Package 'mdsOpt'

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Title Searching for Optimal MDS Procedure for Metric and Interval-Valued Data

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Depends R (>= 3.6.0), smacof, clusterSim, symbolicDA

Imports animation, plotrix, spdep

Suggests testthat, R.rsp

VignetteBuilder R.rsp

Description Selecting the optimal multidimensional scaling (MDS) procedure for metric data via metric MDS (ratio, interval, mspline) and nonmetric MDS (ordinal). Selecting the optimal multidimensional scaling (MDS) procedure for interval-valued data via metric MDS (ratio, interval, mspline).Selecting the optimal multidimensional scaling procedure for interval-valued data by varying all combinations of normalization and optimization methods.Selecting the optimal MDS procedure for statistical data referring to the evaluation of tourist attractiveness of Lower Silesian counties.
(Borg, I., Groenen, P.J.F., Mair, P. (2013) <doi:10.1007/978-3-642-31848-1>,
Walesiak, M. (2016) <doi:10.15611/ekt.2016.2.01>,
Walesiak, M. (2017) <doi:10.15611/ekt.2017.3.01>).

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`data_lower_silesian` *The evaluation of tourist attractiveness of Lower Silesian counties*

Description

The empirical study uses the statistical data presented in the article (Gryszel, Walesiak, 2014) and referring to the attractiveness level of 31 objects (29 Lower Silesian counties, pattern and antipattern object) The evaluation of tourist attractiveness of Lower Silesian counties was performed using 16 metric variables (measured on a ratio scale): x1 – beds in hotels per 1 km2 of a county area, x2 – number of nights spent daily by resident tourists per 1000 inhabitants of a county, x3 – number of nights spent daily by foreign tourists per 1000 inhabitants of a county, x4 – gas pollution emission in tons per 1 km2 of a county area, x5 – number of criminal offences and crimes against life and health per 1000 inhabitants of a county, x6 – number of property crimes per 1000 inhabitants of a county, x7 – number of historical buildings per 100 km2 of a county area, x8 – x9 – x10 – number of events as well as cultural and tourist ventures in a county, x11 – number of natural monuments calculated per 1 km2 of a county area, x12 – number of tourist economy entities per 1000 inhabitants of a county (natural and legal persons), x13 – expenditure of municipalities and counties on tourism, culture and national heritage protection as well as physical culture per 1 inhabitant of a county in PLN, x14 – viewers in cinemas per 1000 inhabitants of a county, x15 – museum visitors per 1000 inhabitants of a county, x16 – number of construction permits (hotels and accommodation buildings, commercial and service buildings, transport and communication buildings, civil and water engineering constructions) issued in a county in the years 2011-2012 per 1 km2 of a county area. The statistical data were collected in 2012 and come from the Local Data Bank of the Central Statistical Office of Poland, the data for x7 variable only were obtained from the regional conservation officer.

Format

data.frame: 31 objects (29 counties, pattern and antipattern object), 16 variables. The coordinates of a pattern object cover the most preferred preference variable (stimulants, destimulants, nominants) values. The coordinates of an anti-pattern object cover the least preferred preference variable values.

Source

Gryszel, P., Walesiak, M., (2014), Zastosowanie uogólnionej miary odległości GDM w ocenie atrakcyjności turystycznej powiatów Dolnego Śląska [The Application of the General Distance Measure (GDM) in the Evaluation of Lower Silesian Districts' Attractiveness], Folia Turistica, 31, 127-147.

Examples

```
library(mdsOpt)
metnor<-c("n1","n2","n3","n5","n5a","n8","n9","n9a","n11","n12a")
metscale<-c("ratio","interval")
metdist<-c("euclidean","GDM1")
data(data_lower_silesian)
res<-optSmacofSym_mMDS(data_lower_silesian,normalizations=metnor,
distances=metdist,mdsmodels=metscale)
print(findOptimalSmacofSym(res))
```

---

drawIsoquants *draw series of isoquants*

Description

function draw series of isoquants (a contour line drawn through the set of points at which the same quantity of output is produced while changing the quantities of two or more inputs)

Usage

```
drawIsoquants(x,y=NULL,number=6,steps=NULL)
```

Arguments

x	two dimensional point (center)
y	optional - second point, used for calculations of step size if steps is null
number	number of isoquants
steps	distance between following isoquants starting from x, if length of this arguments is lower than number argument last item is repeated

Value

This is a plotting function, thus does not return any value

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Walesiak, M., Dudek, A. (2017), *Selecting the Optimal Multidimensional Scaling Procedure for Metric Data with R Environment*, STATISTICS IN TRANSITION new series, September, Vol. 18, No. 3, pp. 521-540.

Examples

```
#Example 1
library(mdsOpt)
library(smacof)
library(clusterSim)
data(data_lower_silesian)
z<-data.Normalization(data_lower_silesian, type="n1")
d<-dist.GDM(z, method="GDM1")
res <- smacofSym(delta=d,ndim=2,type="interval")
print("Objects configuration", quote=FALSE)
plot(res, plot.type="confplot")
r1<-res$conf[nrow(z),1]
r2<-res$conf[nrow(z),2]
r3<-res$conf[nrow(z)-1,1]
r4<-res$conf[nrow(z)-1,2]
arrows(r1,r2,r3,r4,length=0.1,col="black")
res_up<-as.matrix(dist(res$conf,method="euclidean"))
drawIsoquants(res$conf[nrow(z)-1,],steps=max(res_up)/6)
# or
# drawIsoquants(res$conf[nrow(z)-1,],steps=c(0.3,0.2),number=8)

#Example 2
library(mdsOpt)
library(smacof)
library(clusterSim)
data(data_lower_silesian)
z<-data.Normalization(data_lower_silesian, type="n1")
d<-dist.GDM(z, method="GDM1")
res<-smacofSym(delta=d,ndim=2,type="interval")
res1<-res$conf
#write.table(res1,"conf_2d.csv",dec=",",sep=";",col.names=NA,row.names=TRUE)
alfa<- 1.05*pi
a<- cos(alfa)
b<- -sin(alfa)
c<- sin(alfa)
d<- cos(alfa)
D<-array(c(a,b,c,d), c(2,2))
#res1<-read.csv2("conf_2d.csv", header=TRUE, row.names=1)
res1<-as.matrix(res1)
res2<-res1
```

```
plot(res2, xlab="Dimension 1",ylab="Dimension 2",main="",asp=1)
points(res2[1:31,],pch=1,font=2)
text(res2[c(1:31),],pos=3,cex=0.7,row.names(z[c(1:31),]))
r1<-res2[nrow(z),1]
r2<-res2[nrow(z),2]
r3<-res2[nrow(z)-1,1]
r4<-res2[nrow(z)-1,2]
arrows(r1,r2,r3,r4,length=0.1,col="black")
res_up<-as.matrix(dist(res2,method="euclidean"))
drawIsoquants(res2[nrow(z)-1,],steps=max(res_up)/6)
```

`findOptimalSmacofSym` *Selecting the optimal multidimensional scaling (MDS) procedure*

Description

Selecting the optimal multidimensional scaling procedure - metric MDS (by varying all combinations of normalization methods, distance measures, and metric MDS models) and nonmetric MDS (by varying all combinations of normalization methods and distance measures)

Usage

```
findOptimalSmacofSym(table,
critical_stress=(max(as.numeric(gsub(",",".",table[,"STRESS 1"],fixed=TRUE)))+
min(as.numeric(gsub(",",".",table[,"STRESS 1"],fixed=TRUE))))/2,
critical_HHI=NA)
```

Arguments

`table`	result from `optSmacofSym_nMDS` or `optSmacofSym_mMDS`. Data frame ordered by increasing value of Stress-1 fit measure or HHI index with columns:
	`Normalization method`
	`Distance measure`
	`MDS model`
	`Spline degree`
	`STRESS 1`
	`HHI spp`

`critical_stress`	threshold value of Kruskal's Stress-1 fit measure. Default - mid-range of Kruskal's Stress-1 fit measures calculated for all MDS procedures
`critical_HHI`	threshold value of Hirschman-Herfindahl HHI index. Only one parameter critical_stress or critical_HHI can be set, and the function finds the optimal value among the procedures for which the selected measure is lower or equal treshold value

Value

Nr	number of row in table with optimal multidimensional scaling procedure
Normalization_method	normalization method used for optimal multidimensional scaling procedure
MDS_model	MDS model used for optimal multidimensional scaling procedure
Spline_degree	Additional spline.degree value for optimal procedure, if mspline model is used for simulation. For other models there is no value for this field
Distance_measure	distance measure used for optimal multidimensional scaling procedure
STRESS_1	value of Kruskal Stress-1 fit measure for optimal multidimensional scaling procedure
HHI_spp	Hirschman-Herfindahl HHI index, calculated based on stress per point, for optimal multidimensional scaling procedure

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See Also

`data.Normalization`, `dist.GDM`, `dist`, `smacofSym`

Examples

```
library(mdsOpt)
metnor<-c("n1","n2","n3","n5","n5a","n8","n9","n9a","n11","n12a")
metscale<-c("ratio","interval")
metdist<-c("euclidean","manhattan","maximum","seuclidean","GDM1")
data(data_lower_silesian)
res<-optSmacofSym_mMDS(data_lower_silesian,normalizations=metnor,
distances=metdist,mdsmodels=metscale,outDec=".")
print(findOptimalSmacofSym(res))
```

`optSmacofSymInterval` *Selecting the optimal multidimensional scaling procedure for interval-valued data*

Description

Selecting the optimal multidimensional scaling procedure by varying all combinations of normalization methods, distance measures for interval-valued data, and metric MDS models/

Usage

```
optSmacofSymInterval(x,dataType="simple",normalizations=NULL,
distances=NULL,mdsmodels=NULL,spline.degrees=c(2),outputCsv="",
outputCsv2="",y=NULL,outDec=",",
stressDigits=6,HHIDigits=2,...)
```

Arguments

x	interval-valued data table or matrix or dataset
dataType	Type of symbolic data table passed to function: 'sda' - full symbolicDA format object; 'simple' - three dimensional array with lower and upper bound of intervals in third dimension; 'separate_tables' - lower bound of intervals in x, upper bound of intervals in y; 'rows' - lower and upper bound of intervals in neighbouring rows; 'columns' - lower and upper bound of intervals in neighbouring columns
normalizations	optional, vector of normalization methods that should be used in procedure
distances	optional, vector of distance measures (Hausdorf, Ichino-Yaguchi) that should be used in procedure
mdsmodels	optional, vector of multidimensional models (ratio, interval, mspline) that should be used in procedure
spline.degrees	optional, vector (e.g. 2:4) of spline.degree parameter values that should be used in procedure for mspline model
outputCsv	optional, name of csv file with results
outputCsv2	optional, name of csv (comma as decimal point sign) file with results
y	matrix or dataset with upper bounds of intervals if argument dataType is equal to "separate_tables"
outDec	decimal sign used in returned table
stressDigits	Number of decimal digits for displaying Stress 1 value
HHIDigits	Number of decimal digits for displaying HHI spp value
...	arguments passed to smacofSym, like ndim, itmax, eps and others

Details

Parameter normalizations may be the subset of the following values:

"n1","n2","n3","n3a","n4","n5","n5a","n6","n6a",

"n7","n8","n9","n9a","n10","n11","n12","n12a","n13"

(e.g. normalizations=c("n1","n2","n3","n5","n5a",

"n8","n9","n9a","n11","n12a"))

if normalizations is set to "n0" no normalization is applied

Parameter distances may be the subset of the following values:

"H_q1","H_q2","U_2_q1","U_2_q2" (In following order: Hausdorff distance with q=1, Euclidean Hausdorff distance with q=2, Ichino-Yaguchi distance with q=1; Euclidean Ichino-Yaguchi distance with q=2)

(e.g. distances=c("H_q1","U_2_q1"))

Parameter mdsmodels may be the subset of the following values (metric MDS):

"ratio","interval","mspline" (e.g. c("ratio","interval"))

Value

Data frame ordered by increasing value of Stress-1 fit measure with columns:

`Normalization method`
: normalization method used for p-th multidimensional scaling procedure

`MDS model`
: MDS model used for p-th multidimensional scaling procedure

`Spline degree`
: Additional spline.degree value if mspline model is used for simulation, for other models there is no value in this cell

`Distance measure`
: distance measures for interval-valued data used for p-th multidimensional scaling procedure

`STRESS 1`
: value of Kruskal Stress-1 fit measure for p-th multidimensional scaling procedure

`HHI spp`
: Hirschman-Herfindahl HHI index calculated based on stress per point for p-th multidimensional scaling procedure

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Borg, I., Groenen, P.J.F., Mair, P. (2013), Applied Multidimensional Scaling, Springer, Heidelberg, New York, Dordrecht, London. Available at: doi:10.1007/9783642318481.

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See Also

data.Normalization, interval_normalization, dist.Symbolic, smacofSym

Examples

```
library(mdsOpt)
library(clusterSim)
data(data_symbolic_interval_polish_voivodships)
metnor<-c("n1","n2","n3","n5","n5a","n8","n9","n9a","n11","n12a")
metscale<-c("ratio","interval","mspline")
metdist<-c("H_q1","H_q2","U_2_q1","U_2_q2")
res<-optSmacofSymInterval(data_symbolic_interval_polish_voivodships,dataType="simple",
normalizations=metnor,distances=metdist,mdsmodels=metscale,spline.degrees=c(2,3),outDec=".")
stress<-as.numeric(gsub(",",".",res[,"STRESS 1"],fixed=TRUE))
hhi<-as.numeric(gsub(",",".",res[,"HHI spp"],fixed=TRUE))
t<-findOptimalSmacofSym(res)
cs<-(min(stress)+max(stress))/2 # critical stress
plot(stress[-t$Nr],hhi[-t$Nr], xlab="Stress-1", ylab="HHI",type="n",font.lab=3)
text(stress[-t$Nr],hhi[-t$Nr],labels=(1:nrow(res))[-t$Nr])
abline(v=cs,col="red")
points(stress[t$Nr],hhi[t$Nr], cex=5,col="red")
text(stress[t$Nr],hhi[t$Nr],labels=(1:nrow(res))[t$Nr],col="red")
print(t)
```

---

optSmacofSym_mMDS *Selecting the optimal multidimensional scaling procedure - metric MDS*

Description

Selecting the optimal multidimensional scaling procedure by varying all combinations of normalization methods, distance measures, and metric MDS models

Usage

```
optSmacofSym_mMDS(x,normalizations=NULL,distances=NULL,
mdsmodels=NULL,weights=NULL,spline.degrees=c(2),
outputCsv="",outputCsv2="",outDec=",",
stressDigits=6,HHIDigits=2,...)
```

Arguments

x	matrix or dataset
normalizations	optional, vector of normalization methods that should be used in procedure
distances	optional, vector of distance measures (manhattan, Euclidean, Chebyshew, squared Euclidean, GDM1) that should be used in procedure
mdsmodels	optional, vector of multidimensional models (ratio, interval, mspline) that should be used in procedure
spline.degrees	optional, vector (e.g. 2:4) of spline.degree parameter values that should be used in procedure for mspline model
weights	optional, variable weights used in distance calculation. Each weight takes value from interval [0; 1] and sum of weights equals one
outputCsv	optional, name of csv file with results
outputCsv2	optional, name of csv (comma as decimal point sign) file with results
outDec	decimal sign used in returned table
stressDigits	Number of decimal digits for displaying Stress 1 value
HHIDigits	Number of decimal digits for displaying HHI spp value
...	arguments passed to smacofSym, like ndim, itmax, eps and others

Details

Parameter normalizations may be the subset of the following values:

"n1","n2","n3","n3a","n4","n5","n5a","n6","n6a",

"n7","n8","n9","n9a","n10","n11","n12","n12a","n13"

(e.g. normalizations=c("n1","n2","n3","n5","n5a",

"n8","n9","n9a","n11","n12a"))

if normalizations is set to "n0" no normalization is applied

Parameter distances may be the subset of the following values:

"euclidean","manhattan","maximum","seuclidean","GDM1"

(e.g. distances=c("euclidean","manhattan"))

Parameter mdsmodels may be the subset of the following values (metric MDS):

"ratio","interval","mspline" (e.g. c("ratio","interval"))

Value

Data frame ordered by increasing value of Stress-1 fit measure with columns:

Normalization method	normalization method used for p-th multidimensional scaling procedure
MDS model	MDS model used for p-th multidimensional scaling procedure
Spline degree	Additional spline.degree value if mspline model is used for simulation, for other models there is no value in this cell

`Distance measure`
: distance measure used for p-th multidimensional scaling procedure

`STRESS 1`
: value of Kruskal Stress-1 fit measure for p-th multidimensional scaling procedure

`HHI spp`
: Hirschman-Herfindahl HHI index calculated based on stress per point for p-th multidimensional scaling procedure

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See Also

data.Normalization, dist.GDM, dist, smacofSym

Examples

```
library(mdsOpt)
metnor<-c("n1","n2","n3","n5","n5a","n8","n9","n9a","n11","n12a")
metscale<-c("ratio","interval","mspline")
metdist<-c("euclidean","manhattan","seuclidean","maximum","GDM1")
data(data_lower_silesian)
res<-optSmacofSym_mMDS(data_lower_silesian,,normalizations=metnor,distances=metdist,
  mdsmodels=metscale, spline.degrees=c(2:3),outDec=".")
stress<-as.numeric(gsub(",",".",res[,"STRESS 1"],fixed=TRUE))
hhi<-as.numeric(gsub(",",".",res[,"HHI spp"],fixed=TRUE))
cs<-(min(stress)+max(stress))/2 # critical stress
t<-findOptimalSmacofSym(res,critical_stress=cs)
print(t)
plot(stress[-t$Nr],hhi[-t$Nr], xlab="Stress-1", ylab="HHI",type="n",font.lab=3)
text(stress[-t$Nr],hhi[-t$Nr],labels=(1:nrow(res))[-t$Nr])
abline(v=cs,col="red")
points(stress[t$Nr],hhi[t$Nr], cex=5,col="red")
text(stress[t$Nr],hhi[t$Nr],labels=(1:nrow(res))[t$Nr],col="red")
```

---

optSmacofSym_nMDS *Selecting the optimal multidimensional scaling procedure - nonmetric MDS*

Description

Selecting the optimal multidimensional scaling procedure by varying all combinations of normalization methods and distance measures

Usage

```
optSmacofSym_nMDS(x,normalizations=NULL,distances=NULL,
mdsmodels=c("ordinal"),weights=NULL,
outputCsv="",outputCsv2="",outDec=",",
stressDigits=6,HHIDigits=2,...)
```

Arguments

x	matrix or dataset
normalizations	optional, vector of normalization methods that should be used in procedure

distances	optional, vector of distance measures (manhattan, Euclidean, Chebyshew, squared Euclidean, GDM1) that should be used in procedure
mdsmodels	"ordinal" (nonmetric MDS)
weights	optional, variable weights used in distance calculation. Each weight takes value from interval [0; 1] and sum of weights equals one
outputCsv	optional, name of csv file with results
outputCsv2	optional, name of csv (comma as decimal point sign) file with results
outDec	decimal sign used in returned table
stressDigits	Number of decimal digits for displaying Stress 1 value
HHIDigits	Number of decimal digits for displaying HHI spp value
...	arguments passed to smacofSym

Details

Parameter normalizations may be the subset of the following values:

"n1","n2","n3","n3a","n4","n5","n5a","n6","n6a",

"n7","n8","n9","n9a","n10","n11","n12","n12a","n13"

(e.g. normalizations=c("n1","n2","n3","n5","n5a",

"n8","n9","n9a","n11","n12a"))

if normalizations is set to "n0" no normalization is applied

Parameter distances may be the subset of the following values:

"euclidean", "manhattan","maximum","seuclidean","GDM1"

(e.g. distances=c("euclidean","manhattan"))

Parameter mdsmodels "ordinal" MDS model (nonmetric MDS)

Value

Data frame ordered by increasing value of Stress-1 fit measure with columns:

Normalization method	normalization method used for p-th multidimensional scaling procedure
MDS model	"ordinal" MDS model (nonmetric MDS) for p-th multidimensional scaling procedure
Distance measure	distance measure used for p-th multidimensional scaling procedure
STRESS 1	value of Kruskal Stress-1 fit measure for p-th multidimensional scaling procedure
HHI spp	Hirschman-Herfindahl HHI index calculated based on stress per point for p-th multidimensional scaling procedure

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See Also

data.Normalization, dist.GDM, dist, smacofSym

Examples

```
library(mdsOpt)
metnor<-c("n1","n2","n3","n5","n5a","n8","n9","n9a","n11","n12a")
metscale<-"ordinal"
metdist<-c("euclidean","manhattan","maximum","seuclidean","GDM1")
data(data_lower_silesian)
res<-optSmacofSym_nMDS(data_lower_silesian,normalizations=metnor,
```

```
distances=metdist,mdsmodels=metscale)
stress<-as.numeric(gsub(",",".",res[,"STRESS 1"],fixed=TRUE))
hhi<-as.numeric(gsub(",",".",res[,"HHI spp"],fixed=TRUE))
cs<-(min(stress)+max(stress))/2 # critical stress
t<-findOptimalSmacofSym(res,critical_stress=cs)
print(t)
plot(stress[-t$Nr],hhi[-t$Nr], xlab="Stress-1", ylab="HHI",type="n",font.lab=3)
text(stress[-t$Nr],hhi[-t$Nr],labels=(1:nrow(res))[-t$Nr])
abline(v=cs,col="red")
points(stress[t$Nr],hhi[t$Nr], cex=5,col="red")
text(stress[t$Nr],hhi[t$Nr],labels=(1:nrow(res))[t$Nr],col="red")
```

`rotation2dAnimation` *Cretaes video by FFmpeg with animation of dataset rotated*

Description

This function opens a graphics device to record the images produced in the code `expr`, then uses FFmpeg to convert these images to a video.

Usage

```
rotation2dAnimation(conf2d,
ani.interval=0.2,
ani.nmax=361,
ani.width=500,
ani.height=500,
ani.video.name="mds_rotate.mp4",
angle.start=-pi,
angle.stop=pi,
angle.step=pi/180)
```

Arguments

`conf2d`	two dimensional dataset ot matrix
`ani.video.name`	the file name of the output video (e.g. '`animation.mp4`' or '`animation.avi`')
`ani.interval`	interval betwwen animation frames
`ani.nmax`	maximal number of frames
`ani.width`	width of movie
`ani.height`	height of movie
`angle.start`	starting angle for animation
`angle.stop`	end angle for animation
`angle.step`	step of animation in radians

Details

This function uses system to call FFmpeg to convert the images to a single video. The command line used in this function is: ffmpeg -y -r <1/interval> -i <img.name>%d.<ani.type> other.opts video.name

where interval comes from ani.options('interval'), and ani.type is from ani.options('ani.type'). For more details on the numerous options of FFmpeg, please see the reference.

Some linux systems may use the alternate software 'avconv' instead of 'ffmpeg'. The package will attempt to determine which command is present and set ani.options('ffmpeg') to an appropriate default value. This can be overridden by passing in the ffmpeg argument.

Value

An integer indicating failure (-1) or success (0) of the converting (refer to system).

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https://yihui.org/animation/example/savevideo/

http://ffmpeg.org/documentation.html

See Also

Other utilities: im.convert, saveGIF, saveHTML, saveLatex, saveSWF

Examples

```
library(mdsOpt)
library(smacof)
library(animation)
library(spdep)
library(clusterSim)
data(data_lower_silesian)
z<-data.Normalization(data_lower_silesian, type="n1")
d<-dist.GDM(z, method="GDM1")
```

```
res<-smacofSym(delta=d,ndim=2,type="interval")
konf<-as.matrix(res$conf)
#Uncomment only if ffmpeg is properly installed for animation package
#see:  https://yihui.org/animation/example/savevideo/
#oopts = if (.Platform$OS.type == "windows") {
# ani.options(ffmpeg = "D:/Installer/ffmpeg/bin/ffmpeg.exe")
#}
#rotation2dAnimation(conf2d=konf,angle.start=-0,angle.stop=2*pi)
```

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