

Package ‘piecepackr’

May 8, 2025

Encoding UTF-8

Type Package

Title Board Game Graphics

Version 1.15.1

Description Functions to make board game graphics with the 'ggplot2', 'grid', 'rayrender', 'rayvertex', and 'rgl' packages. Specializes in game diagrams, animations, and ``Print & Play'' layouts for the 'piecepack' <<https://www.ludism.org/ppwiki>> but can make graphics for other board game systems. Includes configurations for several public domain game systems such as checkers, (double-18) dominoes, go, 'piecepack', playing cards, etc.

License MIT + file LICENSE

URL <https://trevorldavis.com/piecepackr/> (blog),
<https://trevorldavis.com/R/piecepackr/> (pkgdown),
<https://groups.google.com/forum/#!forum/piecepackr> (forum)

BugReports <https://github.com/piecepackr/piecepackr/issues>

LazyData true

LazyLoad yes

Imports affiner (>= 0.1.1), grid, gridGeometry, grImport2, grDevices, purrr, jpeg, png, R6, rlang, stringr, tibble, tools, utils

Suggests animation (>= 2.7), ggplot2, gifski, gridpattern, magick, pdftools, rayrender (>= 0.34.3), rayvertex (>= 0.10.4), readobj (>= 0.4.0), rgl (>= 0.106.8), scales (>= 0.5.0), systemfonts, testthat, tweenr, vdiff, xmpdf (>= 0.1.1), XML (>= 3.99-0.9)

RoxygenNote 7.3.1

Config/testthat/edition 3

NeedsCompilation no

Author Trevor L. Davis [aut, cre] (ORCID:
<<https://orcid.org/0000-0001-6341-4639>>),
Linux Foundation [dct] (Uses some data from the ``SPDX License List''
<<https://github.com/spdx/license-list-XML>>),
Delapouite <<https://delapouite.com/>> [ill] (Meeple shape extracted from

``Meeple icon" <<https://game-icons.net/1x1/delapouite/meeple.html>> /
 ``CC BY 3.0" <<https://creativecommons.org/licenses/by/3.0/>>),
 Creative Commons [ill] (`save_print_and_play()` uses ``license badges"
 from Creative Commons to describe the generated print-and-play
 file's license)

Maintainer Trevor L. Davis <trevor.l.davis@gmail.com>

Depends R (>= 2.10)

Repository CRAN

Date/Publication 2025-05-08 06:20:02 UTC

Contents

piecepackr-package	3
aabb_piece	4
AA_to_R	5
animate_piece	7
basicPieceGrobs	9
font_utils	10
game_systems	11
geom_piece	15
grid.cropmark	18
grid.crosshair	21
grid.piece	23
install_ppverse	26
op_transform	27
piece	29
piece3d	31
piecepackr-defunct	33
piece_mesh	34
pmap_piece	35
pp_cfg	37
pp_shape	40
pp_utils	43
render_piece	44
save_ellipsoid_obj	47
save_piece_images	48
save_piece_obj	49
save_print_and_play	51
scale_x_piece	52
spx_license_list	55

Index

56

piecepackr-package *piecepackr: Board Game Graphics*

Description

Functions to make board game graphics with the 'ggplot2', 'grid', 'rayrender', 'rayvertex', and 'rgl' packages. Specializes in game diagrams, animations, and "Print & Play" layouts for the 'piecepack' <https://www.ludism.org/ppwiki> but can make graphics for other board game systems. Includes configurations for several public domain game systems such as checkers, (double-18) dominoes, go, 'piecepack', playing cards, etc.

Package options

The following piecepackr function arguments may be set globally via `base::options()`:

piecepackr.at.inform If FALSE turns off messages when affine transformation support not detected in active graphics device.

piecepackr.cfg Sets a new default for the `cfg` argument

piecepackr.check.cairo If FALSE don't check the version of cairo

piecepackr.default.units Sets a new default for the `default.units` argument

piecepackr.envir Sets a new default for the `envir` argument

piecepackr.fs.inform If FALSE turns off messages when stroking and filling path support not detected in active graphics device.

piecepackr.metadata.inform If FALSE turns off messages when support for embedding metadata not detected.

piecepackr.op_angle Sets a new default for the `op_angle` argument

piecepackr.op_scale Sets a new default for the `op_scale` argument

piecepackr.rgr.inform If FALSE turns off messages when radial gradient support not detected in active graphics device.

piecepackr.trans Sets a new default for the `trans` argument

Author(s)

Maintainer: Trevor L. Davis <trevor.l.davis@gmail.com> ([ORCID](#))

Other contributors:

- Linux Foundation (Uses some data from the "SPDX License List" <<https://github.com/spdx/license-list-XML>>) [data contributor]
- Delapouite <<https://delapouite.com/>> (Meeple shape extracted from "Meeple icon" <<https://game-icons.net/1x1/delapouite/meeple.html>> / "CC BY 3.0" <<https://creativecommons.org/licenses/by/3.0/>>) [illustrator]
- Creative Commons ('save_print_and_play()') uses "license badges" from Creative Commons to describe the generated print-and-play file's license) [illustrator]

See Also

Useful links:

- blog: <https://trevorldavis.com/piecepackr/>
- pkgdown: <https://trevorldavis.com/R/piecepackr/>
- forum: <https://groups.google.com/forum/#!forum/piecepackr>
- Report bugs: <https://github.com/piecepackr/piecepackr/issues>

aabb_piece

Calculate axis-aligned bounding box for set of game pieces

Description

Calculate axis-aligned bounding box (AABB) for set of game pieces with and without an “oblique projection”.

Usage

```
aabb_piece(
  df,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  envir = getOption("piecepackr.envir"),
  op_scale = getOption("piecepackr.op_scale", 0),
  op_angle = getOption("piecepackr.op_angle", 45),
  ...
)
```

Arguments

df	A data frame of game piece information with (at least) the named columns “piece_side”, “x”, and “y”.
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
envir	Environment (or named list) containing configuration list(s).
op_scale	How much to scale the depth of the piece in the oblique projection (viewed from the top of the board). 0 (the default) leads to an “orthographic” projection, 0.5 is the most common scale used in the “cabinet” projection, and 1.0 is the scale used in the “cavalier” projection.
op_angle	What is the angle of the oblique projection? Has no effect if op_scale is 0.
...	Ignored

Details

The “oblique projection” of a set of (x, y, z) points onto the xy-plane is $(x + \lambda * z * \cos(\alpha), y + \lambda * z * \sin(\alpha))$ where λ is the scale factor and α is the angle.

Value

A named list of ranges with five named elements *x*, *y*, and *z* for the axis-aligned bounding cube in xyz-space plus *x_op* and *y_op* for the axis-aligned bounding box of the “oblique projection” onto the xy plane.

Examples

```
df_tiles <- data.frame(piece_side="tile_back", x=0.5+c(3,1,3,1), y=0.5+c(3,3,1,1),
                      suit=NA, angle=NA, z=NA, stringsAsFactors=FALSE)
df_coins <- data.frame(piece_side="coin_back", x=rep(4:1, 4), y=rep(4:1, each=4),
                      suit=1:16%%2+rep(c(1,3), each=8),
                      angle=rep(c(180,0), each=8), z=1/4+1/16, stringsAsFactors=FALSE)
df <- rbind(df_tiles, df_coins)

aabb_piece(df, op_scale = 0)
aabb_piece(df, op_scale = 1, op_angle = 45)
aabb_piece(df, op_scale = 1, op_angle = -90)
```

AA_to_R

*Helper functions for making geometric calculations.***Description**

`to_x()`, `to_y()`, `to_r()`, `to_t()` convert between polar coordinates (in degrees) and Cartesian coordinates. `to_degrees()` and `to_radians()` converts between degrees and radians. `AA_to_R()` and `R_to_AA()` convert back and forth between (post-multiplied) rotation matrix and axis-angle representations of 3D rotations. `R_x()`, `R_y()`, and `R_z()` build (post-multiplied) rotation matrices for simple rotations around the x, y, and z axes.

Usage

```
AA_to_R(angle = 0, axis_x = 0, axis_y = 0, axis_z = NA, ...)
```

```
R_to_AA(R = diag(3))
```

```
R_x(angle = 0)
```

```
R_y(angle = 0)
```

```
R_z(angle = 0)
```

```
to_radians(t)
```

```
to_degrees(t)
```

```
to_x(t, r)
```

to_y(t, r)

to_r(x, y)

to_t(x, y)

Arguments

angle	Numeric vector in degrees (counter-clockwise) or an <code>affiner::angle()</code> vector.
axis_x	First coordinate of the axis unit vector.
axis_y	Second coordinate of the axis unit vector.
axis_z	Third coordinate of the axis unit vector (usually inferred).
...	Ignored
R	3D rotation matrix (post-multiplied)
t	Numeric vector in degrees (or radians for <code>to_degrees()</code>) or an <code>affiner::angle()</code> vector.
r	Radial distance
x	Cartesian x coordinate
y	Cartesian y coordinate

Details

`pp_cfg()` uses polar coordinates to determine where the "primary" and "directional" symbols are located on a game piece. They are also useful for drawing certain shapes and for making game diagrams on hex boards.

`piecepackr` and `grid` functions use angles in degrees but the base trigonometry functions usually use radians.

`piecepackr`'s 3D graphics functions `save_piece_obj()`, `piece()`, `piece3d()`, and `piece_mesh()` use the axis-angle representation for 3D rotations. The axis-angle representation involves specifying a unit vector indicating the direction of an axis of rotation and an angle describing the (counter-clockwise) rotation around that axis. Because it is a unit vector one only needs to specify the first two elements, `axis_x` and `axis_y`, and we are able to infer the 3rd element `axis_z`. The default of `axis = 0`, `axis_y = 0`, and implied `axis_z = 1` corresponds to a rotation around the z-axis which is reverse-compatible with the originally 2D angle interpretation in `grid.piece()`. In order to figure out the appropriate axis-angle representation parameters `R_to_AA()`, `R_x()`, `R_y()`, and `R_z()` allow one to first come up with an appropriate (post-multiplied) 3D rotation matrix by chaining simple rotations and then convert them to the corresponding axis-angle representation. Pieces are rotated as if their center was at the origin.

See Also

https://en.wikipedia.org/wiki/Axis-angle_representation for more details about the Axis-angle representation of 3D rotations. See `Trig` for R's built-in trigonometric functions.

Examples

```

to_x(90, 1)
to_y(180, 0.5)
to_t(0, -1)
to_r(0.5, 0)
all.equal(pi, to_radians(to_degrees(pi)))
# default axis-angle axis is equivalent to a rotation about the z-axis
all.equal(AA_to_R(angle=60), R_z(angle=60))
# axis-angle representation of 90 rotation about the x-axis
R_to_AA(R_x(90))
# find Axis-Angle representation of first rotating about x-axis 180 degrees
# and then rotating about z-axis 45 degrees
R_to_AA(R_x(180) %*% R_z(45))

```

animate_piece

Animate board game pieces

Description

animate_piece() animates board game pieces.

Usage

```

animate_piece(
  dfs,
  file = "animation.gif",
  ...,
  .f = piecepackr::grid.piece,
  cfg = getOption("piecepackr.cfg", NULL),
  envir = getOption("piecepackr.envir", game_systems("sans")),
  width = NULL,
  height = NULL,
  ppi = NULL,
  annotate = TRUE,
  annotation_scale = NULL,
  open_device = new_device,
  n_transitions = 0L,
  n_pauses = 1L,
  fps = n_transitions + n_pauses,
  xbreaks = NULL,
  ybreaks = NULL,
  new_device = TRUE
)

```

Arguments

dfs	A list of data frames of game data to plot.
file	Filename to save animation unless NULL in which case it uses the current graphics device.
...	Arguments to <code>pmap_piece()</code>
.f	Low level graphics function to use e.g. <code>grid.piece()</code> , <code>piece3d()</code> , <code>piece()</code> , or <code>piece_mesh()</code> .
cfg	A piecepackr configuration list
envir	Environment (or named list) of piecepackr configuration lists
width	Width of animation (in inches). Inferred by default.
height	Height of animation (in inches). Inferred by default.
ppi	Resolution of animation in pixels per inch. By default set so image max 600 pixels wide or tall.
annotate	If TRUE or "algebraic" annotate the plot with "algebraic" coordinates, if FALSE or "none" don't annotate, if "cartesian" annotate the plot with "cartesian" coordinates.
annotation_scale	Multiplicative factor that scales (stretches) any annotation coordinates. By default uses <code>attr(df, "scale_factor") % % 1</code> .
open_device	If TRUE open a new graphics device otherwise draw in the active graphics.
n_transitions	Integer, if over zero (the default) how many transition frames to add between moves.
n_pauses	Integer, how many paused frames per completed move.
fps	Double, frames per second.
xbreaks, ybreaks	Subset (of integers) to provide axis labels for if annotate is TRUE. If NULL infer a reasonable choice.
new_device	If file is NULL should we open up a new graphics device? This argument is deprecated. Use the open_device argument instead.

Value

Nothing, as a side effect creates an animation.

Examples

```
# Basic tic-tac-toe animation
dfs <- list()
d.frame <- function(piece_side = "bit_back", ..., rank = 1L) {
  data.frame(piece_side = piece_side, ..., rank = rank,
             cfg = "checkers1", stringsAsFactors = FALSE)
}
df <- d.frame("board_back", suit = 2L, rank = 3L, x = 2, y = 2, id = "1")
dfs[[1L]] <- df
df <- rbind(df, d.frame(suit = 1L, x = 2, y = 2, id = "2"))
```



```

dfs[[2L]] <- df
df <- rbind(df, d.frame(suit = 2L, x = 1, y = 2, id = "3"))
dfs[[3L]] <- df
df <- rbind(df, d.frame(suit = 1L, x = 3, y = 1, id = "4"))
dfs[[4L]] <- df
df <- rbind(df, d.frame(suit = 2L, x = 1, y = 3, id = "5"))
dfs[[5L]] <- df
df <- rbind(df, d.frame(suit = 1L, x = 1, y = 1, id = "6"))
dfs[[6L]] <- df
df <- rbind(df, d.frame(suit = 2L, x = 3, y = 3, id = "7"))
dfs[[7L]] <- df
df <- rbind(df, d.frame(suit = 1L, x = 2, y = 1, id = "8"))
dfs[[8L]] <- df

## Press enter to walk through moves in a "game" in new graphics device
if (interactive()) {
  animate_piece(dfs, file = NULL)
}

## Save GIF of game with animation transitions
## Not run: # May take more than 5 seconds on CRAN servers
if ((requireNamespace("animation", quietly = TRUE) ||
  requireNamespace("gifski", quietly = TRUE)) &&
  requireNamespace("tweenr", quietly = TRUE)) {
  file <- tempfile("tic-tac-toe", fileext = ".gif")
  animate_piece(dfs, file = file,
    n_transitions = 5L, n_pauses = 2L, fps = 9)
}

## End(Not run)

```

basicPieceGrobs

Piece Grob Functions

Description

basicPieceGrob() is the most common “grob” function that `grid.piece()` uses to create grid graphical grob objects. picturePieceGrobFn() is a function that returns a “grob” function that imports graphics from files found in its directory argument.

Usage

```
basicPieceGrob(piece_side, suit, rank, cfg = pp_cfg())
```

```
picturePieceGrobFn(directory, filename_fn = find_pp_file)
```

```
pyramidTopGrob(piece_side, suit, rank, cfg = pp_cfg())
```

```
previewLayoutGrob(piece_side, suit, rank, cfg = pp_cfg())
```

Arguments

piece_side	A string with piece and side separated by an underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or <code>pp_cfg()</code> object.
directory	Directory that <code>picturePieceGrobfFn</code> will look in for piece graphics.
filename_fn	Function that takes arguments <code>directory</code> , <code>piece_side</code> , <code>suit</code> , <code>rank</code> , and optionally <code>cfg</code> and returns the (full path) filename of the image that the function returned by <code>picturePieceGrobfFn</code> should import.

Examples

```

if (requireNamespace("grid", quietly = TRUE) && piecepackr:::device_supports_unicode()) {
  cfg <- pp_cfg(list(grob_fn.tile=basicPieceGrobf, invert_colors=TRUE))
  grid.piece("tile_face", suit=1, rank=3, cfg=cfg)
}

# May take more than 5 seconds on CRAN servers
try({
  if (requireNamespace("grid", quietly = TRUE) && capabilities(c("cairo")))) {
    cfg <- pp_cfg(list(grob_fn.tile=basicPieceGrobf, invert_colors=TRUE))
    directory <- tempdir()
    save_piece_images(cfg, directory=directory, format="svg", angle=0)
    cfg2 <- pp_cfg(list(grob_fn=picturePieceGrobfFn(directory)))

    grid::grid.newpage()
    grid.piece("coin_back", suit=3, rank=5, cfg=cfg2)
  }
})

```

font_utils

Font utility functions

Description

`get_embedded_font()` returns which font is actually embedded by `cairo_pdf()` for a given character. `has_font()` tries to determine if a given font is available on the OS.

Usage

```
get_embedded_font(font, char)
```

```
has_font(font)
```

Arguments

font A character vector of font(s).
char A character vector of character(s) to be embedded by `grid::grid.text()`

Details

`get_embedded_font()` depends on the suggested `pdftools` package being installed and R being compiled with Cairo support. `has_font()` depends on either the suggested `systemfonts` (preferred) or `pdftools` packages being installed.

Value

`get_embedded_font()` returns character vector of fonts that were actually embedded by `cairo_pdf()`. NA's means no embedded font detected: this either means that no font was found or that a color emoji font was found and instead of a font an image was embedded.

Examples

```
if (requireNamespace("pdftools", quietly = TRUE) &&
    capabilities("cairo") &&
    !piecepackr:::is_cairo_maybe_buggy()) {
  chars <- c("a", "\u2666")
  fonts <- c("sans", "Sans Noto", "Noto Sans", "Noto Sans Symbols2")
  try(get_embedded_font(fonts, chars))
}

if (requireNamespace("systemfonts", quietly = TRUE) ||
    (requireNamespace("pdftools", quietly = TRUE) &&
     capabilities("cairo") && !piecepackr:::is_cairo_maybe_buggy()) {
  try(has_font("Dejavu Sans"))
}
```

game_systems

Standard game systems

Description

`game_systems()` returns a list of `pp_cfg()` objects representing several game systems and pieces. `to_subpack()` and `to_hexpack()` will attempt to generate matching (piecepack stackpack) subpack and (piecepack) hexpack `pp_cfg()` R6 objects respectively given a piecepack configuration.

Usage

```
game_systems(
  font = style,
  round = FALSE,
  pawn = "token",
  ...,
```

```

    shading = FALSE,
    border = TRUE,
    background_color = ifelse(border, "white", "burlywood"),
    edge_color = ifelse(border, "white", "black"),
    style = NULL
)

to_hexpack(cfg = getOption("piecepackr.cfg", pp_cfg()))

to_subpack(cfg = getOption("piecepackr.cfg", pp_cfg()))

```

Arguments

font	If NULL (the default) uses suit glyphs from the default “sans” font. If “dejavu” it will use suit glyphs from the “DejaVu Sans” font (must be installed on the system).
round	If TRUE the “shape” of “tiles” and “cards” (and some boards) will be “roundrect” instead of “rect” (the default).
pawn	If “token” (default) the piecepack pawn will be a two-sided token in a “halma” outline, if “peg-doll” the piecepack pawn will be a “peg doll” style pawn, and if “joystick” the piecepack pawn will be a “joystick” style pawn. Note for the latter two pawn styles only pawn_top will work with grid.piece() .
...	Must be empty
shading	If TRUE add a shading effect to marbles and stones when drawn with grid.piece() .
border	If TRUE draw a black border line on piece edges. Should normally be TRUE when drawing with {grid} graphics and FALSE when drawing with 3D graphic systems.
background_color	Background color to use for certain pieces like boards and piecepack tiles.
edge_color	Edge color to use for certain pieces like boards and piecepack tiles.
style	Deprecated argument.
cfg	List of configuration options

Details

Contains the following game systems:

alquerque Boards and pieces in six color schemes for Alquerque

checkers1, checkers2 Checkers and checkered boards in six color schemes. Checkers are represented by a piecepackr “bit”. The “board” “face” is a checkered board and the “back” is a lined board. Color is controlled by suit and number of rows/columns by rank. checkers1 has one inch squares and checkers2 has two inch squares.

chess1, chess2 Chess pieces, boards, and dice in six color schemes. Chess pieces are represented by a “bit” (face). The “board” “face” is a checkered board and the “back” is a lined board. Color is controlled by suit and number of rows/columns by rank. chess1 has one inch squares and chess2 has two inch squares. Currently uses print-and-play style discs instead of 3D Staunton chess pieces.

- dice** Traditional six-sided pipped dice in six color schemes (color controlled by their suit).
- dice_d4, dice_numeral, dice_d8, dice_d10, dice_d10_percentile, dice_d12, dice_d20** Polyhedral dice most commonly used to play wargames, roleplaying games, and trading card games:
- dice_d4** Four-sided dice in six color schemes (color controlled by their suit). Tetrahedrons with the rank as a numeral at the top point.
- dice_numeral** Six-sided dice with numerals instead of pips in six color schemes (color controlled by their suit).
- dice_d8** Eight-sided dice in six color schemes (color controlled by their suit). Octahedrons with the rank as a numeral at the top face.
- dice_d10** Ten-sided dice in six color schemes (color controlled by their suit). Pentagonal trapezohedrons with the rank as a numeral at the top face. The rank of ten is represented by a zero.
- dice_d10_percentile** Ten-sided dice in six color schemes (color controlled by their suit). Pentagonal trapezohedrons with the rank as a numeral followed by a zero at the top face. The rank of ten is represented by a zero.
- dice_d12** Twelve-sided dice in six color schemes (color controlled by their suit). Dodecahedrons with the rank as a numeral at the top face.
- dice_d20** Twenty-sided dice in six color schemes (color controlled by their suit). Icosahedrons with the rank as a numeral at the top face.
- dice_fudge** “Fudge” dice in six color schemes (color controlled by their suit). “Fudge” dice have three ranks "+", "-", and "-" repeated twice.
- dominoes, dominoes_black, dominoes_blue, dominoes_green, dominoes_red, dominoes_white, dominoes_yellow** Traditional pipped dominoes in six color schemes (dominoes and dominoes_white are the same). In each color scheme the number of pips on the “top” of the domino is controlled by their “rank” and on the “bottom” by their “suit”. Supports up to double-18 sets.
- dominoes_chinese, dominoes_chinese_black** dominoes_chinese has Asian-style six-sided pipped dice with white background and black and red pips. The “tile”s are Chinese dominoes (1" x 2.5") whose number of pips are controlled by both their “rank” and their “suit”. dominoes_chinese_black are like dominoes_chinese but the dice and dominoes have a black background and white and red pips.
- go** Go stones and lined boards in six color schemes. Go stones are represented by a “bit” and the board is a “board”. Color is controlled by suit and number of rows/columns by rank.
- marbles** Marbles in nine sizes and six colors represented by a “bit”. Color is controlled by suit and size of marble by rank. Sizes go from 1/2" (rank 1) to 1" (rank 9) in 1/16" increments. There are also square holed boards spaced for 1" marbles: their color is controlled by suit and number of holes per row/column by rank.
- meeples** Standard 16mm x 16mm x 10mm “meeples” in six colors represented by a “bit”.
- morris** Various morris aka mills aka merels games in six colors. Color is controlled by suit and “size” of morris board is controlled by rank e.g. “Six men’s morris” corresponds to a rank of 6 and “Nine men’s morris” corresponds to a rank of 9. Game pieces are represented by stones.
- piecepack, dual_piecepacks_expansion, playing_cards_expansion, hexpack, subpack, piecepack_inverted** The piecepack is a public domain game system invented by James "Kyle" Droscha. See <https://www.ludism.org/ppwiki> for more info about the piecepack and its accessories/expansions.
- piecepack** A standard piecepack. The configuration also contains the following piecepack accessories:

- piecepack dice cards** An accessory proposed by John Braley. See <https://www.ludism.org/ppwiki/PiecepackDiceCards>.
- piecepack matchsticks** A public domain accessory developed by Dan Burkey. See <https://www.ludism.org/ppwiki/PiecepackMatchsticks>.
- piecepack pyramids** A public domain accessory developed by Tim Schutz. See <https://www.ludism.org/ppwiki/PiecepackPyramids>.
- piecepack saucers** A public domain accessory developed by Karol M. Boyle at Mesomorph Games. See <https://web.archive.org/web/20190719155827/http://www.piecepack.org/Accessories.html>.
- piecepack_inverted** The standard piecepack with its color scheme inverted. Intended to aid in highlighting special pieces in diagrams.
- dual_piecepacks_expansion** A companion piecepack with a special suit scheme. See <https://trevorldavis.com/piecepackr/dual-piecepacks-pnp.html>.
- playing_cards_expansion** A piecepack with the standard “French” playing card suits. See <https://www.ludism.org/ppwiki/PlayingCardsExpansion>.
- hexpack** A hexagonal extrapolation of the piecepack designed by Nathan Morse and Daniel Wilcox. See <https://boardgamegeek.com/boardgameexpansion/35424/hexpack>.
- subpack** A mini piecepack. Designed to be used with the piecepack to make piecepack “stackpack” diagrams. See <https://www.ludism.org/ppwiki/StackPack>.
- playing_cards, playing_cards_colored, playing_cards_tarot** Poker-sized “card” components for various playing card decks:
- playing_cards** A traditional deck of playing cards with 4 suits and 13 ranks (A, 2-10, J, Q, K) plus a 14th “Joker” rank.
 - playing_cards_colored** Like `playing_cards` but with five colored suits: red hearts, black spades, green clubs, blue diamonds, and yellow stars.
 - playing_cards_tarot** A (French Bourgeois) deck of tarot playing cards: first four suits are hearts, spades, clubs, and diamonds with 14 ranks (ace through jack, knight, queen, king) plus a 15th “Joker” rank and a fifth “suit” of 22 trump cards (1-21 plus an “excuse”).
- reversi** Boards and pieces for Reversi. “`board_face`” provides lined boards with colored backgrounds. “`board_back`” provides checkered boards. “`bit_face`” / “`bit_back`” provides circular game tokens with differently colored sides: red paired with green, black paired with white, and blue paired with yellow.

See Also

`pp_cfg()` for information about the `pp_cfg()` objects returned by `game_systems()`.

Examples

```

cfgs <- game_systems(pawn = "joystick")
names(cfgs)

# May take more than 5 seconds on CRAN servers
# standard dice, meeples, and joystick pawns
if (requireNamespace("grid", quietly = TRUE) && piecepackr:::device_supports_unicode()) {

  opt <- options(piecepackr.at.inform = FALSE)

```

```

grid::grid.newpage()
dice <- c("d4", "numeral", "d8", "d10", "d12", "d20")
cfg <- paste0("dice_", dice)
grid.piece("die_face", suit = c(1:6, 1), rank = 1:6,
           cfg = cfg, envir = cfigs, x = 1:6, y = 1,
           default.units = "in", op_scale = 0.5)
grid.piece("die_face", rank=1:6, suit=1:6,
           x=1:6, y=2, default.units="in",
           op_scale=0.5, cfg=cfigs$dice)
grid.piece("bit_face", suit=1:6,
           x=1:6, y=3, default.units="in",
           op_scale=0.5, cfg=cfigs$meeple)
grid.piece("pawn_top", suit=1:6,
           x=1:6, y=4, default.units="in",
           op_scale=0.5, cfg=cfigs$piecepack)
options(opt)
}

# dominoes
if (requireNamespace("grid", quietly = TRUE)) {
  grid::grid.newpage()
  colors <- c("black", "red", "green", "blue", "yellow", "white")
  cfg <- paste0("dominoes_", rep(colors, 2))
  grid.piece("tile_face", suit=1:12, rank=1:12+1,
            cfg=cfg, envir=cfigs,
            x=rep(6:1, 2), y=rep(2*2:1, each=6),
            default.units="in", op_scale=0.5)
}

# piecepack "playing card expansion"
if (requireNamespace("grid", quietly = TRUE) && piecepackr:::device_supports_unicode()) {
  grid::grid.newpage()
  df_tiles <- data.frame(piece_side="tile_back",
                        x=0.5+c(3,1,3,1), y=0.5+c(3,3,1,1),
                        suit=NA, angle=NA, z=1/8,
                        stringsAsFactors=FALSE)
  df_coins <- data.frame(piece_side="coin_back",
                        x=rep(4:1, 4), y=rep(4:1, each=4),
                        suit=c(1,4,1,4,4,1,4,1,2,3,2,3,3,2,3,2),
                        angle=rep(c(180,0), each=8), z=1/4+1/16,
                        stringsAsFactors=FALSE)
  df <- rbind(df_tiles, df_coins)
  pmap_piece(df, cfg = cfigs$playing_cards_expansion, op_scale=0.5,
            default.units="in")
}

```

Description

geom_piece() creates a ggplot2 geom. aes_piece() takes a data frame and generates an appropriate ggplot2::aes() mapping.

Usage

```
geom_piece(
  mapping = NULL,
  data = NULL,
  stat = "identity",
  position = "identity",
  ...,
  envir = getOption("piecepackr.envir", piecepackr::game_systems()),
  op_scale = getOption("piecepackr.op_scale", 0),
  op_angle = getOption("piecepackr.op_angle", 45),
  inherit.aes = TRUE
)

aes_piece(df)
```

Arguments

mapping	Set of aesthetic mappings created by aes() . If specified and inherit.aes = TRUE (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 NULL, the default, the data is inherited from the plot data as specified in the call to ggplot() . A data.frame, or other object, will override the plot data. All objects will be fortified to produce a data frame. See fortify() for which variables will be created. A function will be called with a single argument, the plot data. The return value must be a data.frame, and will be used as the layer data. A function can be created from a formula (e.g. ~ head(.x, 10)).
stat	The statistical transformation to use on the data for this layer. When using a geom_*() function to construct a layer, the stat argument can be used to override the default coupling between geoms and stats. The stat argument accepts the following: <ul style="list-style-type: none"> • A Stat ggproto subclass, for example StatCount. • A string naming the stat. To give the stat as a string, strip the function name of the stat_ prefix. For example, to use stat_count(), give the stat as "count". • For more information and other ways to specify the stat, see the layer stat documentation.
position	A position adjustment to use on the data for this layer. This can be used in various ways, including to prevent overplotting and improving the display. The position argument accepts the following:

- The result of calling a position function, such as `position_jitter()`. This method allows for passing extra arguments to the position.
- A string naming the position adjustment. To give the position as a string, strip the function name of the `position_` prefix. For example, to use `position_jitter()`, give the position as "jitter".
- For more information and other ways to specify the position, see the [layer position](#) documentation.

...	Aesthetics, used to set an aesthetic to a fixed value.
envir	Environment (or named list) containing configuration list(s).
op_scale	How much to scale the depth of the piece in the oblique projection (viewed from the top of the board). 0 (the default) leads to an "orthographic" projection, 0.5 is the most common scale used in the "cabinet" projection, and 1.0 is the scale used in the "cavalier" projection.
op_angle	What is the angle of the oblique projection? Has no effect if <code>op_scale</code> is 0.
inherit.aes	If FALSE, 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> .
df	A data frame of game piece information with (at least) the named columns "piece_side", "x", and "y".

Details

`geom_piece()` requires a fixed scale coordinate system with an aspect ratio of 1 as provided by `ggplot2::coord_fixed()`. `geom_piece()` also requires that `cfg` is a character vector (and not a `pp_cfg()` object). In particular if using `op_transform()` one should set its argument `cfg_class = "character"` if intending for use with `geom_piece()`.

Aesthetics

`geom_piece()` understands the following aesthetics (required aesthetics are in bold). See [pieceGrob\(\)](#) for more details.

- x
- y
- z
- **piece_side**
- rank
- suit
- **cfg**
- width
- height
- depth
- angle
- scale
- type

See Also

`geom_piece()` is a wrapper around `pieceGrob()`. `scale_x_piece()` and `scale_y_piece()` are wrappers around `ggplot2::scale_x_continuous()` and `ggplot2::scale_y_continuous()` with better defaults for board game diagrams.

Examples

```
if (require("ggplot2", quietly = TRUE) && require("tibble", quietly = TRUE)) {
  envir <- game_systems("sans")
  df_board <- tibble(piece_side = "board_face", suit = 3, rank = 8,
                    x = 4.5, y = 4.5)
  df_w <- tibble(piece_side = "bit_back", suit = 6, rank = 1,
                x = rep(1:8, 2), y = rep(1:2, each=8))
  df_b <- tibble(piece_side = "bit_back", suit = 1, rank = 1,
                x = rep(1:8, 2), y = rep(7:8, each=8))
  df <- rbind(df_board, df_w, df_b)
  # 2D example
  # `cfg` must be a character vector for `geom_piece()`
  ggplot(df, aes_piece(df)) +
    geom_piece(cfg = "checkers1", envir = envir) +
    coord_fixed() +
    scale_x_piece() +
    scale_y_piece() +
    theme_minimal(28) +
    theme(panel.grid = element_blank())
}
if (require("ggplot2", quietly = TRUE) && require("tibble", quietly = TRUE)) {
  # 3D "oblique" projection example
  # `cfg_class` must be "character" when using with `geom_piece()`
  df3d <- op_transform(df, cfg = "checkers1", envir = envir,
                    op_angle = 45, cfg_class = "character")
  ggplot(df3d, aes_piece(df3d)) +
    geom_piece(cfg = "checkers1", envir = envir,
              op_angle = 45, op_scale = 0.5) +
    coord_fixed() +
    theme_void()
}
```

Description

`grid.cropmark()` draws “crop marks” to the active graphics device. `cropmarkGrob()` is its grid grob counterpart. Intended for use in adding crop marks around game pieces in print-and-play layouts.

Usage

```
cropmarkGrob(
  ...,
  piece_side = "tile_back",
  suit = NA,
  rank = NA,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  x = unit(0.5, "npc"),
  y = unit(0.5, "npc"),
  angle = 0,
  width = NA,
  height = NA,
  scale = 1,
  default.units = "npc",
  envir = getOption("piecepackr.envir"),
  name = NULL,
  gp = gpar(),
  vp = NULL,
  bleed = unit(0.125, "in"),
  cm_select = "12345678",
  cm_width = unit(0.25, "mm"),
  cm_length = unit(0.125, "in")
)
```

```
grid.cropmark(..., draw = TRUE)
```

Arguments

...	cropmarkGrob() ignores; grid.cropmark() passes to cropmarkGrob().
piece_side	A string with piece and side separated by a underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
x	Where to place piece on x axis of viewport
y	Where to place piece on y axis of viewport
angle	Angle (on xy plane) to draw piece at
width	Width of piece
height	Height of piece
scale	Multiplicative scaling factor to apply to width, height, and depth.
default.units	A string indicating the default units to use if 'x', 'y', 'width', and/or 'height' are only given as numeric vectors.
envir	Environment (or named list) containing configuration list(s).

name	A character identifier (for grid)
gp	An object of class “gpar”.
vp	A grid viewport object (or NULL).
bleed	Bleed zone size to assume: <ul style="list-style-type: none"> • If bleed is a <code>grid::unit()</code> simply use it • If bleed is numeric then convert via <code>grid::unit(bleed, default.units)</code> • If bleed is TRUE assume 1/8 inch bleed zone size • If bleed is FALSE assume 0 inch bleed zone size
cm_select	A string of integers from "1" to "8" indicating which crop marks to draw. "1" represents the top right crop mark then we proceeding clockwise to "8" which represents the top left crop mark. Default "12345678" draws all eight crop marks.
cm_width	Width of crop mark.
cm_length	Length of crop mark.
draw	A logical value indicating whether graphics output should be produced.

Value

A grid grob.

Examples

```
if (requireNamespace("grid", quietly = TRUE) &&
    piecepackr:::device_supports_unicode()) {
  cfg <- pp_cfg(list(mat_color = "pink", mat_width=0.05, border_color=NA))
  grid::grid.newpage()
  df <- data.frame(piece_side = "tile_face", suit = 2, rank = 2,
                  x = 2, y = 2, angle = 0,
                  stringsAsFactors = FALSE)
  pmap_piece(df, grid.cropmark, cfg = cfg, default.units = "in")
  pmap_piece(df, grid.piece, cfg = cfg, default.units = "in", bleed=TRUE)
}
if (requireNamespace("grid", quietly = TRUE) &&
    piecepackr:::device_supports_unicode()) {
  grid::grid.newpage()
  df <- data.frame(piece_side = "coin_back", suit = 2, rank = 2,
                  x = 2, y = 2, angle = 0,
                  stringsAsFactors = FALSE)
  pmap_piece(df, grid.cropmark, cfg = cfg, default.units = "in", bleed=TRUE)
  pmap_piece(df, grid.piece, cfg = cfg, default.units = "in", bleed=TRUE)
}
```

grid.crosshair	<i>Draw crosshairs with grid</i>
----------------	----------------------------------

Description

grid.crosshair() draws crosshairs at the corners of a rectangular area. crosshairGrob() is its grid grob counterpart. They are intended for use in adding crosshairs at the corners of game pieces in print-and-play layouts.

Usage

```
crosshairGrob(  
  ...,  
  piece_side = "tile_back",  
  suit = NA,  
  rank = NA,  
  cfg = getOption("piecepackr.cfg", pp_cfg()),  
  x = unit(0.5, "npc"),  
  y = unit(0.5, "npc"),  
  angle = 0,  
  width = NA,  
  height = NA,  
  scale = 1,  
  default.units = "npc",  
  envir = getOption("piecepackr.envir"),  
  name = NULL,  
  gp = gpar(),  
  vp = NULL,  
  ch_width = unit(1/6, "in"),  
  ch_grob = squaresCrosshairGrob()  
)
```

```
grid.crosshair(..., draw = TRUE)
```

```
segmentsCrosshairGrob(  
  ...,  
  x = unit(0.5, "npc"),  
  y = unit(0.5, "npc"),  
  width = unit(1, "snpc"),  
  height = unit(1, "snpc"),  
  default.units = "npc",  
  name = NULL,  
  gp = gpar(),  
  vp = NULL  
)
```

```
squaresCrosshairGrob(  
  ...,  
  x = unit(0.5, "npc"),  
  y = unit(0.5, "npc"),  
  width = unit(1, "snpc"),  
  height = unit(1, "snpc"),  
  default.units = "npc",  
  name = NULL,  
  gp = gpar(),  
  vp = NULL  
)
```

```

... ,
x = unit(0.5, "npc"),
y = unit(0.5, "npc"),
width = unit(1, "snpc"),
height = unit(1, "snpc"),
default.units = "npc",
name = NULL,
gp = gpar(),
vp = NULL
)

```

Arguments

...	crosshairGrob() ignores; grid.crosshair() passes to crosshairGrob().
piece_side	A string with piece and side separated by a underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
x	Where to place piece on x axis of viewport
y	Where to place piece on y axis of viewport
angle	Angle (on xy plane) to draw piece at
width	Width of piece
height	Height of piece
scale	Multiplicative scaling factor to apply to width, height, and depth.
default.units	A string indicating the default units to use if 'x', 'y', 'width', and/or 'height' are only given as numeric vectors.
envir	Environment (or named list) containing configuration list(s).
name	A character identifier (for grid)
gp	An object of class "gpar".
vp	A grid viewport object (or NULL).
ch_width	Width/height of ch_grob's viewport.
ch_grob	Crosshair grob. Will be drawn in each corner of the piece in a viewport with ch_width width and ch_width height. segmentsCrosshairGrob() simply wraps grid::segmentsGrob() while squaresCrosshairGrob() wraps grid::rectGrob() and alternates black/white squares for visibility on both light and dark backgrounds.
draw	A logical value indicating whether graphics output should be produced.

Details

One can use the lower level segmentsCrosshairGrob() and squaresCrosshairGrob() (which can be drawn with [grid::grid.draw\(\)](#)) to add individual crosshairs to specified (x,y) locations.

Value

A grid grob.

Examples

```
if (requireNamespace("grid", quietly = TRUE) &&
    piecepackr:::device_supports_unicode()) {
  cfg <- pp_cfg(list(border_color = NA))
  grid::grid.newpage()
  df <- data.frame(piece_side = "tile_face", suit = 2, rank = 2,
                  x = 2, y = 2, angle = 0,
                  stringsAsFactors = FALSE)
  pmap_piece(df, grid.piece, cfg = cfg, default.units = "in")
  pmap_piece(df, grid.crosshair, cfg = cfg, default.units = "in")
}
if (requireNamespace("grid", quietly = TRUE) &&
    piecepackr:::device_supports_unicode()) {
  grid::grid.newpage()
  pmap_piece(df, grid.piece, cfg = cfg, default.units = "in")
  pmap_piece(df, grid.crosshair, cfg = cfg, default.units = "in",
             ch_grob = segmentsCrosshairGrob())
}
```

grid.piece

Draw board game pieces with grid

Description

grid.piece() draws board game pieces onto the graphics device. pieceGrob() is its grid “grob” counterpart.

Usage

```
pieceGrob(
  piece_side = "tile_back",
  suit = NA,
  rank = NA,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  x = unit(0.5, "npc"),
  y = unit(0.5, "npc"),
  z = NA,
  angle = 0,
  ...,
  width = NA,
  height = NA,
  depth = NA,
  op_scale = getOption("piecepackr.op_scale", 0),
  op_angle = getOption("piecepackr.op_angle", 45),
```

```

default.units = getOption("piecepackr.default.units", "npc"),
envir = getOption("piecepackr.envir"),
name = NULL,
gp = NULL,
vp = NULL,
scale = 1,
alpha = 1,
type = "normal",
bleed = FALSE
)

grid.piece(
  piece_side = "tile_back",
  suit = NA,
  rank = NA,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  x = unit(0.5, "npc"),
  y = unit(0.5, "npc"),
  z = NA,
  angle = 0,
  ...,
  width = NA,
  height = NA,
  depth = NA,
  op_scale = getOption("piecepackr.op_scale", 0),
  op_angle = getOption("piecepackr.op_angle", 45),
  default.units = getOption("piecepackr.default.units", "npc"),
  envir = getOption("piecepackr.envir"),
  name = NULL,
  gp = NULL,
  draw = TRUE,
  vp = NULL,
  scale = 1,
  alpha = 1,
  type = "normal",
  bleed = FALSE
)

```

Arguments

piece_side	A string with piece and side separated by a underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
x	Where to place piece on x axis of viewport

y	Where to place piece on y axis of viewport
z	z-coordinate of the piece. Has no effect if op_scale is 0.
angle	Angle (on xy plane) to draw piece at
...	Ignored.
width	Width of piece
height	Height of piece
depth	Depth (thickness) of piece. Has no effect if op_scale is 0.
op_scale	How much to scale the depth of the piece in the oblique projection (viewed from the top of the board). 0 (the default) leads to an “orthographic” projection, 0.5 is the most common scale used in the “cabinet” projection, and 1.0 is the scale used in the “cavalier” projection.
op_angle	What is the angle of the oblique projection? Has no effect if op_scale is 0.
default.units	A string indicating the default units to use if 'x', 'y', 'width', and/or 'height' are only given as numeric vectors.
envir	Environment (or named list) containing configuration list(s).
name	A character identifier (for grid)
gp	An object of class “gpar”.
vp	A grid viewport object (or NULL).
scale	Multiplicative scaling factor to apply to width, height, and depth.
alpha	Alpha channel for transparency.
type	Type of grid grob to use. Either “normal” (default), “picture”, “raster”, or “transformation”. “picture” exports to (temporary) svg and re-exports as a <code>grImport2::pictureGrob()</code> . “raster” exports to (temporary) png and re-exports as a <code>grid::rasterGrob()</code> . “transformation” uses the affine transformation feature only supported in R 4.2+ within select graphic devices. The latter three can be useful if drawing pieces really big or small and don't want to mess with re-configuring font sizes and linewidths.
bleed	If FALSE do not add a “bleed” zone around the piece, otherwise add a “bleed” zone around the piece: <ul style="list-style-type: none"> • If bleed is TRUE we will add 1/8 inch bleeds • If bleed is a <code>grid::unit()</code> we will use it as bleed size • If bleed is numeric we will convert to <code>grid::unit()</code> via <code>grid::unit(bleed, default.units)</code> <p>A non-FALSE bleed is incompatible with <code>op_scale > 0</code> (drawing in an “oblique projection”).</p>
draw	A logical value indicating whether graphics output should be produced.

Value

A grid grob object. If draw is TRUE then as a side effect `grid.piece()` will also draw it to the graphics device.

See Also

`pmap_piece()` which applies `pieceGrob()` over rows of a data frame.

Examples

```

if (requireNamespace("grid", quietly = TRUE) && piecepackr:::device_supports_unicode()) {
  opt <- options(piecepackr.at.inform = FALSE)

  draw_pp_diagram <- function(cfg=pp_cfg(), op_scale=0) {
    g.p <- function(...) {
      grid.piece(..., op_scale=op_scale, cfg=cfg, default.units="in")
    }
    g.p("tile_back", x=0.5+c(3,1,3,1), y=0.5+c(3,3,1,1))
    g.p("tile_back", x=0.5+3, y=0.5+1, z=1/4+1/8)
    g.p("tile_back", x=0.5+3, y=0.5+1, z=2/4+1/8)
    g.p("die_face", suit=3, rank=5, x=1, y=1, z=1/4+1/4)
    g.p("pawn_face", x=1, y=4, z=1/4+1/2, angle=90)
    g.p("coin_back", x=3, y=4, z=1/4+1/16, angle=180)
    g.p("coin_back", suit=4, x=3, y=4, z=1/4+1/8+1/16, angle=180)
    g.p("coin_back", suit=2, x=3, y=1, z=3/4+1/8, angle=90)
  }

  # default piecepack, orthogonal projection
  draw_pp_diagram(cfg=pp_cfg())

  options(opt) # Reset options
}
if (requireNamespace("grid", quietly = TRUE) && piecepackr:::device_supports_unicode()) {
  # custom configuration, orthogonal projection
  grid::grid.newpage()
  dark_colorscheme <- list(suit_color="darkred,black,darkgreen,darkblue,black",
                          invert_colors.suited=TRUE, border_color="black", border_lex=2)
  traditional_ranks <- list(use_suit_as_ace=TRUE, rank_text="a,2,3,4,5")
  cfg <- c(dark_colorscheme, traditional_ranks)
  draw_pp_diagram(cfg=pp_cfg(cfg))
}
if (requireNamespace("grid", quietly = TRUE) && piecepackr:::device_supports_unicode()) {
  # custom configuration, oblique projection
  grid::grid.newpage()
  cfg3d <- list(width.pawn=0.75, height.pawn=0.75, depth.pawn=1,
               dm_text.pawn="", shape.pawn="convex6", invert_colors.pawn=TRUE,
               edge_color.coin="tan", edge_color.tile="tan")
  cfg <- pp_cfg(c(cfg, cfg3d))
  draw_pp_diagram(cfg=pp_cfg(cfg), op_scale=0.5)
}

```

Description

Uses `utils::install.packages()` to install additional R packages from the piecepackr universe <https://piecepackr.r-universe.dev/builds>. `pkgs_ppverse()` returns a character vector of R packages in the piecepackr universe.

Usage

```
install_ppverse(
  pkgs = pkgs_ppverse(free_libre_only),
  ...,
  dependencies = TRUE,
  free_libre_only = TRUE
)

pkgs_ppverse(free_libre_only = TRUE)
```

Arguments

<code>pkgs</code>	Packages to install. Passed to <code>utils::install.packages()</code> .
<code>...</code>	Passed to <code>utils::install.packages()</code> .
<code>dependencies</code>	Logical indicating whether to install dependencies of <code>pkgs</code> . Passed to <code>utils::install.packages()</code> .
<code>free_libre_only</code>	Flag to only include packages that are Free/Libre Open Source.

Examples

```
pkgs_ppverse()
## Not run: # Installs non-CRAN packages from the piecepackr universe
  install_ppverse()

## End(Not run)
```

op_transform

Oblique projection helper function

Description

`op_transform()` guesses z coordinates and sorting order to more easily make 3D graphics with `pmap_piece()`. `marbles_transform()` is a wrapper around `op_transform()` that handles the special case of stacking 1" marbles in a pyramid with a square base on a holed board.

Usage

```
op_transform(
  df,
  ...,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  envir = getOption("piecepackr.envir"),
  op_angle = getOption("piecepackr.op_angle", 45),
  pt_thickness = 0.01,
  as_top = character(0),
  cfg_class = "list"
)

marbles_transform(df, ...)
```

Arguments

df	A data frame with coordinates and dimensions in inches
...	Ignored by op_transform(). marbles_transform() passes to op_transform().
cfg	Piecepack configuration list or pp_cfg() object, a list of pp_cfg() objects, or a character vector of the names of pp_cfg() objects contained in envir.
envir	Environment (or named list) containing configuration list(s).
op_angle	Intended oblique projection angle (used for re-sorting)
pt_thickness	Thickness of pyramid tip i.e. value to add to the z-value of a pyramid top if it is a (weakly) smaller ranked pyramid (top) placed on top of a larger ranked pyramid (top).
as_top	Character vector of components whose "side" should be converted to "top" e.g. "pawn_face".
cfg_class	Either "list" (default) or "character". Desired class of the cfg column in the returned tibble. "list" is more efficient for use with pmap_piece() but geom_piece() needs "character".

Details

The heuristics used to generate guesses for z coordinates and sorting order aren't guaranteed to work in every case. In some cases you may get better sorting results by changing the op_angle or the dimensions of pieces.

Value

A tibble with extra columns added and re-sorted rows

See Also

<https://trevorldavis.com/piecepackr/3d-projections.html> for more details and examples of oblique projections in piecepackr.

Examples

```
df <- tibble::tibble(piece_side="tile_back",
                     x=c(2,2,2,4,6,6,4,2,5),
                     y=c(4,4,4,4,4,2,2,2,3))
cfg <- game_systems()$piecepack
pmap_piece(df, op_angle=135, trans=op_transform,
           op_scale=0.5, default.units="in", cfg=cfg)
```

 piece

Create rayrender board game piece objects

Description

piece() creates 3d board game piece objects for use with the rayrender package.

Usage

```
piece(
  piece_side = "tile_back",
  suit = NA,
  rank = NA,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  x = 0,
  y = 0,
  z = NA,
  angle = 0,
  axis_x = 0,
  axis_y = 0,
  width = NA,
  height = NA,
  depth = NA,
  envir = getOption("piecepackr.envir"),
  ...,
  scale = 1,
  res = 72
)
```

Arguments

piece_side	A string with piece and side separated by a underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
x	Where to place piece on x axis of viewport

<code>y</code>	Where to place piece on y axis of viewport
<code>z</code>	z-coordinate of the piece. Has no effect if <code>op_scale</code> is 0.
<code>angle</code>	Angle (on xy plane) to draw piece at
<code>axis_x</code>	First coordinate of the axis unit vector.
<code>axis_y</code>	Second coordinate of the axis unit vector.
<code>width</code>	Width of piece
<code>height</code>	Height of piece
<code>depth</code>	Depth (thickness) of piece. Has no effect if <code>op_scale</code> is 0.
<code>envir</code>	Environment (or named list) containing configuration list(s).
<code>...</code>	Ignored.
<code>scale</code>	Multiplicative scaling factor to apply to width, height, and depth.
<code>res</code>	Resolution of the faces.

Value

A rayrender object.

See Also

See <https://www.rayrender.net> for more information about the rayrender package. See [geometry_utils](#) for a discussion of the 3D rotation parameterization.

Examples

```
# May take more than 5 seconds on CRAN servers
opt <- options(cores = getOption("Ncpus"))
cfg <- game_systems("sans3d")$piecepack
if (requireNamespace("rayrender", quietly = TRUE) && all(capabilities(c("cairo", "png")))) {
  rayrender::render_scene(piece("tile_face", suit = 3, rank = 3, cfg = cfg))
}
if (requireNamespace("rayrender", quietly = TRUE) && all(capabilities(c("cairo", "png")))) {
  rayrender::render_scene(piece("coin_back", suit = 4, rank = 2, cfg = cfg))
}
if (requireNamespace("rayrender", quietly = TRUE) && all(capabilities(c("cairo", "png")))) {
  rayrender::render_scene(piece("pawn_face", suit = 2, cfg = cfg))
}
options(opt)
```

piece3d *Render board game pieces with rgl*

Description

piece3d() draws board games pieces using the rgl package.

Usage

```
piece3d(
  piece_side = "tile_back",
  suit = NA,
  rank = NA,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  x = 0,
  y = 0,
  z = NA,
  angle = 0,
  axis_x = 0,
  axis_y = 0,
  width = NA,
  height = NA,
  depth = NA,
  envir = getOption("piecepackr.envir"),
  ...,
  scale = 1,
  res = 72,
  alpha = 1,
  lit = FALSE,
  shininess = 50,
  textype = NA
)
```

Arguments

piece_side	A string with piece and side separated by a underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
x	Where to place piece on x axis of viewport
y	Where to place piece on y axis of viewport
z	z-coordinate of the piece. Has no effect if op_scale is 0.
angle	Angle (on xy plane) to draw piece at

axis_x	First coordinate of the axis unit vector.
axis_y	Second coordinate of the axis unit vector.
width	Width of piece
height	Height of piece
depth	Depth (thickness) of piece. Has no effect if op_scale is 0.
envir	Environment (or named list) containing configuration list(s).
...	Ignored.
scale	Multiplicative scaling factor to apply to width, height, and depth.
res	Resolution of the faces.
alpha	Alpha channel for transparency.
lit	logical, specifying if rgl lighting calculation should take place.
shininess	Properties for rgl lighting calculation.
textype	Use "rgba" when sure texture will have alpha transparency. Use "rgb" when sure texture will not have alpha transparency (in particular rgl's WebGL export will likely work better). If NA we will read the texture and figure out a reasonable value.

Value

A numeric vector of rgl object IDs.

See Also

See [rgl-package](#) for more information about the rgl package. See `rgl::material3d()` for more info about setting rgl material properties. See [geometry_utils](#) for a discussion of the 3D rotation parameterization.

Examples

```
if (requireNamespace("rgl", quietly = TRUE) && all(capabilities(c("cairo", "png")))) {
  rgl::open3d()
  cfg <- game_systems("sans3d")$piecepack
  piece3d("tile_back", suit = 3, rank = 3, cfg = cfg, x = 0, y = 0, z = 0)
  piece3d("coin_back", suit = 4, rank = 2, cfg = cfg, x = 0.5, y = 0.5, z = 0.25)
  piece3d("pawn_top", suit = 1, cfg = cfg, x = -0.5, y = 0.5, z = 0.6)
  piece3d("die_face", suit = 3, cfg = cfg, x = -0.5, y = -0.5, z = 0.375)
  piece3d("pyramid_top", suit = 2, rank = 3, cfg = cfg, x = 1.5, y = 0.0, z = 0.31875)
  invisible(NULL)
}
```

piecepackr-defunct *Defunct functions*

Description

These functions are Defunct and have been removed from piecepackr.

Usage

halmaGrob(...)

kiteGrob(...)

pyramidGrob(...)

convexGrobFn(...)

concaveGrobFn(...)

gridlinesGrob(...)

matGrob(...)

checkersGrob(...)

hexlinesGrob(...)

get_shape_grob_fn(...)

Arguments

... Ignored

Details

1. For `get_shape_grob_fn` use `pp_shape()$shape` instead.
2. For `gridlinesGrob()` use `pp_shape()$gridlines()` instead.
3. For `matGrob()` use `pp_shape()$mat()` instead.
4. For `checkersGrob()` use `pp_shape()$checkers()` instead.
5. For `hexlinesGrob()` use `pp_shape()$hexlines()` instead.
6. For `halmaGrob()` use `pp_shape("halma")$shape()` instead.
7. For `kiteGrob()` use `pp_shape("kite")$shape()` instead.
8. For `pyramidGrob()` use `pp_shape("pyramid")$shape()` instead.
9. For `convexGrobFn(n, t)` use `pp_shape(paste0("convex", n), t)$shape` instead.
10. For `concaveGrobFn(n, t, r)` use `pp_shape(paste0("concave", n), t, r)$shape` instead.

 piece_mesh

 Create rayvertex board game piece objects

Description

piece_mesh() creates 3d board game piece objects for use with the rayvertex package.

Usage

```
piece_mesh(
  piece_side = "tile_back",
  suit = NA,
  rank = NA,
  cfg = pp_cfg(),
  x = 0,
  y = 0,
  z = NA,
  angle = 0,
  axis_x = 0,
  axis_y = 0,
  width = NA,
  height = NA,
  depth = NA,
  envir = NULL,
  ...,
  scale = 1,
  res = 72
)
```

Arguments

piece_side	A string with piece and side separated by an underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
x	Where to place piece on x axis of viewport
y	Where to place piece on y axis of viewport
z	z-coordinate of the piece. Has no effect if op_scale is 0.
angle	Angle (on xy plane) to draw piece at
axis_x	First coordinate of the axis unit vector.
axis_y	Second coordinate of the axis unit vector.
width	Width of piece

height	Height of piece
depth	Depth (thickness) of piece. Has no effect if op_scale is 0.
envir	Environment (or named list) containing configuration list(s).
...	Ignored.
scale	Multiplicative scaling factor to apply to width, height, and depth.
res	Resolution of the faces.

Value

A rayvertex object.

See Also

See <https://www.rayvertex.com> for more information about the rayvertex package. See [geometry_utils](#) for a discussion of the 3D rotation parameterization.

Examples

```
# May take more than 5 seconds on CRAN servers
if (requireNamespace("rayvertex", quietly = TRUE) && all(capabilities(c("cairo", "png")))) {
  cfg <- game_systems("sans3d")$piecepack
  rs <- function(shape) {
    opt <- options(cores = getOption("Ncpus"))
    light <- rayvertex::directional_light(c(0, 0, 1))
    rayvertex::rasterize_scene(shape, light_info = light)
    options(opt)
  }
  rs(piece_mesh("tile_face", suit = 3, rank = 3, cfg = cfg))
}
if (requireNamespace("rayvertex", quietly = TRUE) && all(capabilities(c("cairo", "png")))) {
  rs(piece_mesh("coin_back", suit = 4, rank = 2, cfg = cfg))
}
if (requireNamespace("rayvertex", quietly = TRUE) && all(capabilities(c("cairo", "png")))) {
  rs(piece_mesh("pawn_face", suit = 1, cfg = cfg))
}
```

pmap_piece

Create graphics using data frame input

Description

pmap_piece() operates on the rows of a data frame applying .f to each row (usually grid.piece).

Usage

```
pmap_piece(
  .l,
  .f = pieceGrob,
  ...,
  cfg = getOption("piecepackr.cfg"),
  envir = getOption("piecepackr.envir"),
  trans = getOption("piecepackr.trans"),
  draw = TRUE,
  name = NULL,
  gp = NULL,
  vp = NULL
)
```

Arguments

<code>.l</code>	A list of vectors, such as a data frame. The length of <code>.l</code> determines the number of arguments that <code>.f</code> will be called with. List names will be used if present.
<code>.f</code>	Function to be applied to <code>.l</code> after adjustments to <code>cfg</code> and <code>envir</code> and the application of <code>trans</code> . Usually <code>grid.piece()</code> , <code>pieceGrob()</code> , <code>piece3d()</code> , or <code>piece()</code> .
<code>...</code>	Extra arguments to pass to <code>.f</code> .
<code>cfg</code>	Piecepack configuration list or <code>pp_cfg</code> object, a list of <code>pp_cfg</code> objects, or a character vector referring to names in <code>envir</code> or a character vector referring to object names that can be retrieved by <code>base::dynGet()</code> .
<code>envir</code>	Environment (or named list) containing configuration list(s).
<code>trans</code>	Function to modify <code>.l</code> before drawing. Default (NULL) is to not modify <code>.l</code> . <code>op_transform</code> can help with using an oblique projection (i.e. <code>op_scale</code> over 0).
<code>draw</code>	A logical value indicating whether graphics output should be produced.
<code>name</code>	A character identifier (for grid)
<code>gp</code>	An object of class "gpar".
<code>vp</code>	A grid viewport object (or NULL).

Details

`pmap_piece()` differs from `purrr::pmap()` in a few ways:

1. If `cfg` and/or `envir` are missing attempts to set reasonable defaults.
2. If not NULL will first apply function `trans` to `.l`.
3. If the output of `.f` is a grid grob object then `pmap_piece` will return a `gTree` object with specified `name`, `gp`, and `vp` values and if `draw` is true draw it.
4. If `.l` lacks a name column or if name column is non-unique attempts to generate a reasonable new default name column and use that to name the return `gTree` children or `list` values.

See Also

[render_piece\(\)](#) is a higher-level function that wraps this function.

Examples

```
if (requireNamespace("grid", quietly = TRUE) && piecepackr:::device_supports_unicode()) {
  dark_colorscheme <- list(suit_color="darkred,black,darkgreen,darkblue,black",
    invert_colors.suited=TRUE, border_color="black", border_lex=2)
  traditional_ranks <- list(use_suit_as_ace=TRUE, rank_text=",a,2,3,4,5")
  cfg3d <- list(width.pawn=0.75, height.pawn=0.75, depth.pawn=1,
    dm_text.pawn="", shape.pawn="convex6", invert_colors.pawn=TRUE,
    edge_color.coin="tan", edge_color.tile="tan")
  cfg <- pp_cfg(c(dark_colorscheme, traditional_ranks, cfg3d))
  grid::grid.newpage()
  df_tiles <- data.frame(piece_side="tile_back", x=0.5+c(3,1,3,1), y=0.5+c(3,3,1,1),
    suit=NA, angle=NA, z=NA, stringsAsFactors=FALSE)
  df_coins <- data.frame(piece_side="coin_back", x=rep(4:1, 4), y=rep(4:1, each=4),
    suit=1:16%2+rep(c(1,3), each=8),
    angle=rep(c(180,0), each=8), z=1/4+1/16, stringsAsFactors=FALSE)
  df <- rbind(df_tiles, df_coins)
  pmap_piece(df, cfg=cfg, op_scale=0.5, default.units="in")
}
```

 pp_cfg

Configuration list R6 object

Description

`pp_cfg()` and `as_pp_cfg()` create piecepack configuration list R6 objects. `is_pp_cfg()` returns TRUE if object is a piecepack configuration list R6 object. `as.list()` will convert it into a list.

Usage

```
pp_cfg(cfg = list())
```

```
is_pp_cfg(cfg)
```

```
as_pp_cfg(cfg = list())
```

Arguments

`cfg` List of configuration options

Details

`pp_cfg` R6 class objects serve the following purposes:

- Customize the appearance of pieces drawn by `grid.piece()`.
- Speed up the drawing of graphics through use of caching.

- Allow the setting and querying of information about the board game components that maybe of use to developers:
 - Number of suits
 - Number of ranks
 - Suit colors
 - Which types of components are included and/or properly supported
 - What would be a good color to use when adding annotations on top of these components.
 - Title, Description, Copyright, License, and Credit metadata

pp_cfg **R6 Class Method Arguments**

piece_side A string with piece and side separated by a underscore e.g. "coin_face".
 suit Number of suit (starting from 1).
 rank Number of rank (starting from 1).
 type Which type of grob to return, either "normal", "picture", "raster", or "transformation".
 scale "scale" factor
 alpha "alpha" value

pp_cfg **R6 Class Methods**

get_grob() Returns a grid “grob” for drawing the piece.
 get_piece_opt() Returns a list with info useful for drawing the piece.
 get_suit_color() Returns the suit colors.
 get_width(), get_height(), get_depth() Dimensions (of the bounding cube) of the piece in inches

pp_cfg **R6 Class Fields and Active Bindings**

annotation_color Suggestion of a good color to annotate with
 cache Cache object which stores intermediate graphical calculations. Default is a memory-cache that does not prune. This can be replaced by another cache that implements the cache API used by the cachem package
 cache_grob Whether we should cache (2D) grobs
 cache_grob_with_bleed_fn Whether we should cache the grob with bleed functions
 cache_piece_opt Whether we should cache piece opt information
 cache_op_fn Whether we should cache the oblique projection functions
 cache_obj_fn Whether we should cache any 3D rendering functions
 copyright Design copyright information
 credit Design credits
 description Design description
 fontfamily Main font family
 has_bits Whether we should assume this supports "bit" pieces

has_boards Whether we should assume this supports "board" pieces
 has_cards Whether we should assume this supports "card" pieces
 has_coins Whether we should assume this supports "coin" pieces
 has_dice Whether we should assume this supports "die" pieces
 has_matchsticks Whether we should assume this supports "matchstick" pieces
 has_pawns Whether we should assume this supports "pawn" pieces
 has_piecepack Binding which simultaneously checks/sets has_coins, has_tiles, has_pawns, has_dice
 has_pyramids Whether we should assume this supports "pyramid" pieces
 has_saucers Whether we should assume this supports "saucer" pieces
 has_tiles Whether we should assume this supports "tile" pieces
 spdx_id SPDX Identifier for graphical design license. See <https://spdx.org/licenses/> for full list.
 title Design title

Defunct pp_cfg R6 Class attributes which have been removed

cache_shadow Use cache_op_fn instead
 i_unsuit Instead add 1L to n_suits
 get_pictureGrob() Use get_grob(..., type = "picture") instead
 get_shadow_fn get_op_grob() returns complete oblique projection grob

See Also

[game_systems\(\)](#) for functions that return configuration list objects for several game systems.
<https://trevorldavis.com/piecepackr/configuration-lists.html> for more details about piecepackr configuration lists.

Examples

```

cfg <- pp_cfg(list(invert_colors=TRUE))
as.list(cfg)
is_pp_cfg(cfg)
as_pp_cfg(list(suit_color="darkred,black,darkgreen,darkblue,gre"))
cfg$get_suit_color(suit=3)
cfg$annotation_color
cfg$has_matchsticks
cfg$has_matchsticks <- TRUE
cfg$has_matchsticks
cfg$get_width("tile_back")
cfg$get_height("die_face")
cfg$get_depth("coin_face")
# May take more than 5 seconds on CRAN servers
# `pp_cfg()` objects use a cache to speed up repeated drawing
pdf(tempfile(fileext = ".pdf"))
cfg <- list()

```

```

system.time(replicate(100, grid.piece("tile_back", 4, 4, cfg)))
cfg <- pp_cfg(list())
system.time(replicate(100, grid.piece("tile_back", 4, 4, cfg)))
invisible(dev.off())

```

pp_shape

*Shape object for generating various grobs***Description**

pp_shape() creates an R6 object with methods for creating various shape based grobs.

Usage

```

pp_shape(
  label = "rect",
  theta = 90,
  radius = 0.2,
  back = FALSE,
  ...,
  width = 1,
  height = 1
)

```

Arguments

label	<p>Label of the shape. One of</p> <ul style="list-style-type: none"> “circle” Circle. “convexN” An N-sided convex polygon. theta controls which direction the first vertex is drawn. “concaveN” A “star” (concave) polygon with N “points”. theta controls which direction the first point is drawn. radius controls the distance of the “inner” vertices from the center. “halma” A 2D outline of a “Halma pawn”. “kite” “Kite” quadrilateral shape. “meeple” A 2D outline of a “meeple”. “oval” Oval. “pyramid” An “Isosceles” triangle whose base is the bottom of the viewport. Typically used to help draw the face of the “pyramid” piece. “rect” Rectangle. “roundrect” “Rounded” rectangle. radius controls curvature of corners.
theta	convex and concave polygon shapes use this to determine where the first point is drawn.

radius	concave polygon and roundrect use this to control appearance of the shape.
back	Whether the shape should be reflected across a vertical line in the middle of the viewport.
...	Should be empty
width, height	Width and height of the piece.

Details

pp_shape objects serve the following purposes:

1. Make it easier for developers to customize game piece appearances either through a "grob_fn" or "op_grob_fn" styles in pp_cfg() or manipulate a piece post drawing via functions like grid::grid.edit().
2. Used internally to generate piecepackr's built-in game piece grobs.

pp_shape R6 Class Method Arguments

mat_width Numeric vector of mat widths.

clip "clip grob" to perform polyclip operation with. See [gridGeometry::grid.polyclip\(\)](#) for more info.

op Polyclip operation to perform. See [gridGeometry::grid.polyclip\(\)](#) for more info.

pattern Pattern to fill in shape with. See [gridpattern::patternGrob\(\)](#) for more info.

... Passed to [gridpattern::patternGrob\(\)](#).

name Grid grob name value.

gp Grid gpar list. See [grid::gpar\(\)](#) for more info.

vp Grid viewport or NULL.

pp_shape R6 Class Methods

checkers(name = NULL, gp = gpar(), vp = NULL) Returns a grob of checkers for that shape.

gridlines(name = NULL, gp = gpar(), vp = NULL) Returns a grob of gridlines for that shape.

hexlines(name = NULL, gp = gpar(), vp = NULL) Returns a grob of hexlines for that shape.

mat(mat_width = 0, name = NULL, gp = gpar(), vp = NULL) Returns a grob for a matting "mat" for that shape.

pattern(pattern = "stripe", ..., name = NULL, gp = gpar(), vp = NULL) Fills in the shape's npc_coords with a pattern. See [gridpattern::patternGrob\(\)](#) for more information.

polyclip(clip, op = "intersection", name = NULL, gp = gpar(), vp = NULL) Returns a grob that is an "intersection", "minus", "union", or "xor" of another grob. Note unlike [gridGeometry::polyclipGrob](#) it can directly work with a pieceGrob "clip grob" argument.

shape(name = NULL, gp = gpar(), vp = NULL) Returns a grob of the shape.

pp_shape R6 Class Active Bindings

label The shape's label.

theta The shape's theta.

radius The shape's radius.

back A boolean of whether this is the shape's "back" side.

npc_coords A named list of "npc" coordinates along the perimeter of the shape.

Examples

```

if (require("grid", quietly = TRUE)) {
  gp <- gpar(col="black", fill="yellow")
  rect <- pp_shape(label="rect")
  convex6 <- pp_shape(label="convex6")
  circle <- pp_shape(label="circle")

  pushViewport(viewport(x=0.25, y=0.75, width=1/2, height=1/2))
  grid.draw(rect$shape(gp=gp))
  grid.draw(rect$gridlines(gp=gpar(col="blue", lex=4)))
  grid.draw(rect$hexlines(gp=gpar(col="green")))
  popViewport()

  pushViewport(viewport(x=0.75, y=0.75, width=1/2, height=1/2))
  grid.draw(convex6$shape(gp=gp))
  grid.draw(convex6$checkers(gp=gpar(fill="blue")))
  popViewport()

  pushViewport(viewport(x=0.25, y=0.25, width=1/2, height=1/2))
  grid.draw(circle$shape(gp=gp))
  grid.draw(circle$mat(mat_width=0.2, gp=gpar(fill="blue")))
  popViewport()

  pushViewport(viewport(x=0.75, y=0.25, width=1/2, height=1/2))
  grid.draw(rect$shape(gp=gp))
  grid.draw(rect$mat(mat_width=c(0.2, 0.1, 0.3, 0.4), gp=gpar(fill="blue")))
  popViewport()
}
if (require("grid", quietly = TRUE)) {
  grid.newpage()
  gp <- gpar(col="black", fill="yellow")

  vp <- viewport(x=1/4, y=1/4, width=1/2, height=1/2)
  grid.draw(pp_shape("halma")$shape(gp=gp, vp=vp))
  vp <- viewport(x=3/4, y=1/4, width=1/2, height=1/2)
  grid.draw(pp_shape("pyramid")$shape(gp=gp, vp=vp))
  vp <- viewport(x=3/4, y=3/4, width=1/2, height=1/2)
  grid.draw(pp_shape("kite")$shape(gp=gp, vp=vp))
  vp <- viewport(x=1/4, y=3/4, width=1/2, height=1/2)
  grid.draw(pp_shape("meeple")$shape(gp=gp, vp=vp))
}
if (require("grid", quietly = TRUE)) {

```

```

grid.newpage()
vp <- viewport(x=1/4, y=1/4, width=1/2, height=1/2)
grid.draw(pp_shape("convex3", 0)$shape(gp=gp, vp=vp))
vp <- viewport(x=3/4, y=1/4, width=1/2, height=1/2)
grid.draw(pp_shape("convex4", 90)$shape(gp=gp, vp=vp))
vp <- viewport(x=3/4, y=3/4, width=1/2, height=1/2)
grid.draw(pp_shape("convex5", 180)$shape(gp=gp, vp=vp))
vp <- viewport(x=1/4, y=3/4, width=1/2, height=1/2)
grid.draw(pp_shape("convex6", 270)$shape(gp=gp, vp=vp))
}
if (require("grid", quietly = TRUE)) {
  grid.newpage()
  vp <- viewport(x=1/4, y=1/4, width=1/2, height=1/2)
  grid.draw(pp_shape("concave3", 0, 0.1)$shape(gp=gp, vp=vp))
  vp <- viewport(x=3/4, y=1/4, width=1/2, height=1/2)
  grid.draw(pp_shape("concave4", 90, 0.2)$shape(gp=gp, vp=vp))
  vp <- viewport(x=3/4, y=3/4, width=1/2, height=1/2)
  grid.draw(pp_shape("concave5", 180, 0.3)$shape(gp=gp, vp=vp))
  vp <- viewport(x=1/4, y=3/4, width=1/2, height=1/2)
  grid.draw(pp_shape("concave6", 270)$shape(gp=gp, vp=vp))
}
if (require("grid", quietly = TRUE) &&
    requireNamespace("gridpattern", quietly = TRUE)) {
  grid.newpage()
  hex <- pp_shape("convex6")
  gp <- gpar(fill = c("blue", "yellow", "red"), col = "black")
  grid.draw(hex$pattern("polygon_tiling", gp = gp, spacing = 0.1,
                       type = "truncated_trihexagonal"))
  gp <- gpar(fill = "black", col = NA)
  grid.draw(hex$mat(mat_width = 0.025, gp = gp))
}

```

pp_utils

Miscellaneous piecepackr utility functions

Description

`cleave()` converts a delimiter separated string into a vector. `inch(x)` is equivalent to `grid::unit(x, "in")`. `is_color_invisible()` tells whether the color is transparent (and hence need not be drawn).

Usage

```
is_color_invisible(col)
```

```
inch(inches)
```

```
cleave(s, sep = ",", float = FALSE, color = FALSE)
```

```
file2grob(file, distort = TRUE)
```

Arguments

col	Color
inches	Number representing number of inches
s	String to convert
sep	Delimiter (defaults to ",")
float	If TRUE cast to numeric
color	if TRUE convert empty strings to "transparent"
file	Filename of image
distort	Logical value of whether one should preserve the aspect ratio or distort to fit the area it is drawn in

Examples

```

cleave("0.5,0.2,0.4,0.5", float=TRUE)
cleave("black,darkred,#050EAA,,", color=TRUE)

is_color_invisible("transparent")
is_color_invisible(NA)
is_color_invisible("blue")
is_color_invisible("#05AE9C")

if (requireNamespace("grid", quietly = TRUE)) {
  identical(inch(1), grid::unit(1, "inch"))
}

```

render_piece

Render image of game pieces

Description

render_piece() renders an image of game pieces to a file or graphics device. It is a wrapper around pmap_piece() that can auto-size files and graphic devices, apply axes offsets, annotate coordinates, and set up rayrender / rayvertex scenes.

Usage

```

render_piece(
  df,
  file = NULL,
  ...,
  .f = piecepackr::grid.piece,
  cfg = getOption("piecepackr.cfg", NULL),
  envir = getOption("piecepackr.envir", game_systems("sans")),
  width = NULL,

```

```

    height = NULL,
    ppi = 72,
    bg = "white",
    xoffset = NULL,
    yoffset = NULL,
    annotate = FALSE,
    annotation_scale = NULL,
    dev = NULL,
    dev.args = list(res = ppi, bg = bg, units = "in"),
    open_device = new_device,
    close_device = open_device && (!is.null(file) || !is.null(dev)),
    image = c("NULL", "raster", "nativeRaster"),
    xbreaks = NULL,
    ybreaks = NULL,
    new_device = TRUE
  )

```

Arguments

df	A data frame of game piece information with (at least) the named columns "piece_side", "x", and "y".
file	Filename to save image to unless NULL in which case it either uses the current graphics device or opens a new device (depending on open_device argument).
...	Arguments to <code>pmap_piece()</code>
.f	Low level graphics function to use e.g. <code>grid.piece()</code> , <code>piece3d()</code> , <code>piece_mesh()</code> , or <code>piece()</code> .
cfg	A piecepackr configuration list
envir	Environment (or named list) of piecepackr configuration lists
width	Width of image (in inches). Inferred by default.
height	Height of image (in inches). Inferred by default.
ppi	Resolution of image in pixels per inch.
bg	Background color (use "transparent" for transparent)
xoffset	Number to add to the x column in df. Inferred by default.
yoffset	Number to add to the y column in df. Inferred by default.
annotate	If TRUE or "algebraic" annotate the plot with "algebraic" coordinates, if FALSE or "none" don't annotate, if "cartesian" annotate the plot with "cartesian" coordinates.
annotation_scale	Multiplicative factor that scales (stretches) any annotation coordinates. By default uses <code>attr(df, "scale_factor") % % 1</code> .
dev	Graphics device function to use if open_device is FALSE. If NULL infer a reasonable choice from file.
dev.args	Additional arguments to pass to dev (besides filename, width, and height). Will filter out any names that aren't in <code>formals(dev)</code> .

open_device	If TRUE open a new graphics device otherwise draw in the active graphics.
close_device	If TRUE close the graphics device (if open_device = TRUE close the newly opened device otherwise close the previously existing graphics device).
image	Class of image object to return in the "image" field of returned list. If "NULL" (the default) return NULL. If "raster" or "nativeRaster" try to return a raster object of the image.
xbreaks, ybreaks	Subset (of integers) to provide axis labels for if annotate is TRUE. If NULL infer a reasonable choice.
new_device	If FALSE draw in the active graphics device instead of opening a new graphics device. This argument is deprecated. Use the open_device argument instead.

Value

An invisible list of the dimensions of the image and possibly an image object specified by image. As a side effect may save a file and/or open/close a graphics device.

See Also

This function is a wrapper around [pmap_piece\(\)](#).

Examples

```
df_board <- data.frame(piece_side = "board_face", suit = 3, rank = 5,
                       x = 3.0, y = 3.0, stringsAsFactors = FALSE)
df_w <- data.frame(piece_side = "bit_back", suit = 6, rank = 1,
                   x = rep(1:5, 2), y = rep(1:2, each=5),
                   stringsAsFactors = FALSE)
df_b <- data.frame(piece_side = "bit_back", suit = 1, rank = 1,
                   x = rep(1:5, 2), y = rep(4:5, each=5),
                   stringsAsFactors = FALSE)
df <- rbind(df_board, df_w, df_b)
df$cfg <- "checkers1"

if (requireNamespace("grid", quietly = TRUE)) {
  render_piece(df, open_device = FALSE)
}
if (requireNamespace("grid", quietly = TRUE)) {
  grid::grid.newpage()
  render_piece(df, open_device = FALSE,
               op_scale = 0.5, trans = op_transform,
               annotate = "algebraic")
}
## Not run: # May take more than 5 seconds on CRAN servers
if (require(rayvertex)) {
  envir3d <- game_systems("sans3d")
  render_piece(df, .f = piece_mesh, envir = envir3d,
               open_device = FALSE,
               op_scale = 0.5, trans = op_transform)
}

## End(Not run)
```

save_ellipsoid_obj *Alternative Wavefront OBJ file generators*

Description

These are alternative Wavefront OBJ generators intended to be used as a `obj_fn` attribute in a `pp_cfg()` “configuration list”. `save_ellipsoid_obj()` saves an ellipsoid with a color equal to that piece’s `background_color`. `save_peg_doll_obj()` saves a “peg doll” style doll with a color equal to that piece’s `edge_color` with a “pawn belt” around it’s waste from that suit’s and rank’s `belt_face`.

Usage

```
save_ellipsoid_obj(  
  piece_side = "bit_face",  
  suit = 1,  
  rank = 1,  
  cfg = getOption("piecepackr.cfg", pp_cfg()),  
  ...,  
  x = 0,  
  y = 0,  
  z = 0,  
  angle = 0,  
  axis_x = 0,  
  axis_y = 0,  
  width = NA,  
  height = NA,  
  depth = NA,  
  filename = tempfile(fileext = ".obj"),  
  subdivide = 3  
)
```

```
save_peg_doll_obj(  
  piece_side = "pawn_top",  
  suit = 1,  
  rank = 1,  
  cfg = getOption("piecepackr.cfg", pp_cfg()),  
  ...,  
  x = 0,  
  y = 0,  
  z = 0,  
  angle = 0,  
  axis_x = 0,  
  axis_y = 0,  
  width = NA,  
  height = NA,  
  depth = NA,
```

```

    filename = tempfile(fileext = ".obj"),
    res = 72
)

```

Arguments

piece_side	A string with piece and side separated by a underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
...	Ignored.
x	Where to place piece on x axis of viewport
y	Where to place piece on y axis of viewport
z	z-coordinate of the piece. Has no effect if op_scale is 0.
angle	Angle (on xy plane) to draw piece at
axis_x	First coordinate of the axis unit vector.
axis_y	Second coordinate of the axis unit vector.
width	Width of piece
height	Height of piece
depth	Depth (thickness) of piece. Has no effect if op_scale is 0.
filename	Name of Wavefront OBJ object. By default tempfile(fileext = ".obj").
subdivide	Increasing this value makes for a smoother ellipsoid (and larger OBJ file and slower render). See rgl::ellipse3d() .
res	Resolution of the faces.

See Also

See [pp_cfg\(\)](#) for a discussion of “configuration lists”. Wavefront OBJ file generators are used by [save_piece_obj\(\)](#) and (by default) [piece3d\(\)](#) (rgl wrapper), [piece\(\)](#) (rayrender wrapper), and [piece_mesh\(\)](#) (rayvertex wrapper).

save_piece_images	<i>Save piecepack images</i>
-------------------	------------------------------

Description

Saves images of all individual piecepack pieces.

Usage

```
save_piece_images(
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  directory = tempdir(),
  format = "svg",
  angle = 0
)
```

Arguments

cfg	Piecepack configuration list
directory	Directory where to place images
format	Character vector of formats to save images in
angle	Numeric vector of angles to rotate images (in degrees)

Examples

```
# May take more than 5 seconds on CRAN server
if (all(capabilities(c("cairo", "png")))) {
  cfg <- pp_cfg(list(suit_color="darkred,black,darkgreen,darkblue,gre"))
  save_piece_images(cfg, directory=tempdir(), format="svg", angle=0)
  save_piece_images(cfg, directory=tempdir(), format="png", angle=90)
}
```

save_piece_obj	<i>Save Wavefront OBJ files of board game pieces</i>
----------------	--

Description

save_piece_obj() saves Wavefront OBJ files (including associated MTL and texture image) of board game pieces.

Usage

```
save_piece_obj(
  piece_side = "tile_face",
  suit = 1,
  rank = 1,
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  ...,
  x = 0,
  y = 0,
  z = 0,
  angle = 0,
  axis_x = 0,
```

```

axis_y = 0,
width = NA,
height = NA,
depth = NA,
envir = getOption("piecepackr.envir"),
filename = tempfile(fileext = "%03d.obj"),
scale = 1,
res = 72
)

```

Arguments

piece_side	A string with piece and side separated by a underscore e.g. "coin_face"
suit	Number of suit (starting from 1).
rank	Number of rank (starting from 1)
cfg	Piecepack configuration list or pp_cfg object, a list of pp_cfg objects, or a character vector referring to names in envir or a character vector referring to object names that can be retrieved by base::dynGet().
...	Ignored.
x	Where to place piece on x axis of viewport
y	Where to place piece on y axis of viewport
z	z-coordinate of the piece. Has no effect if op_scale is 0.
angle	Angle (on xy plane) to draw piece at
axis_x	First coordinate of the axis unit vector.
axis_y	Second coordinate of the axis unit vector.
width	Width of piece
height	Height of piece
depth	Depth (thickness) of piece. Has no effect if op_scale is 0.
envir	Environment (or named list) containing configuration list(s).
filename	Name of Wavefront OBJ object. By default tempfile(fileext = ".obj").
scale	Multiplicative scaling factor to apply to width, height, and depth.
res	Resolution of the faces.

Value

A data frame with named elements "obj", "mtl", "png" with the created filenames.

See Also

See [geometry_utils](#) for a discussion of the 3D rotation parameterization.

Examples

```

if (all(capabilities(c("cairo", "png")))) {
  cfg <- game_systems("sans3d")$dominoes
  files <- save_piece_obj("tile_face", suit = 3+1, rank=6+1, cfg = cfg)
  print(files)
}

```

save_print_and_play *Save piecepack print-and-play (PnP) file*

Description

Save piecepack print-and-play (PnP) file

Usage

```

save_print_and_play(
  cfg = getOption("piecepackr.cfg", pp_cfg()),
  output_filename = "piecepack.pdf",
  size = c("letter", "A4", "A5", "4x6"),
  pieces = NULL,
  arrangement = c("single-sided", "double-sided"),
  dev = NULL,
  dev.args = list(family = cfg$fontfamily, onefile = TRUE, units = "in", bg = "white",
    res = 300),
  quietly = FALSE,
  ...,
  bleed = FALSE,
  size_bleed = NULL
)

```

Arguments

cfg	Piecepack configuration list or pp_cfg object
output_filename	Filename for print-and-play file
size	PnP output size (currently supports either "letter", "A4", "A5", or "4x6"). This is the targeted “trim” size of the print-and-play file (size_bleed can be used to make the print-and-play file larger than this). Size "4x6" currently only supports pieces = "piecepack" and doesn't support bleed = TRUE. "A5" is in “portrait” mode whereas the other sizes are in “landscape” mode.
pieces	Character vector of desired PnP pieces. Supports "piecepack", "matchsticks", "pyramids", "subpack", or "all". If NULL and combination of size / bleed values supports "matchsticks" and "pyramids" then defaults to c("piecepack", "pyramids", "matchsticks") else just "piecepack".
arrangement	Either "single-sided" or "double-sided". Ignored if size = "4x6".

dev	Graphics device function to use if open_device is FALSE. If NULL infer a reasonable choice from file.
dev.args	Additional arguments to pass to dev (besides filename, width, and height). Will filter out any names that aren't in formals(dev).
quietly	Whether to hide messages about missing metadata in the provided configuration.
...	Currently ignored.
bleed	If TRUE produce a variant print-and-play file with "bleed" zones and "crop marks" around game pieces. Currently only supports pieces = "piecepack" and doesn't support size = "4x6".
size_bleed	A list with names "top", "right", "bottom", "left" containing numeric values indicating the inches "bleed" to add to the size of the print-and-play layout. The default NULL means no such bleed added to "letter", "A4", "A5" layouts and a small bleed added to "4x6" layouts (1/16" to top/bottom and 3/32" to left/right). NB. multiply millimeters by 0.0393700787 to convert to inches. We currently don't support an asymmetric left/right bleed combined with arrangement = "double-sided".

Examples

```
# May take more than 5 seconds on CRAN servers
if (capabilities("cairo")) {
  cfg <- pp_cfg(list(invert_colors.suited=TRUE))
  cfg$description <- 'Piecepack with an "inverted" color scheme.'
  cfg$title <- '"Inverted" piecepack'
  cfg$copyright <- "\u00a9 2022 Trevor L Davis. Some Right Reserved."
  cfg$spdx_id <- "CC-BY-4.0"
  cfg$credit <- ""

  file <- tempfile("my_pnp_file", fileext = ".pdf")
  file_ds <- tempfile("my_pnp_file_ds", fileext = ".pdf")
  file_a4 <- tempfile("my_pnp_file_a4", fileext = ".pdf")
  file_a5 <- tempfile("my_pnp_file_a5", fileext = ".pdf")

  save_print_and_play(cfg, file)
  save_print_and_play(cfg, file_ds, arrangement="double-sided")
  save_print_and_play(cfg, file_a4, size="A4", pieces="all")
  save_print_and_play(cfg, file_a5, size="A5")
}
```

Description

scale_x_piece() and scale_y_piece() are wrappers around `ggplot2::scale_x_continuous()` and `ggplot2::scale_y_continuous()` with "better" defaults for board game diagrams. `label_letter()` labels breaks with letters and `label_counting()` labels breaks with positive integers to more easily generate (i.e. chess) algebraic notation coordinates. `breaks_counting()` generates breaks of just the positive integers within the limits.

Usage

```
scale_x_piece(
  ...,
  name = NULL,
  breaks = breaks_counting(),
  minor_breaks = NULL,
  labels = label_letter()
)
```

```
scale_y_piece(
  ...,
  name = NULL,
  breaks = breaks_counting(),
  minor_breaks = NULL,
  labels = label_counting()
)
```

```
label_letter()
```

```
label_counting()
```

```
breaks_counting()
```

Arguments

...	Passed to <code>ggplot2::scale_x_continuous()</code> or <code>ggplot2::scale_y_continuous()</code> .
name	The name of the scale. Used as the axis or legend title. If <code>waiver()</code> , the default, the name of the scale is taken from the first mapping used for that aesthetic. If <code>NULL</code> , the legend title will be omitted.
breaks	One of: <ul style="list-style-type: none"> • <code>NULL</code> for no breaks • <code>waiver()</code> for the default breaks computed by the transformation object • A numeric vector of positions • A function that takes the limits as input and returns breaks as output (e.g., a function returned by <code>scales::extended_breaks()</code>). Note that for position scales, limits are provided after scale expansion. Also accepts rlang lambda function notation.
minor_breaks	One of: <ul style="list-style-type: none"> • <code>NULL</code> for no minor breaks

- `waiver()` for the default breaks (one minor break between each major break)
- A numeric vector of positions
- A function that given the limits returns a vector of minor breaks. Also accepts rlang `lambda` function notation. When the function has two arguments, it will be given the limits and major breaks.

labels

One of:

- `NULL` for no labels
- `waiver()` for the default labels computed by the transformation object
- A character vector giving labels (must be same length as breaks)
- An expression vector (must be the same length as breaks). See `?plotmath` for details.
- A function that takes the breaks as input and returns labels as output. Also accepts rlang `lambda` function notation.

Value

`scale_x_piece()` and `scale_y_piece()` return ggplot2 scale objects. `label_letter()` and `label_counting()` return functions suitable for use with the labels scale argument. `breaks_counting()` returns a function suitable for use with the breaks scale argument.

Examples

```
if (require("ggplot2", quietly = TRUE) && require("tibble", quietly = TRUE)) {
  envir <- game_systems("sans")
  df_board <- tibble(piece_side = "board_face", suit = 3, rank = 8,
                    x = 4.5, y = 4.5)
  df_w <- tibble(piece_side = "bit_back", suit = 6, rank = 1,
                x = rep(1:8, 2), y = rep(1:2, each=8))
  df_b <- tibble(piece_side = "bit_back", suit = 1, rank = 1,
                x = rep(1:8, 2), y = rep(7:8, each=8))
  df <- rbind(df_board, df_w, df_b)

  # `cfg` must be a character vector for `geom_piece()`
  ggplot(df, aes_piece(df)) +
    geom_piece(cfg = "checkers1", envir = envir) +
    coord_fixed() +
    scale_x_piece() +
    scale_y_piece() +
    theme_minimal(28) +
    theme(panel.grid = element_blank())
}
```

spdx_license_list *SPDX License List data*

Description

spdx_license_list is a data frame of SPDX License List data.

Usage

```
spdx_license_list
```

Format

a data frame with eight variables:

id SPDX Identifier.

name Full name of license. For Creative Commons licenses these have been tweaked from the SPDX version to more closely match the full name used by Creative Commons Foundation.

url URL for copy of license located at `spdx.org`

fsf Is this license considered Free/Libre by the FSF?

osi Is this license OSI approved?

deprecated Has this SPDFX Identifier been deprecated by SPDX?

badge Filename of appropriate “button mark” badge (if any) located in `system.file("extdata/badges", package = "piecepackr")`.

url_alt Alternative URL for license. Manually created for a subset of Creative Commons licenses. Others taken from <https://github.com/sindresorhus/spdx-license-list>.

See Also

See <https://spdx.org/licenses/> for more information.

Index

* datasets

- spdx_license_list, 55
- AA_to_R, 5
- aabb_piece, 4
- aes(), 16
- aes_piece (geom_piece), 15
- affiner::angle(), 6
- animate_piece, 7
- as_pp_cfg (pp_cfg), 37
- base::options(), 3
- basicPieceGrob (basicPieceGrobs), 9
- basicPieceGrobs, 9
- borders(), 17
- breaks_counting (scale_x_piece), 52
- checkersGrob (piecepackr-defunct), 33
- cleave (pp_utils), 43
- concaveGrobFn (piecepackr-defunct), 33
- convexGrobFn (piecepackr-defunct), 33
- cropmarkGrob (grid.cropmark), 18
- crosshairGrob (grid.crosshair), 21
- file2grob (pp_utils), 43
- font_utils, 10
- fortify(), 16
- game_systems, 11
- game_systems(), 39
- geom_piece, 15
- geometry_utils, 30, 32, 35, 50
- geometry_utils (AA_to_R), 5
- get_embedded_font (font_utils), 10
- get_shape_grob_fn (piecepackr-defunct), 33
- ggplot(), 16
- ggplot2::scale_x_continuous(), 18, 53
- ggplot2::scale_y_continuous(), 18, 53
- grid.cropmark, 18
- grid.crosshair, 21
- grid.piece, 23
- grid.piece(), 6, 8, 9, 12, 36, 45
- grid::gpar(), 41
- grid::grid.draw(), 22
- grid::rasterGrob(), 25
- grid::rectGrob(), 22
- grid::segmentsGrob(), 22
- grid::unit(), 20, 25
- gridGeometry::grid.polyclip(), 41
- gridlinesGrob (piecepackr-defunct), 33
- gridpattern::patternGrob(), 41
- grImport2::pictureGrob(), 25
- halmaGrob (piecepackr-defunct), 33
- has_font (font_utils), 10
- hexlinesGrob (piecepackr-defunct), 33
- inch (pp_utils), 43
- install_ppverse, 26
- is_color_invisible (pp_utils), 43
- is_pp_cfg (pp_cfg), 37
- kiteGrob (piecepackr-defunct), 33
- label_counting (scale_x_piece), 52
- label_letter (scale_x_piece), 52
- lambda, 53, 54
- layer position, 17
- layer stat, 16
- marbles_transform (op_transform), 27
- matGrob (piecepackr-defunct), 33
- op_transform, 27
- picturePieceGrobFn (basicPieceGrobs), 9
- piece, 29
- piece(), 6, 8, 36, 45, 48
- piece3d, 31
- piece3d(), 6, 8, 36, 45, 48
- piece_mesh, 34

piece_mesh(), [6](#), [8](#), [45](#), [48](#)
 pieceGrob (grid.piece), [23](#)
 pieceGrob(), [17](#), [18](#), [36](#)
 piecepackr (piecepackr-package), [3](#)
 piecepackr-defunct, [33](#)
 piecepackr-package, [3](#)
 pkgs_ppverse (install_ppverse), [26](#)
 pmap_piece, [35](#)
 pmap_piece(), [8](#), [26](#), [27](#), [45](#), [46](#)
 pp_cfg, [37](#)
 pp_cfg(), [6](#), [10](#), [11](#), [14](#), [28](#), [47](#), [48](#)
 pp_shape, [40](#)
 pp_utils, [43](#)
 previewLayoutGrob (basicPieceGrobs), [9](#)
 pyramidGrob (piecepackr-defunct), [33](#)
 pyramidTopGrob (basicPieceGrobs), [9](#)

R_to_AA (AA_to_R), [5](#)
 R_x (AA_to_R), [5](#)
 R_y (AA_to_R), [5](#)
 R_z (AA_to_R), [5](#)
 render_piece, [44](#)
 render_piece(), [37](#)
 rgl::ellipse3d(), [48](#)
 rgl::material3d(), [32](#)

save_ellipsoid_obj, [47](#)
 save_peg_doll_obj (save_ellipsoid_obj),
 [47](#)
 save_piece_images, [48](#)
 save_piece_obj, [49](#)
 save_piece_obj(), [6](#), [48](#)
 save_print_and_play, [51](#)
 scale_x_piece, [52](#)
 scale_x_piece(), [18](#)
 scale_y_piece (scale_x_piece), [52](#)
 scale_y_piece(), [18](#)
 scales::extended_breaks(), [53](#)
 segmentsCrosshairGrob (grid.crosshair),
 [21](#)
 spdx_license_list, [55](#)
 squaresCrosshairGrob (grid.crosshair),
 [21](#)

to_degrees (AA_to_R), [5](#)
 to_hexpack (game_systems), [11](#)
 to_r (AA_to_R), [5](#)
 to_radians (AA_to_R), [5](#)
 to_subpack (game_systems), [11](#)
 to_t (AA_to_R), [5](#)
 to_x (AA_to_R), [5](#)
 to_y (AA_to_R), [5](#)
 transformation object, [53](#)
 Trig, [6](#)
 utils::install.packages(), [27](#)