

little_tour	<i>A little tour path.</i>
-------------	----------------------------

---

**Description**

The little tour is a planned tour that travels between all axis parallel projections. (John McDonald named this type of tour.)

**Usage**

```
little_tour(d = 2)
```

**Arguments**

d	target dimensionality
---	-----------------------

**Details**

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

**Examples**

```
animate_xy(flea[, 1:6], little_tour())
animate_pcp(flea[, 1:6], little_tour(3))
animate_scatmat(flea[, 1:6], little_tour(3))
animate_pcp(flea[, 1:6], little_tour(4))
```

---

local_tour	<i>A local tour path.</i>
------------	---------------------------

---

**Description**

The local tour alternates between the starting position and a nearby random projection.

**Usage**

```
local_tour(start, angle = pi/4)
```

**Arguments**

start	initial projection matrix
angle	distance in radians to stay within

**Details**

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

**Examples**

```
animate_xy(flea[, 1:3], local_tour(basis_init(3, 2)))
animate_xy(flea[, 1:3], local_tour(basis_init(3, 2), 0.2))
animate_xy(flea[, 1:3], local_tour(basis_random(3, 2), 0.2))
```

---

mapColors	<i>Map vector of factors to color</i>
-----------	---------------------------------------

---

**Description**

Map vector of factors to color

**Usage**

```
mapColors(x)
```

**Arguments**

x	vector
---	--------

---

norm_bin	<i>Normality index.</i>
----------	-------------------------

---

**Description**

Compares the similarity between the projected distribution and a normal distribution.

- norm\_bin compares the count in 100 histogram bins
- norm\_kol compares the cdf based on the Kolmogorov–Smirnov test (KS test)

**Usage**

```
norm_bin(nr)
```

```
norm_kol(nr)
```

**Arguments**

nr	The number of rows in the target matrix
----	---

### Examples

```
# manually compute the norm_kol index
# create the index function
set.seed(123)
index <- norm_kol(nrow(flea[, 1:3]))
# create the projection
proj <- matrix(c(1, 0, 0), nrow = 3)
# pre-process the example data
flea_s <- sphere_data(flea[, 1:3])
# produce the index value
index(flea_s %*% proj)
```

---

Olive oil measurements

*Olive oil samples from Italy*

---

### Description

This data is from a paper by Forina, Armanino, Lanteri, Tiscornia (1983) Classification of Olive Oils from their Fatty Acid Composition, in Martens and Russwurm (ed) Food Research and Data Analysis. We thank Prof. Michele Forina, University of Genova, Italy for making this dataset available.

### Format

A 572 x 10 numeric array

### Details

- region Three super-classes of Italy: North, South and the island of Sardinia
- area Nine collection areas: three from North, four from South and 2 from Sardinia
- palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, arachidic, eicosenoic fatty acids percent x 100

### Examples

```
head(olive)
animate_xy(olive[, c(7, 9, 10)])
animate_xy(olive[, c(7, 9, 10)], col = olive[, 1])
```

---

Ozone measurements      *Monthly ozone measurements over Central America*

---

**Description**

This data set is a subset of the data from the 2006 ASA Data expo challenge. The data are monthly ozone averages on a very coarse 24 by 24 grid covering Central America, from Jan 1995 to Dec 2000. The data is stored in a 3d area with the first two dimensions representing latitude and longitude, and the third representing time.

**Format**

A 24 x 24 x 72 numeric array

**Examples**

```
example(display_image)
```

---

path\_curves      *Draw the path that the geodesics took.*

---

**Description**

This computes the projected values of each observation at each step, and allows you to recreate static views of the animated plots.

**Usage**

```
path_curves(history, data = attr(history, "data"))
```

**Arguments**

history      list of bases produced by `save_history` (or otherwise)  
 data      dataset to be projected on to bases

**Examples**

```
path1d <- save_history(flea[, 1:6], grand_tour(1), 10)
path2d <- save_history(flea[, 1:6], grand_tour(2), 10)

if (require("ggplot2")) {
  plot(path_curves(path1d))
  plot(path_curves(interpolate(path1d)))

  plot(path_curves(path2d))
}
```

```

plot(path_curves(interpolate(path2d)))

# Instead of relying on the built in plot method, you might want to
# generate your own. Here are few examples of alternative displays:

df <- path_curves(path2d)
ggplot(data = df, aes(x = step, y = value, group = obs:var, colour = var)) +
  geom_line() +
  facet_wrap(~obs)

library(tidyr)
ggplot(
  data = pivot_wider(df,
    id_cols = c(obs, step),
    names_from = var, names_prefix = "Var",
    values_from = value
  ),
  aes(x = Var1, y = Var2)
) +
  geom_point() +
  facet_wrap(~step) +
  coord_equal()
}

```

---

path\_dist

*Compute distance matrix from bases.*


---

### Description

Compute distance matrix from bases.

### Usage

```
path_dist(history)
```

### Arguments

history            history of the plots

### Examples

```

## Not run:
grand <- interpolate(save_history(flea[, 1:6], max = 50), 0.2)
# The grand tour -----
# Look at the tour path in a tour, how well does it cover a sphere
# Using MDS
d <- path_dist(grand)
ord <- as.data.frame(MASS::isoMDS(d)$points)
ggplot(data = ord, aes(x=V1, y=V2)) +
  geom_path() +

```

```

  coord_equal() +
  labs(x = NULL, y = NULL)

## End(Not run)

# 5 guided tours -----
holes1d <- guided_tour(holes(), 1)
tour_reps <- replicate(5, save_history(flea[, 1:6], holes1d, max = 10),
  simplify = FALSE
)
tour_reps2 <- lapply(tour_reps, interpolate, 0.2)

bases <- unlist(lapply(tour_reps2, as.list), recursive = FALSE)
class(bases) <- "history_list"
index_values <- paths_index(tour_reps2, holes())
d <- path_dist(bases)
ord <- as.data.frame(cmdscale(d, 2))

info <- cbind(ord, index_values)
if (require("ggplot2")) {
  ggplot(data = info, aes(x = step, y = value, group = try)) +
    geom_line()
  ggplot(data = info, aes(x = V1, y = V2, group = try)) +
    geom_path() +
    geom_point(aes(size = value)) +
    coord_equal()
  last_plot() + facet_wrap(~try)
}

```

---

path\_index

*Compute index values for a tour history.*


---

### Description

Compute index values for a tour history.

### Usage

```
path_index(history, index_f, data = attr(history, "data"))
```

### Arguments

history	list of bases produced by <a href="#">save_history</a> (or otherwise)
index_f	index function to apply to each basis
data	dataset to be projected on to bases

### See Also

[save\\_history](#) for options to save history

**Examples**

```

fl_holes <- save_history(flea[, 1:6], guided_tour(holes()), sphere = TRUE)
path_index(fl_holes, holes())
path_index(fl_holes, cmass())

plot(path_index(fl_holes, holes()), type = "l")
plot(path_index(fl_holes, cmass()), type = "l")

# Use interpolate to show all intermediate bases as well
## Not run:
hi <- path_index(interpolate(fl_holes), holes())
hi
plot(hi)

## End(Not run)

```

---

pda\_pp *PDA projection pursuit index.*

---

**Description**

Calculate the PDA projection pursuit index. See Lee and Cook (2009) A Projection Pursuit Index for Large p, Small n Data

**Usage**

```
pda_pp(cl, lambda = 0.2)
```

**Arguments**

cl class to be used. Such as "color"  
lambda shrinkage parameter (0 = no shrinkage, 1 = full shrinkage)

---

Places Ratings *Ratings of different locations across North America*

---

**Description**

The "places data" were distributed to interested ASA members a few years ago so that they could apply contemporary data analytic methods to describe these data and then present results in a poster session at the ASA annual conference. Latitude and longitude have been added by Paul Tukey.

**Format**

A 329 x 14 numeric array



## Details

---

The first dataset is taken from the Places Rated Almanac, by Richard Boyer and David Savageau, copyrighted and published by Rand McNally. This book order (SBN) number is 0-528-88008-X, and it retails for \$14.95 . The data are reproduced on disk by kind permission of the publisher, and with the request that the copyright notice of Rand McNally, and the names of the authors appear in any paper or presentation using these data.

The nine rating criteria used by Places Rated Almanac are: Climate and Terrain Housing Health Care and Environment Crime Transportation Education The Arts Recreation Economics

For all but two of the above criteria, the higher the score, the better. For Housing and Crime, the lower the score the better.

The scores are computed using the following component statistics for each criterion (see the Places Rated Almanac for details):

Climate and Terrain: very hot and very cold months, seasonal temperature variation, heating- and cooling-degree days, freezing days, zero-degree days, ninety-degree days.

Housing: utility bills, property taxes, mortgage payments.

Health Care and Environment: per capita physicians, teaching hospitals, medical schools, cardiac rehabilitation centers, comprehensive cancer treatment centers, hospices, insurance/hospitalization costs index, flouridation of drinking water, air pollution.

Crime: violent crime rate, property crime rate.

Transportation: daily commute, public transportation, Interstate highways, air service, passenger rail service.

Education: pupil/teacher ratio in the public K-12 system, effort index in K-12, accademic options in higher education.

The Arts: museums, fine arts and public radio stations, public television stations, universities offering a degree or degrees in the arts, symphony orchestras, theatres, opera companies, dance companies, public libraries.

Recreation: good restaurants, public golf courses, certified lanes for tenpin bowling, movie theatres, zoos, aquariums, family theme parks, sanctioned automobile race tracks, pari-mutuel betting attractions, major- and minor- league professional sports teams, NCAA Division I football and basketball teams, miles of ocean or Great Lakes coastline, inland water, national forests, national parks, or national wildlife refuges, Consolidated Metropolitan Statistical Area access.

Economics: average household income adjusted for taxes and living costs, income growth, job growth.

## Examples

```
head(places)
animate_xy(places[, 1:9])
```

---

planned_tour	<i>A planned tour path.</i>
--------------	-----------------------------

---

### Description

The planned tour takes you from one basis to the next in a set order. Once you have visited all the planned bases, you either stop or start from the beginning once more (if `cycle = TRUE`).

### Usage

```
planned_tour(basis_set, cycle = FALSE)
```

### Arguments

basis_set	the set of bases as a list of projection matrices or a 3d array
cycle	cycle through continuously (TRUE) or stop after first pass (FALSE)

### Details

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

### See Also

The [little\\_tour](#), a special type of planned tour which cycles between all axis parallel projections.

### Examples

```
twod <- save_history(flea[, 1:3], max = 5)
str(twod)
animate_xy(flea[, 1:3], planned_tour(twod))
animate_xy(flea[, 1:3], planned_tour(twod, TRUE))

oned <- save_history(flea[, 1:6], grand_tour(1), max = 3)
animate_dist(flea[, 1:6], planned_tour(oned))
```

---

proj_dist	<i>Calculate the distance between two bases.</i>
-----------	--

---

### Description

Computes the Frobenius norm between two bases, in radians. This is equals to the Euclidean norm of the vector of principal angles between the two subspaces.

### Usage

```
proj_dist(x, y)
```

**Arguments**

x	projection matrix a
y	projection matrix b

---

radial_tour	<i>A radial tour path.</i>
-------------	----------------------------

---

**Description**

The radial tour rotates a chosen variable axis out of the current projection.

**Usage**

```
radial_tour(start, mvar = 1, ...)
```

**Arguments**

start	initial projection matrix
mvar	variable chosen to rotate out
...	additional arguments for drawing

**Details**

Usually, you will not call this function directly, but will pass it to a method that works with tour paths like [animate](#), [save\\_history](#) or [render](#).

**Examples**

```
animate_xy(flea[, 1:6], radial_tour(basis_random(6, 2), mvar = 4))
animate_dist(flea[, 1:6], radial_tour(basis_random(6, 1), mvar = 4))
animate_scatmat(flea[, 1:6], radial_tour(basis_random(6, 3), mvar = 4))
```

---

Rat CNS	<i>Rat CNS Gene Expression</i>
---------	--------------------------------

---

**Description**

Columns:

**Format**

A 112 x 11 numeric array

**Details**

e11 e13 e15 e18 e21 p0 p7 p14 a class1 class2

- e11, an embryonic timepoint from the original data with the number corresponding to the day
- e13, an embryonic timepoint from the original data with the number corresponding to the day
- e15, an embryonic timepoint from the original data with the number corresponding to the day
- e18, an embryonic timepoint from the original data with the number corresponding to the day
- e21, an embryonic timepoint from the original data with the number corresponding to the day
- p0, a postnatal timepoint from the original data with the number corresponding to the day
- p7, a postnatal timepoint from the original data with the number corresponding to the day
- p14, a postnatal timepoint from the original data with the number corresponding to the day
- a, a postnatal timepoint from the original data. It is equivalent to p90.
- class1, is the high-level class: its range is 1:4
- class2, breaks down the high-level classes, so its range is 1:14

Rows: Each case is a gene (or gene family?) And each cell is the gene expression level for that gene at time t, averaging a few measured values and normalizing using the maximum expression value for that gene.

Reference (available on the web at [pnas.org](https://www.pnas.org)): Large-scale temporal gene expression mapping of central nervous system development by X. Wen, S. Fuhrman, G. S. Michaels, D. B. Carr, S. Smith, J. L. Barker, R. Somogyi in the Proceedings of the National Academy of Science, Vol 95, pp. 334-339, January 1998

**References**

<https://www.pnas.org>

**Examples**

```
head(ratcns)
animate_xy(ratcns[, 1:8], col = ratcns[, 10])
```

---

render

*Render frames of animation to disk*

---

**Description**

Render frames of animation to disk

## Usage

```
render(  
  data,  
  tour_path,  
  display,  
  dev,  
  ...,  
  apf = 1/10,  
  frames = 50,  
  rescale = TRUE,  
  sphere = FALSE,  
  start = NULL  
)
```

## Arguments

data	matrix, or data frame containing numeric columns
tour_path	tour path generator
display	the method used to render the projected data, e.g. <a href="#">display_xy</a> , <a href="#">display_pcp</a>
dev	name of output device to use (e.g. <a href="#">png</a> , <a href="#">pdf</a> )
...	other options passed to output device
apf	angle (in radians) per frame
frames	number of frames in output
rescale	if true, rescale all variables to range [0,1]
sphere	if true, sphere all variables
start	starting projection. If NULL, uses path default.

## Examples

```
## Not run:  
tmp_path <- tempdir()  
render(flea[, 1:6], grand_tour(), display_xy(), "pdf",  
  frames = 3,  
  file.path(tmp_path, "test.pdf")  
)  
render(flea[, 1:6], grand_tour(), display_xy(), "png",  
  frames = 3,  
  file.path(tmp_path, "test-%03d.png")  
)  
  
## End(Not run)
```

---

render_gif	<i>Render frames of animation to a gif file</i>
------------	---

---

### Description

Render frames of animation to a gif file

### Usage

```
render_gif(
  data,
  tour_path,
  display,
  gif_file = "animation.gif",
  ...,
  apf = 1/10,
  frames = 50,
  rescale = TRUE,
  sphere = FALSE,
  start = NULL
)
```

### Arguments

data	matrix, or data frame containing numeric columns
tour_path	tour path generator
display	the method used to render the projected data, e.g. <a href="#">display_xy</a> , <a href="#">display_pcp</a>
gif_file	Name of gif file (default = "animation.gif")
...	other options passed to <a href="#">png</a>
apf	angle (in radians) per frame
frames	number of frames in output
rescale	if true, rescale all variables to range [0,1]
sphere	if true, sphere all variables
start	starting projection. If NULL, uses path default.

### Examples

```
## Not run:
# gifski needs to be installed to render a gif
if (requireNamespace("gifski", quietly = TRUE)) {
  gif_file <- file.path(tempdir(), "test.gif")
  render_gif(flea[, 1:6], grand_tour(), display_xy(), gif_file)
  utils::browseURL(gif_file)
  unlink(gif_file)
}

## End(Not run)
```

---

rescale	<i>Rescale a matrix or data frame</i>
---------	---------------------------------------

---

**Description**

Standardise each column to have range [0, 1]

**Usage**

```
rescale(df)
```

**Arguments**

df	data frame or matrix
----	----------------------

---

save_history	<i>Save tour history.</i>
--------------	---------------------------

---

**Description**

Save a tour path so it can later be displayed in many different ways.

**Usage**

```
save_history(
  data,
  tour_path = grand_tour(),
  max_bases = 100,
  start = NULL,
  rescale = TRUE,
  sphere = FALSE,
  step_size = Inf,
  ...
)
```

**Arguments**

data	matrix, or data frame containing numeric columns
tour_path	tour path generator
max_bases	maximum number of new bases to generate. Some tour paths (like the guided tour) may generate less than the maximum.
start	starting projection, if you want to specify one
rescale	if true, rescale all variables to range [0,1]?
sphere	if true, sphere all variables

```

step_size      distance between each step - defaults to Inf which forces new basis generation
                at each step.
...           additional arguments passed to tour path

```

### Examples

```

# You can use a saved history to replay tours with different visualisations

t1 <- save_history(flea[, 1:6], max = 3)
animate_xy(flea[, 1:6], planned_tour(t1))
## andrews_history(t1)
## andrews_history(interpolate(t1))

t1 <- save_history(flea[, 1:6], grand_tour(4), max = 3)
animate_pcp(flea[, 1:6], planned_tour(t1))
animate_scatmat(flea[, 1:6], planned_tour(t1))

t1 <- save_history(flea[, 1:6], grand_tour(1), max = 3)
animate_dist(flea[, 1:6], planned_tour(t1))

testdata <- matrix(rnorm(100 * 3), ncol = 3)
testdata[1:50, 1] <- testdata[1:50, 1] + 10
testdata <- sphere_data(testdata)
t2 <- save_history(testdata, guided_tour(holes(), max.tries = 100),
  max = 5, rescale = FALSE
)
animate_xy(testdata, planned_tour(t2))

# Or you can use saved histories to visualise the path that the tour took.
plot(path_index(interpolate(t2), holes()))
plot(path_curves(interpolate(t2)))

```

---

search\_better

*Search for a better projection near the current projection.*

---

### Description

Search for a better projection near the current projection.

### Usage

```

search_better(
  current,
  alpha = 0.5,
  index,
  tries,
  max.tries = Inf,
  ...,
  method = "linear",

```



```

    cur_index = NA
  )

```

### Arguments

current	starting projection
alpha	the angle used to search the target basis from the current basis
index	index function
tries	the counter of the outer loop of the optimiser
max.tries	maximum number of iteration before giving up
...	other arguments being passed into the search_better()
method	whether the nearby bases are found by a linear/ geodesic formulation
cur_index	the index value of the current basis

### Examples

```
animate_xy(flea[, 1:6], guided_tour(holes(), search_f = search_better))
```

---

search\_better\_random *Search for a better projection using simulated annealing*

---

### Description

Given an initial  $t_0$ , the cooling scheme updates temperature at

$$T = t_0 / \log(i + 1)$$

The candidate basis is sampled via

$$B_j = (1 - \alpha) * B_i + \alpha * B$$

where alpha defines the neighbourhood,  $B_i$  is the current basis,  $B$  is a randomly generated basis

The acceptance probability is calculated as

$$prob = \exp(-abs(I(B_i) - I(B_j))/T)$$

For more information, see [https://projecteuclid.org/download/pdf\\_1/euclid.ss/1177011077](https://projecteuclid.org/download/pdf_1/euclid.ss/1177011077)

### Usage

```

search_better_random(
  current,
  alpha = 0.5,
  index,
  tries,
  max.tries = Inf,
  method = "linear",
  cur_index = NA,
  t0 = 0.01,
  ...
)

```

**Arguments**

current	starting projection
alpha	the angle used to search the target basis from the current basis
index	index function
tries	the counter of the outer loop of the optimiser
max.tries	maximum number of iteration before giving up
method	whether the nearby bases are found by a linear/ geodesic formulation
cur_index	the index value of the current basis
t0	initial decrease in temperature
...	other arguments being passed into the search_better_random()

**Examples**

```
animate_xy(flea[, 1:6], guided_tour(holes(), search_f = search_better_random))
```

---

search\_geodesic      *A pseudo-derivative, line search algorithm.*

---

**Description**

This is a novel method for finding more interesting projections for the guided tour. It works by first taking a small step in  $n$  random directions, and then picking the direction that looks most promising (based on the height of the index function), which is effectively a gradient search. Then it performs a linear search along the geodesic in that direction, traveling up to half way around the sphere.

**Usage**

```
search_geodesic(  
  current,  
  alpha = 1,  
  index,  
  tries,  
  max.tries = 5,  
  ...,  
  n = 5,  
  delta = 0.01,  
  cur_index = NA  
)
```

**Arguments**

current	starting projection
alpha	maximum distance to travel (currently ignored)
index	interestingness index function
tries	the counter of the outer loop of the optimiser
max.tries	maximum number of failed attempts before giving up
...	other arguments being passed into the search_geodesic()
n	number of random steps to take to find best direction
delta	step size for evaluation of best direction
cur_index	index value for starting projection, set NA if it needs to be calculated

**Details**

You should not to have call this function directly, but should supply it to the [guided\\_tour](#) as a search strategy.

**Examples**

```
animate_xy(flea[, 1:6], guided_tour(holes(), search_f = search_geodesic))
```

---

search_polish	<i>Search very locally to find slightly better projections to polish a broader search.</i>
---------------	--

---

**Description**

Search very locally to find slightly better projections to polish a broader search.

**Usage**

```
search_polish(
  current,
  alpha = 0.5,
  index,
  tries,
  polish_max_tries = 30,
  cur_index = NA,
  n_sample = 100,
  polish_cooling = 1,
  ...
)
```

**Arguments**

current	the current projection basis
alpha	the angle used to search the target basis from the current basis
index	index function
tries	the counter of the outer loop of the optimiser
polish_max_tries	maximum number of iteration before giving up
cur_index	the index value of the current basis
n_sample	number of samples to generate
polish_cooling	percentage of reduction in polish_alpha when no better basis is found
...	other arguments being passed into the search_polish()

**Examples**

```

set.seed(2020)
t1 <- save_history(flea[, 1:6], guided_tour(holes()), max = 100)
attr(t1, "class") <- NULL
best_proj <- t1[, , dim(t1)[3]]
animate_xy(
  flea[, 1:6],
  guided_tour(holes(),
    search_f = search_polish,
    cur_index = 0
  ),
  start = best_proj
)

```

---

search\_posse

*Search for a better projection based on Poss, 1995*


---

**Description**

Search for a better projection based on Poss, 1995

**Usage**

```

search_posse(
  current,
  alpha = 0.5,
  index,
  tries,
  max.tries = 300,
  cur_index = NA,
  ...
)

```

**Arguments**

current	starting projection
alpha	the angle used to search the target basis from the current basis
index	index function
tries	the counter of the outer loop of the optimizer
max.tries	maximum number of iteration before giving up
cur_index	the index value of the current basis
...	other arguments being passed into the search_better()

---

slice_index	<i>Section pursuit index.</i>
-------------	-------------------------------

---

**Description**

Calculates a section pursuit index that compares the distribution inside and outside a slice.

**Usage**

```
slice_index(
  breaks_x,
  breaks_y,
  eps,
  bintype = "polar",
  power = 1,
  flip = 1,
  reweight = FALSE,
  p = 4
)
```

**Arguments**

breaks_x	binning on the first variable (x or radius).
breaks_y	binning on the second variable (y or angle).
eps	cutoff values to suppress summing up small differences. Vector with one entry for each bin, can be estimated using <a href="#">estimate_eps</a> .
bintype	select polar (default) or square binning.
power	exponent q used in the index computation.
flip	sign of the index computation, select +1 when searching for low densities and -1 when searching for high densities.
reweight	if TRUE will reweight according to the expected distribution in a uniform hypersphere (default is FALSE).
p	number of variables in the data (needed for accurate reweighting, default is 4).

---

sphere_data	<i>Sphere a matrix (or data frame) by transforming variables to principal components.</i>
-------------	---

---

**Description**

Sphering is often useful in conjunction with the guided tour, as it removes simpler patterns that may conceal more interesting findings.

**Usage**

```
sphere_data(df)
```

**Arguments**

df	data frame or matrix
----	----------------------

---

splines2d	<i>Spline based index.</i>
-----------	----------------------------

---

**Description**

Compares the variance in residuals of a fitted spline model to the overall variance to find functional dependence in 2D projections of the data.

**Usage**

```
splines2d()
```

---

Tropical Atmosphere Ocean	<i>Tropical Atmosphere Ocean data</i>
---------------------------	---------------------------------------

---

**Description**

This is a subset of data taken from the NOAA web site <https://www.pmel.noaa.gov/tao/>. The data is generated from recording instruments on a grid of buoys laid out over the Pacific Ocean. The grid was setup to monitor El Nino and La Nina events. This subset contains measurements from 5 locations (0deg/110W, 2S/110W, 0deg/95W, 2S/95W, 5S/95W) and two time points Nov-Jan 1993 (normal), 1997 (El Nino). There are missing values in this data set, which need to be removed, or imputed before running a tour.

**Format**

A 736 x 8 numeric array

**References**

<https://www.pmel.noaa.gov/tao/>

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