

Package ‘ggsector’

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Title Draw Sectors

Version 1.6.6

Description Some useful functions that can use 'grid' and 'ggplot2' to plot sectors and interact with 'Seurat' to plot gene expression percentages. Also, there are some examples of how to draw sectors in 'ComplexHeatmap'.

License Artistic-2.0

Encoding UTF-8

RoxygenNote 7.2.1

Suggests ComplexHeatmap, knitr, rmarkdown, reshape2, utils

Depends ggplot2, grid

Imports dplyr, magrittr, Matrix, prettydoc, rlang, Seurat, stats, tibble, tidyr

VignetteBuilder knitr

BugReports <https://github.com/yanpd01/ggsector>

NeedsCompilation no

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draw_key_sector	<i>draw_key_sector</i>
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Description

draw_key_sector

Usage

```
draw_key_sector(data, params, size)
```

Arguments

data	A single row data frame containing the scaled aesthetics to display in this key
params	A list of additional parameters supplied to the geom.
size	Width and height of key in mm.

Value

ggplot legend

GeomSectorPanel	<i>ggplot sector</i>
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Description

Draw sector with ggplot2.

Usage

```
geom_sector(
  mapping = NULL,
  data = NULL,
  stat = "identity",
  position = "identity",
  ...,
  na.rm = FALSE,
  show.legend = NA,
  inherit.aes = TRUE,
  individual = FALSE,
  verbose = TRUE
)
```

Arguments

mapping	Set of aesthetic mappings created by <code>aes()</code> or <code>aes_()</code> . If specified and <code>inherit.aes = TRUE</code> (the default), it is combined with the default mapping at the top level of the plot. You must supply mapping if there is no plot mapping.
data	The data to be displayed in this layer. There are three options: If <code>NULL</code> , the default, the data is inherited from the plot data as specified in the call to <code>ggplot()</code> . A <code>data.frame</code> , or other object, will override the plot data. All objects will be fortified to produce a data frame. See <code>fortify()</code> for which variables will be created. A function will be called with a single argument, the plot data. The return value must be a <code>data.frame</code> , and will be used as the layer data. A function can be created from a formula (e.g. <code>~ head(.x, 10)</code>).
stat	The statistical transformation to use on the data for this layer, as a string.
position	Position adjustment, either as a string, or the result of a call to a position adjustment function.
...	Other arguments passed on to <code>layer()</code> . These are often aesthetics, used to set an aesthetic to a fixed value, like <code>colour = "red"</code> or <code>size = 3</code> . They may also be parameters to the paired geom/stat.
na.rm	If <code>FALSE</code> , the default, missing values are removed with a warning. If <code>TRUE</code> , missing values are silently removed.
show.legend	logical. Should this layer be included in the legends? <code>NA</code> , the default, includes if any aesthetics are mapped. <code>FALSE</code> never includes, and <code>TRUE</code> always includes. It can also be a named logical vector to finely select the aesthetics to display.
inherit.aes	If <code>FALSE</code> , overrides the default aesthetics, rather than combining with them. This is most useful for helper functions that define both data and aesthetics and shouldn't inherit behaviour from the default plot specification, e.g. <code>borders()</code> .
individual	Logical, default is <code>FALSE</code> . When <code>"individual=FALSE"</code> , draw very quickly with a vector form, when <code>"individual=TRUE"</code> , draw individually at a slower speed. Anyway, for better presentation, please add <code>coord_fixed()</code> .
verbose	Logical, default is <code>TRUE</code> . Whether to display reminder information.

Details

When `"individual=FALSE"`, draw very quickly with a vector form, when `"individual=TRUE"`, draw individually at a slower speed.

The required parameters in mapping are `"x"`, `"y"`, `"theta"`, and the additional modifiable parameters are `"r"`, `"start"`, `"r_start"`, `"type"`, `"colour"`, `"fill"`, `"ratio"`, `"size"` for line size, `"linetype"`.

When there is `coord_fixed()`, `r = 0.5` means that the sector-shaped background circle just fills the entire cell

The `ratio` parameter is still an experimental parameter, if it is not necessary, please do not set it yourself. The `ratio` parameter only works when `individual = FALSE`. When `ratio` is null, it will be auto calculated.

For better display effect, please always add `coord_fixed()`.

For details, please check the [grid.sector\(\)](#).

For more details, please type `vignette("ggsector")`.

Value

ggplot object

Examples

```
## prepare data
library(ggsector)
library(reshape2)
df <- cor(mtcars)[1:3, 1:5] %>%
  abs() %>%
  melt(varnames = c("x", "y"))

###
## Note, for better display effect, please always add coord_fixed()
## Note, for better display effect, please always add coord_fixed()
## Note, for better display effect, please always add coord_fixed()

## theta
ggplot(df) +
  ## type = "percent", theta = 0-100
  geom_sector(
    aes(y, x, theta = value * 100),
    type = "percent",
    color = "blue",
    individual = TRUE
  ) +
  ## type = "degree", theta = 0-360
  geom_sector(
    aes(y, x, theta = value * 360),
    type = "degree",
    color = "red",
    alpha = 0.5,
    individual = TRUE
  ) +
  coord_fixed() +
  theme_bw() +
  theme(axis.title = element_blank())

## r
ggplot(df) +
  geom_sector(
    aes(y, x, theta = value * 100),
    r = rep(c(0.15, 0.3, 0.45), 5),
    fill = 2,
    individual = TRUE
  ) +
  coord_fixed() +
  theme_bw() +
```

```

    theme(axis.title = element_blank())

## start
ggplot(df) +
  geom_sector(
    aes(y, x, theta = value * 100),
    start = rep(c(60, 40, 20), 5),
    fill = 2,
    individual = TRUE
  ) +
  coord_fixed() +
  theme_bw() +
  theme(axis.title = element_blank())

## r_start
ggplot(df) +
  geom_sector(
    aes(y, x, theta = value * 100),
    r_start = rep(c(0.15, 0.25, 0.35), 5),
    fill = 2,
    individual = TRUE
  ) +
  coord_fixed() +
  theme_bw() +
  theme(axis.title = element_blank())

##### individual #####
##### individual with coord_fixed() #####

## `individual = TRUE` + coord_fixed()
# x = x, y = y
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +
  facet_wrap(~t1, ncol = 2) +
  geom_sector(
    aes(x, y),
    theta = 75,
    fill = 2,
    r = 0.5,
    individual = TRUE
  ) +
  coord_fixed() +
  theme_bw() +
  theme(axis.title = element_blank())

# x = y, y = x
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +

```

```

facet_wrap(~t1, ncol = 2) +
geom_sector(
  aes(y, x),
  theta = 75,
  fill = 2,
  r = 0.5,
  individual = TRUE
) +
coord_fixed() +
theme_bw() +
theme(axis.title = element_blank())

## `individual = FALSE` + coord_fixed()
# x = x, y = y
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +
facet_wrap(~t1, ncol = 2) +
geom_sector(
  aes(x, y),
  theta = 75,
  fill = 2,
  r = 0.5,
  individual = FALSE
) +
coord_fixed() +
theme_bw() +
theme(axis.title = element_blank())

# x = y, y = x
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +
facet_wrap(~t1, ncol = 2) +
geom_sector(
  aes(y, x),
  theta = 75,
  fill = 2,
  r = 0.5,
  individual = TRUE
) +
coord_fixed() +
theme_bw() +
theme(axis.title = element_blank())

##### individual without coord_fixed() #####
## If you are in a special situation and cannot use coord_fixed(),
## then it is recommended that you use `individual = TRUE` and
## the `r` parameter to fine-tune.
## Also, to reduce the radius, you need to try it manually.

```

```

## `individual = TRUE` without coord_fixed()
# x = x, y = y
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +
  facet_wrap(~t1, ncol = 2) +
  geom_sector(
    aes(x, y),
    theta = 75,
    fill = 2,
    r = 0.35, ## To reduce the radius, you need to try it manually
    individual = TRUE
  ) +
  theme_bw() +
  theme(axis.title = element_blank())

# x = y, y = x
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +
  facet_wrap(~t1, ncol = 2) +
  geom_sector(
    aes(y, x),
    theta = 75,
    fill = 2,
    r = 0.25, ## To reduce the radius, you need to try it manually
    individual = TRUE
  ) +
  theme_bw() +
  theme(axis.title = element_blank())

## `individual = FALSE`
## If you really want to use `individual = FALSE` without coord_fixed(),
## you might try the experimental parameter `ratio`
## You need to manually adjust the `ratio` value
## to prevent sector deformation.
# x = x, y = y
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +
  facet_wrap(~t1, ncol = 2) +
  geom_sector(
    aes(x, y),
    theta = 75,
    fill = 2,
    r = 0.5,
    ## You need to manually adjust the `ratio` value
    ## to prevent sector deformation.
    ratio = 1.6,
    individual = FALSE
  )

```

```

) +
  theme_bw() +
  theme(axis.title = element_blank())

# x = y, y = x
ggplot(rbind(
  cbind(df, t1 = 1),
  cbind(df[1:9, ], t1 = 2)
)) +
  facet_wrap(~t1, ncol = 2) +
  geom_sector(
    aes(y, x),
    theta = 75,
    fill = 2,
    r = 0.5,
    ## You need to manually adjust the `ratio` value
    ## to prevent sector deformation.
    ratio = 1.6,
    individual = FALSE
  ) +
  # coord_fixed() +
  theme_bw() +
  theme(axis.title = element_blank())

```

 sectorGrob

Draw sector with grid

Description

`sectorGrob()` return a polygon grob. `grid.sector()` draw sector. For more details, please type `vignette("ggsector")`.

Usage

```

sectorGrob(
  x = 0.5,
  y = 0.5,
  theta = 25,
  r = 0.5,
  start = 0,
  r_start = 0,
  type = "percent",
  ratio = 1,
  group,
  default.units = "npc",
  vp = viewport(height = unit(1, "snpc"), width = unit(1, "snpc")),
  gp = gpar(col = "black", fill = "transparent")

```



```

)

grid.sector(
  x = 0.5,
  y = 0.5,
  theta = 25,
  r = 0.5,
  start = 0,
  r_start = 0,
  type = "percent",
  ratio = 1,
  group,
  default.units = "npc",
  vp = viewport(height = unit(1, "snpc"), width = unit(1, "snpc")),
  gp = gpar(col = "black", fill = "transparent")
)

```

Arguments

<code>x</code>	Numeric, the x-axis coordinate of the sector center.
<code>y</code>	Numeric, the y-axis coordinate of the sector center.
<code>theta</code>	Numeric, the angle of the sector, if <code>'type = "percent"</code> , the input is a percentage(0-100), if <code>'type = "degree"</code> , the input is an angle(0-360).
<code>r</code>	Numeric, radius of the outer circle of the sector(0-0.5).
<code>start</code>	Numeric, starting angle of sector.
<code>r_start</code>	Numeric, radius of the inner circle of the sector(0-r).
<code>type</code>	"percent", "degree" or an integer (preferably greater than 50), represents the number of scattered points on the circle where the sector is drawn. When <code>type = "percent"</code> , the circumference of the circle where the sector is located is composed of 100 scattered points; when <code>type = "degree"</code> , the circumference of the circle where the sector is located is composed of 360 scattered points; when <code>type = 150</code> , the circumference of the circle where the sector is located is composed of 150 scattered points.
<code>ratio</code>	aspect ratio, expressed as y / x .
<code>group</code>	A numeric vector used to separate locations in x and y into multiple sectors. If missing, it will be automatically added as a number.
<code>default.units</code>	A string indicating the default units to use if x, y, width, or height are only given as numeric vectors.
<code>vp</code>	A Grid viewport object (or NULL).
<code>gp</code>	An object of class <code>"gpar"</code> , typically the output from a call to the function <code>gpar</code> . This is basically a list of graphical parameter settings.

Value

polygon grob
 draw sector

Examples

```

## Draw basic grid

# sectorGrob with units of "cm" and type of "degree"
grid.newpage()
gp <- sectorGrob(
  x = unit(c(3, 9, 15), "cm"),
  y = unit(c(5, 9, 15), "cm"),
  theta = c(90, 180, 270),
  r = 1,
  start = c(180, 180, 270),
  r_start = c(0.6, 0.3, 0),
  type = "degree",
  group = factor(1:3, levels = c(2, 3, 1)),
  gp = gpar(fill = c("green", "red", "blue"))
)
grid.draw(gp)

# grid.sector with units of "npc" and type of "percent"
grid.newpage()
grid.sector(
  x = c(0.1, 0.5, 0.9),
  y = c(0.9, 0.6, 0.1),
  theta = c(25, 50, 90),
  r = .1,
  start = c(25, 50, 100),
  r_start = c(0.06, 0.03, 0),
  type = "percent",
  group = factor(1:3, levels = c(2, 3, 1)),
  gp = gpar(col = c("green", "red", "blue"), fill = 2:4),
  default.units = "npc"
)

## Draw sector with ComplexHeatmap

# prepare data
library(magrittr)
library(ComplexHeatmap)
t0 <- cor(mtcars) %>%
  set_colnames(paste("y_", colnames(.))) %>%
  set_rownames(paste("x_", rownames(.)))
mat <- abs(t0)
mat[1:5, 1:5]

# Realized by modifying the [grid::viewport()],
# the sector can be set with a fixed width and height
set.seed(1)
Heatmap(
  mat,
  name = "vp",
  rect_gp = gpar(type = "none"),

```

```

cell_fun = function(j, i, x, y, width, height, fill) {
  grid.rect(
    x = x, y = y, width = width, height = height,
    gp = gpar(col = "grey", fill = NA)
  )
  grid.sector(
    theta = mat[i, j] * 100,
    r = 0.5,
    start = mat[i, j] * 100 * runif(1),
    r_start = mat[i, j] * 0.49 * runif(1),
    vp = viewport(x, y, width, height),
    gp = gpar(fill = fill, col = "transparent")
  )
},
width = unit(.7, "snpc"),
height = unit(.7, "snpc")
)

# Realized in the form of coordinates + radius.
# The default viewport locks the horizontal and vertical axes
# so that the sector does not deform, which needs to be removed here.
# The radius 'r' is half the min(length, width).
set.seed(2)
Heatmap(
  mat,
  name = "xy + r",
  rect_gp = gpar(type = "none"),
  cell_fun = function(j, i, x, y, width, height, fill) {
    grid.rect(
      x = x, y = y, width = width, height = height,
      gp = gpar(col = "grey", fill = NA)
    )
    r <- as.numeric(min(width, height)) / 2
    grid.sector(
      x,
      y,
      theta = mat[i, j] * 100,
      r = r,
      start = mat[i, j] * 100 * runif(1),
      r_start = mat[i, j] * r * 0.9 * runif(1),
      vp = NULL,
      gp = gpar(fill = fill, col = "transparent")
    )
  },
  width = unit(.7, "snpc"),
  height = unit(.7, "snpc")
)

# layer full
# The input matrix needs to be extracted with pindex(mat, i, j)
set.seed(3)
Heatmap(
  mat,

```

```

name = "layer",
rect_gp = gpar(type = "none"),
layer_fun = function(j, i, x, y, width, height, fill) {
  grid.rect(
    x = x, y = y, width = width, height = height,
    gp = gpar(col = "grey", fill = NA)
  )
  r <- as.numeric(min(width, height)) / 2
  grid.sector(
    x,
    y,
    theta = pindex(mat, i, j) * 100,
    r = r,
    start = pindex(mat, i, j) * 100 * runif(nrow(mat) * ncol(mat)),
    r_start = pindex(mat, i, j) * r * 0.9 * runif(nrow(mat) * ncol(mat)),
    vp = NULL,
    gp = gpar(fill = fill, col = "transparent")
  )
},
width = unit(.7, "snpc"),
height = unit(.7, "snpc")
)

```

SectorPlot

Draw sector for seurat object

Description

A better alternative to `Seurat::DotPlot()`. For more details, please type `vignette("ggsector")`.

Usage

```

SectorPlot(
  object,
  features,
  features.level,
  assay,
  slot = c("data", "scale.data", "counts"),
  group.by,
  group.level,
  split.by,
  split.level,
  col_low = "blue",
  col_mid = "white",
  col_high = "red",
  col_midpoint,
  ...
)

```

Arguments

object	Seurat object
features	Input vector of genes list.
features.level	Levels of genes list.
assay	Specific assay to get data from or set data for; defaults to the default assay.
slot	Specific assay data to get or set.
group.by	Column of metadata to group the cells by, default is Idents().
group.level	Levels of group.
split.by	Column of metadata to split the cells by, default is NULL.
split.level	Levels of split vars.
col_low	Colours for low ends of the gradient.
col_mid	Colour for mid point.
col_high	Colours for high ends of the gradient.
col_midpoint	The midpoint (in data value) of the diverging scale.
...	Other arguments for <code>ggplot2::facet_wrap()</code> . Defaults to <code>quantile(exp, 0.5)</code>

Value

ggplot

Examples

```
## Download pbmc data from
# https://cf.10xgenomics.com/samples/cell/pbmc3k/pbmc3k_filtered_gene_bc_matrices.tar.gz
library(Seurat)
path <- paste0(tempdir(), "/pbmc3k.tar.gz")
file <- paste0(tempdir(), "/filtered_gene_bc_matrices/hg19")
download.file(
  "https://cf.10xgenomics.com/samples/cell/pbmc3k/pbmc3k_filtered_gene_bc_matrices.tar.gz",
  path
)
untar(path, exdir = tempdir())
pbmc.data <- Read10X(data.dir = file)
pbmc <- CreateSeuratObject(
  counts = pbmc.data,
  project = "pbmc3k",
  min.cells = 3,
  min.features = 200
)
pbmc <- NormalizeData(pbmc)
pbmc <- FindVariableFeatures(pbmc, selection.method = "vst", nfeatures = 2000)
pbmc <- ScaleData(pbmc, features = rownames(pbmc))
pbmc <- RunPCA(pbmc)
pbmc <- RunUMAP(pbmc, dim = 1:10)
pbmc <- FindNeighbors(pbmc, dims = 1:10)
```

```

pbmc <- FindClusters(pbmc, resolution = 1)
pbmc <- FindClusters(pbmc, resolution = 0.5)
markers <- tibble::tribble(
  ~type, ~marker,
  "Naive CD4+ T", "IL7R,CCR7",
  "CD14+ Mono", "CD14,LYZ",
  "Memory CD4+", "IL7R,S100A4",
  "B", "MS4A1",
  "CD8+ T", "CD8A",
  "FCGR3A+ Mono", "FCGR3A,MS4A7",
  "NK", "GNLY,NKG7",
  "DC", "FCER1A,CST3",
  "Platelet", "PPBP",
) %>%
  tidyr::separate_rows(marker, sep = ", *") %>%
  dplyr::distinct()

# Dotplot
DotPlot(pbmc, features = unique(markers$marker)) + coord_flip()

# contrast with DotPlot
SectorPlot(pbmc, markers$marker, features.level = unique(rev(markers$marker)))

SectorPlot(pbmc, markers$marker, group.by = "RNA_snn_res.1")

# split plot
# Assume a variable 'day', expressed as the number of days of cell development.
set.seed(1)
pbmc[["day"]] <- sample(1:3, ncol(pbmc), TRUE)
SectorPlot(pbmc, markers$marker, group.by = "RNA_snn_res.0.5", split.by = "day")
SectorPlot(
  pbmc, markers$marker,
  group.by = "day", split.by = "RNA_snn_res.0.5", nrow = 1
)

```

sector_df

sector coordinates

Description

According to the input center position, radius and angle, get the polygon coordinates of a sector.

Usage

```

sector_df(
  x = 0.5,
  y = 0.5,
  theta = 25,

```

```

    r = 0.5,
    start = 0,
    r_start = 0,
    type = "percent",
    ratio = 1
)

sector_df_multiple(
  x = 0.5,
  y = 0.5,
  theta = 25,
  r = 0.5,
  start = 0,
  r_start = 0,
  type = "percent",
  ratio = 1,
  group
)

```

Arguments

x	Numeric, the x-axis coordinate of the sector center.
y	Numeric, the y-axis coordinate of the sector center.
theta	Numeric, the angle of the sector, if 'type = "percent"', the input is a percentage(0-100), if 'type = "degree"', the input is an angle(0-360).
r	Numeric, radius of the outer circle of the sector(0-0.5).
start	Numeric, starting angle of sector.
r_start	Numeric, radius of the inner circle of the sector(0-r).
type	"percent", "degree" or an integer (preferably greater than 50), represents the number of scattered points on the circle where the sector is drawn. When type = "percent", the circumference of the circle where the sector is located is composed of 100 scattered points; when type = "degree", the circumference of the circle where the sector is located is composed of 360 scattered points; when type = 150, the circumference of the circle where the sector is located is composed of 150 scattered points.
ratio	aspect ratio, expressed as y / x.
group	A numeric vector used to separate locations in x and y into multiple sectors. If missing, it will be automatically added as a number.

Details

[sector_df\(\)](#) Only one value can be passed in for each parameter, and a sector coordinate is returned.

[sector_df_multiple\(\)](#) Each parameter can pass in multiple values, and return multiple sector coordinates

The value of the 'type' parameter is "percent", "degree" or an integer (preferably greater than 50), represents the number of scattered points on the circle where the sector is drawn. When type = "percent", the circumference of the circle where the sector is located is composed of 100 scattered points; when type = "degree", the circumference of the circle where the sector is located is composed of 360 scattered points

For more details, please type vignette("ggsector").

Value

coordinates of sector.

coordinates of sectors.

Examples

```
## coordinates of single sector
# type of percent, start = 0, r_start = 0
tmp_df <- sector_df(x = 0.5, y = 0.5, theta = 25, r = 0.4, start = 0, r_start = 0)
tmp_df
grid.newpage()
grid.polygon(
  tmp_df$x, tmp_df$y,
  vp = viewport(height = unit(1, "npc"), width = unit(1, "npc"))
)
# type of percent, start = 50, r_start = 0.2
tmp_df <- sector_df(x = 0.5, y = 0.5, theta = 25, r = 0.4, start = 50, r_start = 0.2)
tmp_df
grid.newpage()
grid.polygon(
  tmp_df$x, tmp_df$y,
  vp = viewport(height = unit(1, "npc"), width = unit(1, "npc"))
)

# type of degree, start = 90, r_start = 0
tmp_df <- sector_df(
  x = 0.5, y = 0.5, theta = 180, r = 0.4,
  start = 90, r_start = 0, type = "degree"
)
tmp_df
grid.newpage()
grid.polygon(
  tmp_df$x, tmp_df$y,
  vp = viewport(height = unit(1, "npc"), width = unit(1, "npc"))
)

# type of degree, start = 180, r_start = 0.2
tmp_df <- sector_df(
  x = 0.5, y = 0.5, theta = 180, r = 0.4,
  start = 270, r_start = 0.2, type = "degree"
)
tmp_df
grid.newpage()
grid.polygon(
```



```
    tmp_df$x, tmp_df$y,
    vp = viewport(height = unit(1, "snpc"), width = unit(1, "snpc"))
  )

## Coordinates of Multiple Sectors
tmp_df <- sector_df_multiple(
  x = c(0.2, 0.5, 0.8),
  theta = c(25, 50, 75),
  r = 0.15,
  start = c(75, 50, 100),
  r_start = c(0, 0.05, 0.1),
  type = "percent"
)
tmp_df
grid.newpage()
grid.polygon(
  tmp_df$x,
  tmp_df$y,
  id = tmp_df$group,
  vp = viewport(height = unit(1, "snpc"), width = unit(1, "snpc")),
  gp = gpar(
    fill = 3:1, col = 1:3
  )
)

# type = 10, 100, 1000
tmp_df <- sector_df_multiple(
  x = c(0.25, 0.5, 0.75),
  theta = c(7.5, 75, 750),
  r = 0.125,
  r_start = c(0.05),
  type = c(c(10, "percent", 1000))
)
tmp_df
grid.newpage()
grid.polygon(
  tmp_df$x,
  tmp_df$y,
  id = tmp_df$group,
  vp = viewport(height = unit(1, "snpc"), width = unit(1, "snpc")),
  gp = gpar(
    fill = 3:1, col = 1:3
  )
)
```

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