

Package ‘cardinalR’

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Type Package

Title Collection of Data Structures

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Description A collection of functions to generate a large variety of structures in high dimensions. These data structures are useful for testing, validating, and improving algorithms used in dimensionality reduction, clustering, machine learning, and visualization.

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URL <https://jayanilakshika.github.io/cardinalR/>

BugReports <https://github.com/JayaniLakshika/cardinalR/issues>

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gen_bkgnoise	<i>Generate Background Noise Data</i>
--------------	---------------------------------------

Description

This function generates background noise data with specified parameters such as the number of samples, number of dimensions, mean, and standard deviation.

Usage

```
gen_bkgnoise(n = 500, p = 4, m = rep(0, p), s = rep(2, p))
```

Arguments

n	A numeric value (default: 500) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.
m	A numeric vector (default: c(0, 0, 0, 0)) representing the mean along each dimensions.
s	A numeric vector (default: c(2, 2, 2, 2)) representing the standard deviation along each dimensions.

Value

A data containing the generated background noise data.

Examples

```
# Generate background noise with custom mean and standard deviation
set.seed(20240412)
gen_bkgnoise(n = 500, p = 4, m = c(0, 0, 0, 0), s = c(2, 2, 2, 2))
```

gen_circle

Generate Circle in p-d

Description

This function generates a dataset representing a structure with a circle.

Usage

```
gen_circle(n = 500, p = 4)
```

Arguments

n	An integer value (default: 500) representing the sample size.
p	An integer value (default: 4) representing the number of dimensions.

Value

A data containing a circle.

Examples

```
set.seed(20240412)
circle <- gen_circle(n = 500, p = 4)
```

gen_clusteredspheres *Generate Small Spheres Within a Big Sphere*

Description

This function generates a dataset representing a structure with a small and big spheres.

Usage

```
gen_clusteredspheres(  
  n_vec = c(1000, 100),  
  k_small = 3,  
  r_vec = c(15, 3),  
  sep = 10/sqrt(3)  
)
```

Arguments

n_vec	A numeric vector (default: c(1000, 100)) representing the sample sizes of the big and small spheres respectively.
k_small	A numeric value (default: 3) representing the number of small spheres.
r_vec	A numeric vector (default: c(15, 3)) representing the radius of the big and small spheres respectively.
sep	A numeric value (default: 10 / sqrt(3)) representing how far the small spheres are placed from each other.

Value

A data containing small spheres within a big sphere.

Examples

```
set.seed(20240412)  
clusteredspheres <- gen_clusteredspheres(n_vec = c(1000, 100), k_small = 3,  
r_vec = c(15, 3), sep = 10 / sqrt(3))
```

gen_clustloc *Generate Cluster Locations*

Description

This function generate locations for any number of clusters in any dimensions.

Usage

```
gen_clustloc(p = 4, k = 3)
```

Arguments

- p A numeric value (default: 4) representing the number of dimensions.
- k A numeric value (default: 3) representing the number of clusters.

Value

A matrix of the locations.

Examples

```
set.seed(20240412)
gen_clustloc(p = 4, k = 3)
```

gen_cone	<i>Generate Blunted Cone</i>
----------	------------------------------

Description

This function generates a dataset representing a cone with the option of a sharp or blunted apex.

Usage

```
gen_cone(n = 500, p = 4, h = 5, ratio = 0.5)
```

Arguments

- n An integer value (default: 500) representing the sample size.
- p An integer value (default: 4) representing the number of dimensions.
- h A numeric value (default: 5) representing the height of the cone.
- ratio A numeric value (default: 0.5) representing the radius tip to radius base ratio of the cone. Should be less than 1.

Value

A tibble containing the cone with the option of a sharp or blunted apex.

Examples

```
set.seed(20240412)
cone <- gen_cone(n = 500, p = 4, h = 5, ratio = 0.5)
```

gen_conicspiral	<i>Generate Conical Spiral</i>
-----------------	--------------------------------

Description

This function generates a dataset representing a conical spiral structure.

Usage

```
gen_conicspiral(n = 500, spins = 1)
```

Arguments

n	A numeric value (default: 500) representing the sample size.
spins	A numeric value (default: 1) representing the number of loops of the spiral.

Value

A data containing a conical spiral structure.

Examples

```
set.seed(20240412)
conicspiral <- gen_conicspiral(n = 500, spins = 1)
```

gen_crescent	<i>Generate Crescent</i>
--------------	--------------------------

Description

This function generates a dataset representing a structure with a Crescent pattern.

Usage

```
gen_crescent(n = 500)
```

Arguments

n	An integer value (default: 500) representing the sample size.
---	---

Value

A tibble containing a Crescent structure.

Examples

```
set.seed(20240412)
crescent <- gen_crescent(n = 500)
```

gen_cubic

Generate Cubic

Description

This function generates a dataset representing a structure with a cubic pattern.

Usage

```
gen_cubic(n = 500, range = c(-1, 2))
```

Arguments

n A numeric value (default: 500) representing the sample size.
range A numeric vector (default: c(-1, 2)) representing the range along x1 axis.

Value

A data containing a cubic structure.

Examples

```
set.seed(20240412)  
cubic <- gen_cubic(n = 500)
```

gen_curvybranches

Generate data with curvy shaped branches

Description

This function generates a dataset representing a structure with non-linear shaped branches.

Usage

```
gen_curvybranches(n = 400, k = 4)
```

Arguments

n A numeric value (default: 400) representing the sample size.
k A numeric value (default: 4) representing the number of branches.

Value

A data containing non-linear shaped branches.

Examples

```
set.seed(20240412)
curvybranches <- gen_curvybranches(n = 400, k = 4)
```

gen_curvycycle	<i>Generate Curvy Cell Cycle in p-d</i>
----------------	---

Description

This function generates a dataset representing a structure with a curvy cell cycle.

Usage

```
gen_curvycycle(n = 500, p = 4)
```

Arguments

n	An integer value (default: 500) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.

Value

A data containing a curvy cell cycle.

Examples

```
set.seed(20240412)
curvycycle <- gen_curvycycle(n = 500, p = 4)
```

gen_curvycylinder	<i>Generate Curvy Cylinder</i>
-------------------	--------------------------------

Description

This function generates a dataset representing a structure with a curvy cylinder.

Usage

```
gen_curvycylinder(n = 500, h = 10)
```

Arguments

n	An integer value (default: 500) representing the sample size.
h	A numeric value (default: 10) representing the height of the cylinder.

Value

A data containing a curvy cylinder.

Examples

```
set.seed(20240412)
curvycylinder <- gen_curvycylinder(n = 500, h = 10)
```

gen_expbranches	<i>Generate data with exponential shaped branches</i>
-----------------	---

Description

This function generates a dataset representing a structure with exponential shaped branches.

Usage

```
gen_expbranches(n = 400, k = 4)
```

Arguments

n	An integer value (default: 400) representing the sample size.
k	An integer value (default: 4) representing the number of branches.

Value

A tibble containing exponential shaped branches.

Examples

```
set.seed(20240412)
expbranches <- gen_expbranches(n = 400, k = 4)
```

gen_gaussian	<i>Generate Multivariate Gaussian Cloud</i>
--------------	---

Description

This function generates a dataset representing a structure with a Gaussian.

Usage

```
gen_gaussian(n = 500, p = 4, m = rep(0, p), s = diag(p) * 0.01)
```

Arguments

n	An integer value (default: 500) representing the sample size.
p	An integer value (default: 4) representing the number of dimensions.
m	A numeric vector (default: c(0, 0, 0, 0)) representing the mean along each dimensions.
s	A numeric matrix (default: diag(4) * 0.01) representing the variance of along each dimension.

Value

A tibble containing a multivariate Gaussian cloud dataset.

Examples

```
set.seed(20240412)
gaussian <- gen_gaussian(n = 500, p = 4, m = rep(0, 4), s = diag(4))
```

gen_gridcube	<i>Generate Cube with grid points</i>
--------------	---------------------------------------

Description

This function generates a grid dataset with specified grid points along each axes.

Usage

```
gen_gridcube(n = 500, p = 4)
```

Arguments

n	An integer vector (default: 500) representing the sample size.
p	An integer value (default: 4) representing the number of dimensions.

Value

A tibble containing the cube with grid points.

Examples

```
set.seed(20240412)
gridcube <- gen_gridcube(n = 500, p = 4)
```

gen_gridedsphere *Generate Grided Sphere*

Description

This function generates a dataset representing a structure with a grided sphere.

Usage

```
gen_gridedsphere(n = 500, p = 4)
```

Arguments

n A numeric value (default: 500) representing the sample size.
p A numeric value (default: 4) representing the number of dimensions.

Value

A data containing a grided sphere.

Examples

```
set.seed(20240412)  
gridedsphere <- gen_gridedsphere(n = 500, p = 4)
```

gen_helicalspiral *Generate Helical Hyper Spiral*

Description

This function generates a dataset representing a structure with a helical hyper spiral.

Usage

```
gen_helicalspiral(n = 500)
```

Arguments

n A numeric value (default: 500) representing the sample size.

Value

A data containing a helical hyper spiral.

Examples

```
set.seed(20240412)  
helicalspiral <- gen_helicalspiral(n = 500)
```

gen_hemisphere	<i>Generate Hemisphere</i>
----------------	----------------------------

Description

This function generates a dataset representing a structure with a hemisphere.

Usage

```
gen_hemisphere(n = 500)
```

Arguments

n A numeric value (default: 500) representing the sample size.

Value

A data containing a hemisphere.

Examples

```
set.seed(20240412)
hemisphere <- gen_hemisphere(n = 500)
```

gen_hole	<i>Remove points within a spherical hole in the middle</i>
----------	--

Description

Remove points within a spherical hole in the middle

Usage

```
gen_hole(df, anchor = NULL, r = 0.5)
```

Arguments

df A tibble of coordinates.
anchor A numeric vector giving the center of the hole.
r A numeric value for the hole radius.

Value

A tibble with the hole removed.

Examples

```
set.seed(20240412)
df <- gen_scurve(n = 1000)
gen_hole(df, r = 0.5)
```

gen_hollowsphere *Generate Hollow Sphere*

Description

This function generates a dataset representing a structure with a sphere with points on the surface.

Usage

```
gen_hollowsphere(n = 500, p = 4)
```

Arguments

n A numeric value (default: 500) representing the sample size.
p A numeric value (default: 4) representing the number of dimensions.

Value

A data containing a hollow sphere.

Examples

```
set.seed(20240412)
hollowsphere <- gen_hollowsphere(n = 500)
```

gen_linearbranches *Generate data with linear shaped branches*

Description

This function generates a dataset representing a structure with linear shaped branches.

Usage

```
gen_linearbranches(n = 400, k = 4)
```

Arguments

n A numeric value (default: 400) representing the sample size.
k A numeric value (default: 4) representing the number of branches.

Value

A data containing linear shaped branches.

Examples

```
set.seed(20240412)
linearbranches <- gen_linearbranches(n = 400, k = 4)
```

gen_longlinear	<i>Generate Long Linear Data</i>
----------------	----------------------------------

Description

This function generates a dataset consisting of long linear data.

Usage

```
gen_longlinear(n = 500, p = 4)
```

Arguments

n An integer value (default: 500) representing the sample size.
p An integer value (default: 4) representing the number of dimensions.

Value

A tibble containing the long linear data.

Examples

```
set.seed(20240412)
longlinear <- gen_longlinear(n = 500, p = 4)
```

gen_mobius	<i>Generate a 3-D Mobius</i>
------------	------------------------------

Description

This function generates a dataset representing a structure with a mobius.

Usage

```
gen_mobius(n = 500)
```

Arguments

n An integer value (default: 500) representing the sample size.

Value

A tibble containing a mobius structure.

Examples

```
set.seed(20240412)
mobius <- gen_mobius(n = 500)
```

gen_multicluster *Generate Multiple Clusters*

Description

This function generates a dataset with multiple clusters in high-dimensional space. Each cluster can have a different shape, scale, rotation, and centroid, allowing the construction of complex synthetic datasets.

Usage

```
gen_multicluster(
  n = c(200, 300, 500),
  k = 3,
  loc = matrix(c(0, 0, 0, 0, 5, 9, 0, 0, 3, 4, 10, 7), nrow = 3, byrow = TRUE),
  scale = c(3, 1, 2),
  shape = c("gaussian", "bluntedcorn", "unifcube"),
  rotation = NULL,
  add_bkg = FALSE,
  ...
)
```

Arguments

n	An integer vector (default: c(200, 500, 300)) representing the sample sizes for each cluster. Must have length k.
k	An integer value (default: 3) representing the number of clusters.
loc	A numeric matrix giving the centroids of the clusters. The number of rows must equal k; the number of columns should match the maximum dimensionality across all shapes.
scale	A numeric vector (default: c(3, 1, 2)) giving the scaling factors for each cluster. Must have length k.
shape	A character vector (default: c("gaussian", "cone", "unifcube")) specifying the generator function to use for each cluster. Must have length k.
rotation	A list of rotation matrices (one per cluster), or NULL. Each matrix must be square with dimension equal to the total number of structural dimensions in the dataset. Rotation matrices can be generated using gen_rotation for convenience.

add_bkg Logical (default: FALSE). If TRUE, adds background noise sampled from a multivariate normal distribution centered on the dataset mean with standard deviations matching the observed spread.

... Additional arguments passed to the cluster generator functions.

Value

A tibble containing all generated clusters, with columns `x1`, `x2`, ... for dimensions and a cluster label.

Examples

```
set.seed(20240412)

# Example rotation matrices for 4D space
rot1 <- gen_rotation(p = 4, planes_angles = list(list(plane = c(1, 2), angle = 60),
                                                list(plane = c(3, 4), angle = 90)))
rot2 <- gen_rotation(p = 4, planes_angles = list(list(plane = c(1, 3), angle = 30)))
rot3 <- gen_rotation(p = 4, planes_angles = list(list(plane = c(2, 4), angle = 45)))

clust_data <- gen_multicluster(
  n = c(200, 300, 500),
  k = 3,
  loc = matrix(c(
    0, 0, 0, 0,
    5, 9, 0, 0,
    3, 4, 10, 7
  ), nrow = 3, byrow = TRUE),
  scale = c(3, 1, 2),
  shape = c("gaussian", "cone", "unifcube"),
  rotation = list(rot1, rot2, rot3),
  add_bkg = FALSE
)
```

gen_noisedims

Generate Random Noise Dimensions

Description

This function generates random noise dimensions to be added to the coordinates of a data structure.

Usage

```
gen_noisedims(n = 500, p = 4, m = rep(0, p), s = rep(2, p))
```

Arguments

n	A numeric value (default: 500) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.
m	A numeric vector (default: c(0, 0, 0, 0)) representing the mean along each dimensions.
s	A numeric vector (default: c(2, 2, 2, 2)) representing the standard deviation along each dimensions.

Value

A data containing the generated random noise dimensions.

Examples

```
set.seed(20240412)
gen_noisedims(n = 500, p = 4, m = c(0, 0, 0, 0), s = c(2, 2, 2, 2))
```

gen_nonlinear	<i>Generate Nonlinear Hyperbola</i>
---------------	-------------------------------------

Description

This function generates a dataset representing a nonlinear hyperbola structure.

Usage

```
gen_nonlinear(n = 500, hc = 1, non_fac = 0.5)
```

Arguments

n	A numeric value (default: 500) representing the sample size.
hc	A numeric value (default: 1) representing the hyperbolic component which define the steepness and vertical scaling of the hyperbola. Larger values of this make the curve more pronounced (sharper dips/rises near 0), while smaller values make it flatter.
non_fac	A numeric value (default: 1) representing the nonlinear factor which describes the strength of this sinusoidal effect. When this is 0, the curve is purely hyperbolic; as it increases, the wave-like fluctuations become more prominent.

Value

A data containing a nonlinear hyperbola structure.

Examples

```
set.seed(20240412)
nonlinear <- gen_nonlinear(n = 500, hc = 1, non_fac = 0.5)
```

gen_nproduct	<i>Generates a vector of positive integers whose product is approximately equal to a target value.</i>
--------------	--

Description

This function takes a target integer 'n' and the number of dimensions 'p', and returns a vector 'n_vec' of length 'p' containing positive integers. The goal is to have the product of the elements in 'n_vec' be as close as possible to 'n', especially when 'n' is not a perfect p-th power.

Usage

```
gen_nproduct(n = 500, p = 4)
```

Arguments

n	The target positive integer value for the product of the output vector.
p	The number of dimensions (the length of the output vector). Must be a positive integer.

Value

A sorted vector of positive integers of length 'p'. The product of the elements in this vector will be approximately equal to 'n'. If 'n' is a perfect p-th power, the elements will be equal.

Examples

```
gen_nproduct(500, 6) # Example with n=500, p=6
gen_nproduct(700, 4) # Example with n=700, p=4
gen_nproduct(625, 4) # Example with n=625 (perfect power)
gen_nproduct(30, 3)  # Example with n=30, p=3
gen_nproduct(7, 2)  # Example where exact product might be hard
```

gen_nsum	<i>Generates a vector of positive integers whose summation is approximately equal to a target value.</i>
----------	--

Description

This function takes a target integer 'n' and the number of clusters 'k', and returns a vector 'n_vec' of length 'k' containing positive integers. The goal is to have the summation of the elements in 'n_vec' be as close as possible to 'n', especially when 'n' is not a perfect multiplier of 'k'.

Usage

```
gen_nsum(n = 500, k = 4)
```

Arguments

n	The target positive integer value for the summation of the output vector.
k	The number of dimensions (the length of the output vector). Must be a positive integer.

Value

A sorted vector of positive integers of length 'k'. The summation of the elements in this vector will be approximately equal to 'n'. If 'n' is a perfectly divisible by 'k', the elements will be equal.

Examples

```
gen_nsum(500, 6) # Example with n=500, p=6
gen_nsum(700, 4) # Example with n=700, p=4
gen_nsum(625, 5) # Example with n=625 (perfect division)
gen_nsum(30, 3) # Example with n=30, p=3
```

gen_orgcurvybranches *Generate data with curvy shaped branches in a initial point*

Description

This function generates a dataset representing a structure with curvy shaped branches.

Usage

```
gen_orgcurvybranches(n = 400, p = 4, k = 4, allow_share = TRUE)
```

Arguments

n	A numeric value (default: 400) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.
k	A numeric value (default: 4) representing the number of branches.
allow_share	A logical value (default: TRUE). If TRUE, multiple branches may share the same 2D subspace. If FALSE, branches are sampled without replacement from all possible 2D subspaces until exhausted.

Value

A data containing curvy shaped branches originated in one point.

Examples

```
set.seed(20240412)
orgcurvybranches <- gen_orgcurvybranches(n = 400, k = 4)
```

gen_orlinearbranches *Generate data with linear shaped branches in a initial point*

Description

This function generates a dataset representing a structure with linear shaped branches.

Usage

```
gen_orlinearbranches(n = 400, p = 4, k = 4, allow_share = TRUE)
```

Arguments

n	A numeric value (default: 400) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.
k	A numeric value (default: 4) representing the number of branches.
allow_share	A logical value (default: TRUE). If TRUE, multiple branches may share the same 2D subspace. If FALSE, branches are sampled without replacement from all possible 2D subspaces until exhausted.

Value

A data containing linear shaped branches originated in one point.

Examples

```
set.seed(20240412)
orglinearbranches <- gen_orlinearbranches(n = 400, p = 4, k = 4)
```

gen_pyrfrac *Generate p-D Triangular Pyramid With Triangular Pyramid shaped holes*

Description

This function generates p-D triangular pyramid with triangular pyramid shaped holes.

Usage

```
gen_pyrfrac(n = 500, p = 4)
```

Arguments

n	An integer value (default: 500) representing the sample size.
p	An integer value (default: 4) representing the number of dimensions.

Value

A data containing a triangular pyramid with triangular pyramid shaped holes.

Examples

```
set.seed(20240412)
pyrfrac <- gen_pyrfrac(n = 500, p = 3)
```

gen_pyrrect

Generate Rectangular-based Pyramid

Description

This function generates a dataset representing a rectangular based pyramid.

Usage

```
gen_pyrrect(n = 500, p = 4, h = 5, l_vec = c(3, 2), rt = 0.5)
```

Arguments

n	An integer value (default: 500) representing the sample size.
p	An integer value (default: 4) representing the number of dimensions.
h	A numeric value (default: 5) representing the height of the pyramid.
l_vec	A numeric vector (default: c(3, 2)) representing the base lengths along the x and y of the pyramid.
rt	A numeric value (default: 0.5) representing the tip radius of the pyramid.

Value

A tibble containing the rectangular-based pyramid.

Examples

```
set.seed(20240412)
pyrrect <- gen_pyrrect(n = 500, p = 4, h = 5, l_vec = c(3, 2), rt = 0.5)
```

gen_pyrstar	<i>Generate Star Based Pyramid</i>
-------------	------------------------------------

Description

This function generates a dataset representing a star based pyramid.

Usage

```
gen_pyrstar(n = 500, p = 4, h = 5, rb = 3)
```

Arguments

n	An integer value (default: 500) representing the sample size.
p	An integer value (default: 4) representing the number of dimensions.
h	A numeric value (default: 5) representing the height of the pyramid.
rb	A numeric value (default: 3) representing the base radius of the pyramid.

Value

A data containing the star based pyramid.

Examples

```
set.seed(20240412)
pyrstar <- gen_pyrstar(n = 500, p = 4, h = 5, rb = 3)
```

gen_pyrtri	<i>Generate Triangular Based Pyramid</i>
------------	--

Description

This function generates a dataset representing a triangular based pyramid.

Usage

```
gen_pyrtri(n = 500, p = 4, h = 5, l = 3, rt = 0.5)
```

Arguments

n	An integer value (default: 500) representing the sample size.
p	An integer value (default: 4) representing the number of dimensions.
h	A numeric value (default: 5) representing the height of the pyramid.
l	A numeric value (default: 3) representing the base length of the pyramid.
rt	A numeric value (default: 0.5) representing the tip radius of the pyramid.

Value

A data containing the triangular based pyramid.

Examples

```
set.seed(20240412)
pyrtri <- gen_pyrtri(n = 500, p = 4, h = 5, l = 3, rt = 0.5)
```

gen_quadratic	<i>Generate Quadratic</i>
---------------	---------------------------

Description

This function generates a dataset representing a structure with a quadratic pattern.

Usage

```
gen_quadratic(n = 500, range = c(-1, 1))
```

Arguments

n A integer value (default: 500) representing the sample size.
range A numeric vector (default: c(-1, 1)) representing the range along x1 axis.

Value

A tibble containing a quadratic structure.

Examples

```
set.seed(20240412)
quadratic <- gen_quadratic(n = 500)
```

gen_rotation	<i>Generate Rotations</i>
--------------	---------------------------

Description

This function generates a rotation matrix.

Usage

```
gen_rotation(p = 4, planes_angles)
```

Arguments

- `p` A numeric value (default: 4) representing the number of dimensions.
- `planes_angles` A numeric list which contains plane and the corresponding angle along that plane.

Value

A matrix containing the rotations.

Examples

```
set.seed(20240412)
rotations_4d <- list(
  list(plane = c(1, 2), angle = 60), # Rotation in the (1, 2) plane
  list(plane = c(3, 4), angle = 90) # Rotation in the (3, 4) plane
)
gen_rotation(p = 4, planes_angles = rotations_4d)
```

gen_scurve	<i>Generate S-curve Data</i>
------------	------------------------------

Description

This function generates S-curve data.

Usage

```
gen_scurve(n = 500)
```

Arguments

- `n` An integer value (default: 500) representing the sample size.

Value

A data containing the generated S-curve data.

References

Buitinck, L., Louppe, G., Blondel, M., Pedregosa, F., Mueller, A., Grisel, O., ... & Varoquaux, G. (2013). API design for machine learning software: experiences from the scikit-learn project. *arXiv preprint arXiv:1309.0238*.

Examples

```
set.seed(20240412)
scurve <- gen_scurve(n = 500)
```

gen_scurvehole	<i>Generate S-curve Data with a Hole</i>
----------------	--

Description

This function generates S-curve data with a hole by filtering out samples that are not close to a specified anchor point.

Usage

```
gen_scurvehole(n = 500, r_hole = 0.5)
```

Arguments

n	A numeric value (default: 500) representing the sample size.
r_hole	A numeric value (default: 0.5) representing the radius of the hole.

Value

A data containing the generated S-curve data with a hole.

References

Wang, Y., Huang, H., Rudin, C., & Shaposhnik, Y. (2021). Understanding how dimension reduction tools work: an empirical approach to deciphering t-SNE, UMAP, TriMAP, and PaCMAP for data visualization. *J Mach. Learn. Res*, 22, 1-73.

See Also

the [PaCMAP homepage](#).

Examples

```
set.seed(20240412)
scurvehole <- gen_scurvehole(n = 1000)
```

gen_sphericalspiral *Generate Spherical Spiral*

Description

This function generates a dataset representing a structure with a spherical spiral.

Usage

```
gen_sphericalspiral(n = 500, spins = 1)
```

Arguments

n A numeric value (default: 500) representing the sample size.
spins A numeric value (default: 1) representing the number of loops of the spiral.

Value

A data containing a spherical spiral.

Examples

```
set.seed(20240412)  
sphericalspiral <- gen_sphericalspiral(n = 500, spins = 1)
```

gen_swissroll *Generate Swiss Roll Data*

Description

This function generates swiss roll data.

Usage

```
gen_swissroll(n = 500, w = c(-1, 1))
```

Arguments

n An integer value (default: 500) representing the sample size.
w A numeric vector (default: c(-1, 1)) representing the vertical variation.

Value

A tibble containing the generated swiss roll data.

References

Agrafiotis, D. K., & Xu, H. (2002). A self-organizing principle for learning nonlinear manifolds. *Proceedings of the National Academy of Sciences*, 99(25), 15869-15872.

Roweis, S. T., & Saul, L. K. (2000). Nonlinear dimensionality reduction by locally linear embedding. *Science*, 290(5500), 2323-2326.

Examples

```
set.seed(20240412)
swissroll <- gen_swissroll(n = 500)
```

gen_trefoil3d

Generate 3-D Trefoil Knot Coordinates (Stereographic Projection)

Description

This function generates coordinates for a 3-D trefoil knot by applying a stereographic projection from 4-D space.

Usage

```
gen_trefoil3d(n = 500, steps = 5)
```

Arguments

n	An integer value (default: 500) representing the sample size.
steps	A numeric value (default: 5) representing the number of steps for the theta parameter.

Value

A data containing 3-D trefoil knot.

Examples

```
set.seed(20240412)
trefoil3d <- gen_trefoil3d(n = 500, steps = 5)
```

gen_trefoil4d	<i>Generate 4-D Trefoil Knot Coordinates</i>
---------------	--

Description

This function generates coordinates for a 4-D trefoil knot. The number of points is determined by the length of the theta and phi sequences.

Usage

```
gen_trefoil4d(n = 500, steps = 5)
```

Arguments

n	An integer value (default: 500) representing the sample size.
steps	A numeric value (default: 5) representing the number of steps for the theta parameter.

Value

A tibble containing 4-D trefoil knot.

Examples

```
set.seed(20240412)
trefoil4d <- gen_trefoil4d(n = 500, steps = 5)
```

gen_unifcube	<i>Generate Cube with uniform points</i>
--------------	--

Description

This function generates a grid dataset with specified uniform points along each axes.

Usage

```
gen_unifcube(n = 500, p = 4)
```

Arguments

n	A numeric vector (default: 500) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.

Value

A data containing the cube with uniform points.

Examples

```
set.seed(20240412)
unifcube <- gen_unifcube(n = 500, p = 4)
```

gen_unifcubehole	<i>Generate Cube with Hole</i>
------------------	--------------------------------

Description

This function generates a dataset representing a cube with a hole.

Usage

```
gen_unifcubehole(n = 5000, p = 4, r_hole = 0.5)
```

Arguments

n	A numeric value (default: 500) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.
r_hole	A numeric value (default: 0.5) representing the radius of the hole.

Value

A data containing the cube data with a hole.

Examples

```
set.seed(20240412)
cubehole <- gen_unifcubehole(n = 1000, p = 4)
```

gen_unifsphere	<i>Generate Uniform Sphere</i>
----------------	--------------------------------

Description

This function generates a dataset representing a structure with a uniform sphere.

Usage

```
gen_unifsphere(n = 500, r = 1)
```

Arguments

n	A numeric value (default: 500) representing the sample size.
r	A numeric vector (default: 1) representing the radius of the sphere.

Value

A data containing a uniform sphere.

Examples

```
set.seed(20240412)
unifsphere <- gen_unifsphere(n = 500)
```

gen_wavydims1

Generate Random Noise Dimensions With Wavy Pattern

Description

This function generates random noise dimensions by adding wavy patterns.

Usage

```
gen_wavydims1(n = 500, p = 4, theta = seq(pi/6, 12 * pi/6, length.out = 500))
```

Arguments

n	A numeric value (default: 500) representing the sample size.
p	A numeric value (default: 4) representing the number of dimensions.
theta	A numeric vector representing the nonlinearity along each dimensions.

Value

A data containing the generated random noise dimensions.

Examples

```
set.seed(20240412)
gen_wavydims1(n = 500, p = 4, theta = seq(pi / 6, 12 * pi / 6, length.out = 500))
```

`gen_wavydims2`*Generate Random Noise Dimensions With Wavy Pattern*

Description

This function generates random noise dimensions by adding wavy patterns.

Usage

```
gen_wavydims2(n = 500, p = 4, x1_vec)
```

Arguments

<code>n</code>	A numeric value (default: 500) representing the sample size.
<code>p</code>	A numeric value (default: 4) representing the number of dimensions.
<code>x1_vec</code>	A numeric vector representing the first dimension of the data structure.

Value

A data containing the generated random noise dimensions.

Examples

```
set.seed(20240412)
theta <- seq(0, 2 * pi, length.out = 500)
x1 <- sin(pi) * cos(theta)
gen_wavydims2(n = 500, p = 4, x1_vec = x1)
```

`gen_wavydims3`*Generate Random Noise Dimensions With Wavy Pattern*

Description

This function generates random noise dimensions by adding wavy patterns.

Usage

```
gen_wavydims3(n = 500, p = 4, data)
```

Arguments

<code>n</code>	A numeric value (default: 500) representing the sample size.
<code>p</code>	A numeric value (default: 4) representing the number of dimensions.
<code>data</code>	A matrix representing the first three dimensions of the data structure.

Value

A data containing the generated random noise dimensions.

Examples

```
set.seed(20240412)
df <- gen_scurve(n = 500) |> as.matrix()
gen_wavydims3(n = 500, p = 3, data = df)
```

make_chain_circles *Generate a Chain of Interlocked Circles in High-Dimensional Space*

Description

This function generates k interlocked circular clusters in a p -dimensional space. Unlike `make_klink_circles()`, the circles are arranged in a **chain-like structure**, where each circle interlocks only with its immediate neighbor, resembling links in a chain.

Usage

```
make_chain_circles(n = c(200, 100), p = 4, k = 2, offset = 0.5, angle = 90)
```

Arguments

<code>n</code>	An integer vector of length k giving the number of points in each circle. Default is <code>c(200, 100)</code> .
<code>p</code>	Integer, the dimensionality of the embedding space. Must be at least 3. Default is 4.
<code>k</code>	Integer, the number of circles to generate. Default is 2.
<code>offset</code>	Numeric, the positional shift applied to each circle along its linking axis to ensure interlocking instead of overlap. Default is 0.5.
<code>angle</code>	Numeric, the rotation angle (in degrees) used when placing each subsequent circle into its respective plane. Default is 90.

Value

A data frame (or tibble, depending on `gen_multicluster()`) containing the generated points and cluster assignments.

Examples

```
# Generate two chain-linked circles in 4-D
twochain_circles <- make_chain_circles()
```

make_chain_curvycycle *Generate a Chain of Interlocked curvycycle in High-Dimensional Space*

Description

This function generates k interlocked circular clusters in a p -dimensional space. Unlike `make_klink_curvycycle()`, the curvycycle are arranged in a **chain-like structure**, where each curvycycle interlocks only with its immediate neighbor, resembling links in a chain.

Usage

```
make_chain_curvycycle(n = c(200, 100), p = 4, k = 2, offset = 0.5, angle = 90)
```

Arguments

n	An integer vector of length k giving the number of points in each curvycycle. Default is <code>c(200, 100)</code> .
p	Integer, the dimensionality of the embedding space. Must be at least 3. Default is 4.
k	Integer, the number of curvycycle to generate. Default is 2.
offset	Numeric, the positional shift applied to each curvycycle along its linking axis to ensure interlocking instead of overlap. Default is 0.5.
angle	Numeric, the rotation angle (in degrees) used when placing each subsequent curvycycle into its respective plane. Default is 90.

Value

A data frame (or tibble, depending on `gen_multicluster()`) containing the generated points and cluster assignments.

Examples

```
# Generate two chain-linked curvycycle in 4-D
twochain_curvycycle <- make_chain_curvycycle()
```

make_curvygau	<i>Generate Curvy Quadratic and Gaussian Clusters</i>
---------------	---

Description

This function generates synthetic high-dimensional data containing two clusters: one quadratic-shaped cluster and one Gaussian-shaped cluster. The clusters are positioned apart in feature space with different scaling factors.

Usage

```
make_curvygau(n = c(200, 100), p = 4)
```

Arguments

n	A numeric vector of length 2, specifying the number of observations in each cluster. All values must be positive.
p	Integer. Number of dimensions. Must be at least 3.

Value

A tibble containing $n[1] + n[2]$ rows and p columns, with generated features (x_1, x_2, \dots, x_p) and a cluster label.

Examples

```
# Generate 2 clusters in 4D: one quadratic, one Gaussian
curvygau <- make_curvygau()
```

make_gaucircles	<i>Generate Concentric Circles with a Gaussian Cluster in High Dimensions</i>
-----------------	---

Description

This function generates a dataset consisting of multiple circular clusters together with a single Gaussian cluster in a p -dimensional space. The circles are placed concentrically at the origin with varying scales, while the Gaussian cluster serves as an additional background or center cluster.

Usage

```
make_gaucircles(  
  n = c(200, 100, 100),  
  p = 4,  
  num_circles = 2,  
  scale_circles = c(1, 2)  
)
```

Arguments

n	An integer vector of length <code>num_circles + 1</code> , giving the number of points in each cluster (circles first, followed by the Gaussian). Default is <code>c(200, 100, 100)</code> .
p	Integer, the dimensionality of the embedding space. Must be at least 3. Default is 4.
num_circles	Integer, the number of circular clusters to generate. Default is 2.
scale_circles	Numeric vector of length <code>num_circles</code> , giving the scale (radius) of each circular cluster. Default is <code>c(1, 2)</code> .

Value

A data frame (or tibble, depending on `gen_multicluster()`) containing the generated dataset with cluster assignments.

Examples

```
# Two circles (radii 1 and 2) plus one Gaussian cluster in 4-D
gaucircles <- make_gaucircles()
```

make_gaucurvycycle *Generate Concentric Curvycycles with a Gaussian Cluster in High Dimensions*

Description

This function generates a dataset consisting of multiple circular clusters together with a single Gaussian cluster in a p -dimensional space. The curvycycle are placed concentrically at the origin with varying scales, while the Gaussian cluster serves as an additional background or center cluster.

Usage

```
make_gaucurvycycle(  
  n = c(200, 100, 100),  
  p = 4,  
  num_curvycycle = 2,  
  scale_curvycycle = c(1, 2)  
)
```

Arguments

- n** An integer vector of length `num_curvycycle + 1`, giving the number of points in each cluster (curvycycle first, followed by the Gaussian). Default is `c(200, 100, 100)`.
- p** Integer, the dimensionality of the embedding space. Must be at least 3. Default is 4.
- num_curvycycle** Integer, the number of circular clusters to generate. Default is 2.
- scale_curvycycle** Numeric vector of length `num_curvycycle`, giving the scale (radius) of each circular cluster. Default is `c(1, 2)`.

Value

A data frame (or tibble, depending on `gen_multicluster()`) containing the generated dataset with cluster assignments.

Examples

```
# Two curvycycle (radii 1 and 2) plus one Gaussian cluster in 4-D
gaucurvycycle <- make_gaucurvycycle()
```

`make_klink_circles` *Generate Multiple Interlocked Circles in High-Dimensional Space*

Description

This function generates k interlocked circular clusters in a p -dimensional space. The circles are constructed using `gen_multicluster()`, with each circle positioned in a different coordinate plane and slightly offset so that they interlock with a central circle (hub-like structure).

Usage

```
make_klink_circles(n = c(200, 100), p = 4, k = 2, offset = 0.5)
```

Arguments

- n** An integer vector of length k giving the number of points in each circle. Default is `c(200, 100)`.
- p** Integer, the dimensionality of the embedding space. Must be at least 3. Default is 4.
- k** Integer, the number of circles to generate. Default is 2.
- offset** Numeric, the amount of positional shift applied to each circle along the second coordinate axis to prevent complete overlap. Default is `0.5`.

Value

A data frame (or tibble, depending on `gen_multicluster()`) containing the generated points and cluster assignments.

Examples

```
# Generate two interlocked circles in 4-D
twolink_circles <- make_klink_circles()
```

`make_klink_curvycycle` *Generate Multiple Interlocked curvycycle in High-Dimensional Space*

Description

This function generates k interlocked circular clusters in a p -dimensional space. The curvycycle are constructed using `gen_multicluster()`, with each curvycycle positioned in a different coordinate plane and slightly offset so that they interlock with a central curvycycle (hub-like structure).

Usage

```
make_klink_curvycycle(n = c(200, 100), p = 4, k = 2, offset = 0.5)
```

Arguments

<code>n</code>	An integer vector of length k giving the number of points in each curvycycle. Default is <code>c(200, 100)</code> .
<code>p</code>	Integer, the dimensionality of the embedding space. Must be at least 3. Default is 4.
<code>k</code>	Integer, the number of curvycycle to generate. Default is 2.
<code>offset</code>	Numeric, the amount of positional shift applied to each curvycycle along the second coordinate axis to prevent complete overlap. Default is 0.5.

Value

A data frame (or tibble, depending on `gen_multicluster()`) containing the generated points and cluster assignments.

Examples

```
# Generate two interlocked curvycycle in 4-D
twolink_curvycycle <- make_klink_curvycycle()
```

make_mobiusgau	<i>Generate Gaussian cluster with the Mobius Cluster</i>
----------------	--

Description

This function generates a dataset consisting of a mobius cluster and Gaussian cluster.

Usage

```
make_mobiusgau(n = c(200, 100), p = 4)
```

Arguments

n An integer vector (default: c(200, 100)) representing the sample sizes.
p An integer value (default: 4) representing the number of dimensions.

Value

A tibble containing the mobius cluster and Gaussian cluster.

Examples

```
mobgau <- make_mobiusgau(n = c(200, 100), p = 4)
```

make_multigau	<i>Generate Multiple Gaussian Clusters</i>
---------------	--

Description

This function generates a dataset consisting of multiple Gaussian clusters.

Usage

```
make_multigau(n = c(300, 200, 500), p = 4, k = 3, loc = NULL, scale = NULL)
```

Arguments

n A numeric vector (default: c(300, 200, 500)) representing the sample sizes.
p A numeric value (default: 4) representing the number of dimensions.
k A numeric value (default: 5) representing the number of clusters.
loc A numeric matrix (default: NULL) representing the locations/centroids of clusters.
scale A numeric vector (default: NULL) representing the scaling factors of clusters.

Value

A data containing the Gaussian clusters.

Examples

```
loc_matrix <- matrix(c(0, 0, 0, 0,
5, 9, 0, 0,
3, 4, 10, 7
), nrow = 3, byrow = TRUE)
multigau <- make_multigau(n = c(300, 200, 500),
p = 4, k = 3,
loc = loc_matrix, scale = c(0.2, 1.5, 0.5))
```

make_onegrid

Generate a Single Grid Cluster in High Dimensions

Description

This function generates a dataset consisting of one grid-like cluster (a structured cube grid) in 2D, with optional Gaussian noise dimensions added to extend the dataset into higher dimensions.

Usage

```
make_onegrid(n = 500)
```

Arguments

n Integer, the number of points in the grid cluster. Must be positive. Default is 500.

Value

A tibble containing the generated dataset with columns:

- x1, x2, x3, x4 — coordinates of the data points.
- cluster — cluster assignment (always 1 for the grid).

Examples

```
# Default: 500 points, 4D space (grid in 2D + 2 noise dimensions)
onegrid <- make_onegrid()
```

make_shape_para *Generate Parallel Multi-Shape Clusters*

Description

This function generates synthetic high-dimensional data consisting of k clusters of a specified shape (e.g., crescents), arranged in parallel along alternating dimensions. The first cluster is shifted along the first dimension, the second along the third dimension, the third along the first dimension again, and so on.

Usage

```
make_shape_para(n = c(500, 300), k = 2, shift = 1, shape = "crescent")
```

Arguments

n	A numeric vector of length k , specifying the number of observations in each cluster. All values must be positive.
k	Integer. Number of clusters to generate. Must be greater than 1.
shift	Numeric. The distance between cluster centers along the alternating dimensions (default is '0.4').
shape	Character string. Shape of the clusters to generate (e.g., "crescent", "grid-cube", etc.). Must be a single value.

Value

A tibble containing $\sum n$ rows and p columns, with the generated features ('x1, x2, x3, x4') and a 'cluster' label.

Examples

```
# Generate 2 crescent-shaped clusters in 4D
twocrescent <- make_shape_para(n = c(500, 300), k = 2, shape = "crescent")
```

make_twogrid_overlap *Generate Two Overlapping Grid Clusters in High Dimensions*

Description

This function generates a dataset consisting of two overlapping grid-like clusters in a 2D space, with optional noise dimensions added to reach higher-dimensional spaces. The overlap is controlled by scaling factors for the grids.

Usage

```
make_twogrid_overlap(n = c(500, 500))
```

Arguments

n A numeric vector of length 2 specifying the number of points in each grid cluster.

Value

A tibble with $n[1] + n[2]$ rows and 5 columns:

- `x1, x2, x3, x4` — coordinates of the generated points.
- `cluster` — cluster membership label.

Examples

```
# Generate two overlapping grid clusters in 4-D
df <- make_twogrid_overlap()
```

`make_twogrid_shift` *Generate Two Shifted Grid Clusters in High Dimensions*

Description

This function generates two grid-shaped clusters in a 2D space, where one grid is shifted relative to the other. Optionally, additional noise dimensions can be added to embed the structure in a higher-dimensional space.

Usage

```
make_twogrid_shift(n = c(500, 500))
```

Arguments

n A numeric vector of length 2 specifying the number of points in each cluster. Default is `c(500, 500)`.

Value

A tibble with $n[1] + n[2]$ rows and 5 columns:

- `x1, x2, x3, x4`: Numeric coordinates of the points.
- `cluster`: Cluster membership label (factor with 2 levels).

Examples

```
# Generate 2 shifted grid clusters in 4-D
make_twogrid_shift <- make_twogrid_shift()
```

mobiusgau

Mobius clust dataset with a noise dimension

Description

The ‘mobiusgau’ dataset contains a 3-dimensional Mobius and Gaussian cluster with added noise dimension. Each data point is represented by five dimensions (x1 to x4).

Usage

```
data(mobiusgau)
```

Format

A data frame with 1000 rows and 4 columns:

x1, x2, x3, x4 High-dimensional coordinates

Source

This dataset is generated for illustrative purposes.

Examples

```
# Load the mobiusgau dataset
data(mobiusgau)

# Display the first few rows of the dataset
head(mobiusgau)
```

mobiusgau_tsne1	<i>tSNE embedding for mobiusgau dataset which with noise dimensions tSNE parameters set to perplexity: 15.</i>
-----------------	--

Description

The ‘mobiusgau_tsne1’ dataset contains the tSNE (t-distributed Stochastic Neighbor Embedding) embeddings of a five-dimensional mobiusgau. Each data point is represented by two tSNE coordinates (emb1 and emb2).

Usage

```
data(mobiusgau_tsne1)
```

Format

‘mobiusgau_tsne1’ A data frame with 1000 rows and 4 columns:

emb1 Numeric, first tSNE 2D embeddings.

emb2 Numeric, second tSNE 2D embeddings.

Source

This dataset is generated for illustrative purposes.

Examples

```
# Load the mobiusgau_tsne1 dataset
data(mobiusgau_tsne1)

# Display the first few rows of the dataset
head(mobiusgau_tsne1)
```

mobiusgau_tsne2	<i>tSNE embedding for mobiusgau dataset which with noise dimensions tSNE parameters set to perplexity: 30.</i>
-----------------	--

Description

The ‘mobiusgau_tsne2’ dataset contains the tSNE (t-distributed Stochastic Neighbor Embedding) embeddings of a five-dimensional mobiusgau. Each data point is represented by two tSNE coordinates (emb1 and emb2).

Usage

```
data(mobiusgau_tsne2)
```

Format

```
## 'mobiusgau_tsne2' A data frame with 1000 rows and 4 columns:
```

emb1 Numeric, first tSNE 2D embeddings.

emb2 Numeric, second tSNE 2D embeddings.

Source

This dataset is generated for illustrative purposes.

Examples

```
# Load the mobiusgau_tsne2 dataset
data(mobiusgau_tsne2)

# Display the first few rows of the dataset
head(mobiusgau_tsne2)
```

mobiusgau_tsne3	<i>tSNE embedding for mobiusgau dataset which with noise dimensions tSNE parameters set to perplexity: 5.</i>
-----------------	---

Description

The 'mobiusgau_tsne3' dataset contains the tSNE (t-distributed Stochastic Neighbor Embedding) embeddings of a five-dimensional mobiusgau. Each data point is represented by two tSNE coordinates (emb1 and emb2).

Usage

```
data(mobiusgau_tsne3)
```

Format

```
## 'mobiusgau_tsne3' A data frame with 1000 rows and 4 columns:
```

emb1 Numeric, first tSNE 2D embeddings.

emb2 Numeric, second tSNE 2D embeddings.

Source

This dataset is generated for illustrative purposes.

Examples

```
# Load the mobiusgau_tsne1 dataset
data(mobiusgau_tsne3)

# Display the first few rows of the dataset
head(mobiusgau_tsne3)
```

mobiusgau_umap1	<i>UMAP embedding for mobiusgau dataset which with noise dimensions UMAP parameters set to n-neighbors: 15 and min-dist: 0.1.</i>
-----------------	---

Description

The ‘mobiusgau_umap1’ dataset contains the UMAP (Uniform Manifold Approximation and Projection) embeddings of a five-dimensional mobiusgau. Each data point is represented by two UMAP coordinates (emb1 and emb2).

Usage

```
data(mobiusgau_umap1)
```

Format

‘mobiusgau_umap1’ A data frame with 1000 rows and 4 columns:

emb1 Numeric, first UMAP 2D embeddings.

emb2 Numeric, second UMAP 2D embeddings.

Source

This dataset is generated for illustrative purposes.

Examples

```
# Load the mobiusgau_umap1 dataset
data(mobiusgau_umap1)

# Display the first few rows of the dataset
head(mobiusgau_umap1)
```

mobiusgau_umap2	<i>UMAP embedding for mobiusgau dataset which with noise dimensions UMAP parameters set to n-neighbors: 30 and min-dist: 0.08.</i>
-----------------	--

Description

The ‘mobiusgau_umap2‘ dataset contains the UMAP (Uniform Manifold Approximation and Projection) embeddings of a five-dimensional mobiusgau. Each data point is represented by two UMAP coordinates (emb1 and emb2).

Usage

```
data(mobiusgau_umap2)
```

Format

```
## ‘mobiusgau_umap2‘ A data frame with 1000 rows and 4 columns:
```

```
emb1 Numeric, first UMAP 2D embeddings.
```

```
emb2 Numeric, second UMAP 2D embeddings.
```

Source

This dataset is generated for illustrative purposes.

Examples

```
# Load the mobiusgau_umap2 dataset  
data(mobiusgau_umap2)  
  
# Display the first few rows of the dataset  
head(mobiusgau_umap2)
```

mobiusgau_umap3	<i>UMAP embedding for mobiusgau dataset which with noise dimensions UMAP parameters set to n-neighbors: 5 and min-dist: 0.9.</i>
-----------------	--

Description

The ‘mobiusgau_umap3‘ dataset contains the UMAP (Uniform Manifold Approximation and Projection) embeddings of a five-dimensional mobiusgau. Each data point is represented by two UMAP coordinates (emb1 and emb2).

Usage

```
data(mobiusgau_umap3)
```

Format

'mobiusgau_umap3' A data frame with 1000 rows and 4 columns:

emb1 Numeric, first UMAP 2D embeddings.

emb2 Numeric, second UMAP 2D embeddings.

Source

This dataset is generated for illustrative purposes.

Examples

```
# Load the mobiusgau_umap3 dataset
data(mobiusgau_umap3)

# Display the first few rows of the dataset
head(mobiusgau_umap3)
```

normalize_data

Generate Normalized data

Description

This function normalize the data by the largest absolute value found in the dataset.

Usage

```
normalize_data(data)
```

Arguments

data A tibble representing the data which needed to be normalized.

Value

A normalized data.

Examples

```
set.seed(20240412)
data1 <- gen_gaussian(n= 500, p = 4)
normalize_data(data = data1)
```

randomize_rows	<i>Randomize Rows of a Data Frame</i>
----------------	---------------------------------------

Description

This function randomly shuffles the rows of a given data frame.

Usage

```
randomize_rows(data)
```

Arguments

data A data frame to be randomized.

Value

A data frame with rows randomly shuffled.

Examples

```
randomize_rows(mobiusgau)
```

relocate_clusters	<i>Relocate Clusters in High-Dimensional Space</i>
-------------------	--

Description

This function relocates clusters in a dataset by centering each cluster and shifting it based on a given transformation matrix.

Usage

```
relocate_clusters(data, vert_mat)
```

Arguments

data A tibble or data frame containing clustered data. It must have a ‘cluster’ column indicating cluster membership.

vert_mat A matrix specifying the translation vectors for each cluster. The number of rows must match the number of clusters.

Value

A tibble containing the relocated clusters with randomized row order.

Examples

```
set.seed(20240412)
df <- tibble::tibble(
  x1 = rnorm(12),
  x2 = rnorm(12),
  x3 = rnorm(12),
  x4 = rnorm(12),
  cluster = rep(1:3, each = 4)
)

# Create a 3x4 matrix to define new cluster centers
vert_mat <- matrix(c(
  5, 0, 0, 0, # Shift cluster 1
  0, 5, 0, 0, # Shift cluster 2
  0, 0, 5, 0 # Shift cluster 3
), nrow = 3, byrow = TRUE)
# Apply relocation
relocated_df <- relocate_clusters(df, vert_mat)
```

three_clust_01

Three-Cluster Dataset in 4-D

Description

The ‘three_clust_01’ dataset contains three distinct clusters in a 4-D space.

Usage

```
data(three_clust_01)
```

Format

A data frame with 1500 rows and 5 columns:

cluster, x1, x2, x3, x4 High-dimensional coordinates

Source

This dataset is generated for example purposes.

Examples

```
# Load the mobiusgau dataset
data(three_clust_01)

# Display the first few rows of the dataset
head(three_clust_01)
```

three_clust_02	<i>Three-Cluster Dataset in 4-D</i>
----------------	-------------------------------------

Description

The 'three_clust_02' dataset contains three distinct clusters in a 4-D space.

Usage

```
data(three_clust_02)
```

Format

A data frame with 1500 rows and 5 columns:

cluster, x1, x2, x3, x4 High-dimensional coordinates

Source

This dataset is generated for example purposes.

Examples

```
# Load the mobiusgau dataset
data(three_clust_02)

# Display the first few rows of the dataset
head(three_clust_02)
```

three_clust_03	<i>Three-Cluster Dataset in 4-D</i>
----------------	-------------------------------------

Description

The 'three_clust_03' dataset contains three distinct clusters in a 4-D space.

Usage

```
data(three_clust_03)
```

Format

A data frame with 1500 rows and 5 columns:

cluster, x1, x2, x3, x4 High-dimensional coordinates

Source

This dataset is generated for example purposes.

Examples

```
# Load the mobiusgau dataset
data(three_clust_03)

# Display the first few rows of the dataset
head(three_clust_03)
```

three_clust_04	<i>Three-Cluster Dataset in 4-D</i>
----------------	-------------------------------------

Description

The 'three_clust_04' dataset contains three distinct clusters in a 4-D space.

Usage

```
data(three_clust_04)
```

Format

A data frame with 1500 rows and 5 columns:

cluster, x1, x2, x3, x4 High-dimensional coordinates

Source

This dataset is generated for example purposes.

Examples

```
# Load the mobiusgau dataset
data(three_clust_04)

# Display the first few rows of the dataset
head(three_clust_04)
```

three_clust_05	<i>Three-Cluster Dataset in 4-D</i>
----------------	-------------------------------------

Description

The 'three_clust_05' dataset contains three distinct clusters in a 4-D space.

Usage

```
data(three_clust_05)
```

Format

A data frame with 1500 rows and 5 columns:

cluster, x1, x2, x3, x4 High-dimensional coordinates

Source

This dataset is generated for example purposes.

Examples

```
# Load the mobiusgau dataset
data(three_clust_05)

# Display the first few rows of the dataset
head(three_clust_05)
```

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