

Package ‘rgl’

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Title 3D Visualization Using OpenGL

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Description Provides medium to high level functions for 3D interactive graphics, including functions modelled on base graphics (plot3d(), etc.) as well as functions for constructing representations of geometric objects (cube3d(), etc.). Output may be on screen using OpenGL, or to various standard 3D file formats including WebGL, PLY, OBJ, STL as well as 2D image formats, including PNG, Postscript, SVG, PGF.

License GPL

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rgl-package	<i>3D visualization device system</i>
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Description

3D real-time rendering system.

Details

RGL is a 3D real-time rendering system for R. Multiple windows are managed at a time. Windows may be divided into “subscenes”, where one has the current focus that receives instructions from the R command-line. The device design is oriented towards the R device metaphor. If you send scene management instructions, and there’s no device open, it will be opened automatically. Opened devices automatically get the current device focus. The focus may be changed by using `rgl.set()` or `useSubscene3d()`.

rgl provides medium to high level functions for 3D interactive graphics, including functions modelled on base graphics (`plot3d()`, etc.) as well as functions for constructing geometric objects (`cube3d()`, etc.). Output may be on screen using OpenGL, or to various standard 3D file formats including WebGL, PLY, OBJ, STL as well as 2D image formats, including PNG, Postscript, SVG, PGF.

The `open3d()` function attempts to open a new RGL window, using default settings specified by the user.

rgl also includes a lower level interface which is described in the [rgl.open](#) help topic. We recommend that you avoid mixing `rgl.*` and `*3d` calls.

See the first example below to display the ChangeLog.

See Also

[r3d](#) for a description of the `*3d` interface; [par3d](#) for a description of scene properties and the rendering pipeline; [rgl.useNULL](#) for a description of how to use **rgl** on a system with no graphics support.

Examples

```
file.show(system.file("NEWS", package = "rgl"))
example(surface3d)
example(plot3d)
```

<code>.check3d</code>	<i>Check for an open rgl window.</i>
-----------------------	--------------------------------------

Description

Mostly for internal use, this function returns the current device number if one exists, or opens a new device and returns that.

Usage

```
.check3d()
```

Value

The device number of an rgl device.

Author(s)

Duncan Murdoch

See Also

[open3d](#)

<code>abclines3d</code>	<i>Lines intersecting the bounding box</i>
-------------------------	--

Description

This adds mathematical lines to a scene. Their intersection with the current bounding box will be drawn.

Usage

```
rgl.abclines(x, y = NULL, z = NULL, a, b = NULL, c = NULL, ...)
abclines3d(x, y = NULL, z = NULL, a, b = NULL, c = NULL, ...)
```

Arguments

<code>x, y, z</code>	Coordinates of points through which each line passes.
<code>a, b, c</code>	Coordinates of the direction vectors for the lines.
<code>...</code>	Material properties.

Details

These functions draw the segment of a line that intersects the current bounding box of the scene using the parametrization $(x, y, z) + (a, b, c) * s$ where s is a real number.

Any reasonable way of defining the coordinates x , y , z and a , b , c is acceptable. See the function [xyz.coords](#) for details.

Value

A shape ID of the object is returned invisibly.

See Also

[planes3d](#), [rgl.planes](#) for mathematical planes.

[segments3d](#) draws sections of lines that do not adapt to the bounding box.

Examples

```
plot3d(rnorm(100), rnorm(100), rnorm(100))
abclines3d(0, 0, 0, a = diag(3), col = "gray")
```

addNormals

Add normal vectors to objects so they render more smoothly.

Description

This generic function adds normals at each of the vertices of a polyhedron by averaging the normals of each incident face. This has the effect of making the surface of the object appear smooth rather than faceted when rendered.

Usage

```
addNormals(x, ...)
```

Arguments

x An object to which to add normals.
 \dots Additional parameters which will be passed to the methods. Currently unused.

Details

Currently methods are supplied for "[mesh3d](#)" and "[shapelist3d](#)" classes.

Value

A new object of the same class as x , with normals added.

Author(s)

Duncan Murdoch

Examples

```

open3d()
y <- subdivision3d(tetrahedron3d(col = "red"), depth = 3)
shade3d(y) # No normals
y <- addNormals(y)
shade3d(translate3d(y, x = 1, y = 0, z = 0)) # With normals

```

ageSetter	<i>Set WebGL scene properties based on the age of components of objects.</i>
-----------	--

Description

Many **rgl** shapes contain lists of vertices with various attributes (available via [rgl.attrib](#)). This function modifies the data for those attributes in a WebGL scene.

Usage

```

ageSetter(births, ages,
          colors = NULL, alpha = NULL, radii = NULL,
          vertices = NULL, normals = NULL, origins = NULL,
          texcoords = NULL,
          objids, prefixes = "", digits = 7,
          param = seq(floor(min(births)), ceiling(max(births))))

```

Arguments

births	Numeric vector with one value per vertex, used to determine the “age” of the vertex when displaying it.
ages	A non-decreasing sequence of “ages”.
colors, alpha, radii, vertices, normals, origins, texcoords	Attributes of the vertices. Non-NULL attributes will be interpolated from these values. See the Details section below.
objids, prefixes	The object ids and scene prefixes to modify. These are recycled to the same length.
digits	How many digits to output in the generated Javascript code.
param	Default values to be used by a slider control calling the generated function.

Details

The vertex attributes are specified as follows:

colors A vector of colors in a format suitable for input to [col2rgb](#)

alpha A numeric vector of alpha values between 0 and 1.

radii A numeric vector of sphere radii.

vertices A 3-column matrix of vertex coordinates.

normals A 3-column matrix of vertex normals.

origins A 2-column matrix of origins for text or sprites.

texcoords A 2-column matrix of texture coordinates.

All attributes must have the same number of entries (rows for the matrices) as the ages vector. The births vector must have the same number of entries as the number of vertices in the object.

Not all objects contain all attributes listed here; if one is chosen that is not a property of the corresponding object, a Javascript `alert()` will be generated.

Value

A character vector of class "propertySetter" containing Javascript code defining a function suitable for use in a [propertySlider](#).

The function takes a single argument, `time`, and uses it to compute the "age" of vertex `i` as `time - births[i]`. Those are then used with the `ages` argument to linearly interpolate settings of the specified attributes. Extrapolation is constant. Repeated values in `ages` can be used to obtain discontinuities in the settings.

Author(s)

Duncan Murdoch

See Also

[propertySlider](#); more detailed control is available in [propertySetter](#).

Examples

```
propertySlider(ageSetter(births = 1:10, ages = c(-1, 0, 1),
  alpha = c(0, 1, 1), objids = 123))
```

`aspect3d`*Set the aspect ratios of the current plot*

Description

This function sets the apparent ratios of the x, y, and z axes of the current bounding box.

Usage

```
aspect3d(x, y = NULL, z = NULL)
```

Arguments

x	The ratio for the x axis, or all three ratios, or "iso"
y	The ratio for the y axis
z	The ratio for the z axis

Details

If the ratios are all 1, the bounding box will be displayed as a cube approximately filling the display. Values may be set larger or smaller as desired. Aspect "iso" signifies that the coordinates should all be displayed at the same scale, i.e. the bounding box should not be rescaled. (This corresponds to the default display before `aspect3d` has been called.) Partial matches to "iso" are allowed.

`aspect3d` works by modifying `par3d("scale")`.

Value

The previous value of the scale is returned invisibly.

Author(s)

Duncan Murdoch

See Also

[plot3d](#), [par3d](#)

Examples

```
x <- rnorm(100)
y <- rnorm(100)*2
z <- rnorm(100)*3

open3d()
plot3d(x, y, z)
aspect3d(1, 1, 0.5)
open3d()
plot3d(x, y, z)
aspect3d("iso")
```


axes3d

*Draw boxes, axes and other text outside the data***Description**

These functions draw axes, boxes and text outside the range of the data. `axes3d`, `box3d` and `title3d` are the higher level functions; normally the others need not be called directly by users.

Usage

```
axes3d(edges = "bbox", labels = TRUE, tick = TRUE, nticks = 5,
       box = FALSE, expand = 1.03, ...)
box3d(...)
title3d(main = NULL, sub = NULL, xlab = NULL, ylab = NULL,
       zlab = NULL, line = NA, ...)
axis3d(edge, at = NULL, labels = TRUE, tick = TRUE, line = 0,
       pos = NULL, nticks = 5, ...)
mtext3d(text, edge, line = 0, at = NULL, pos = NA, ...)
```

Arguments

<code>edges</code>	a code to describe which edge(s) of the box to use; see Details below
<code>labels</code>	whether to label the axes, or (for <code>axis3d</code>) the labels to use
<code>tick</code>	whether to use tick marks
<code>nticks</code>	suggested number of ticks
<code>box</code>	draw the full box if "bbox" axes are used
<code>expand</code>	how much to expand the box around the data
<code>main</code>	the main title for the plot
<code>sub</code>	the subtitle for the plot
<code>xlab</code> , <code>ylab</code> , <code>zlab</code>	the axis labels for the plot
<code>line</code>	the "line" of the plot margin to draw the label on
<code>edge</code> , <code>pos</code>	the position at which to draw the axis or text
<code>text</code>	the text to draw
<code>at</code>	the value of a coordinate at which to draw the axis
<code>...</code>	additional parameters which are passed to <code>bbox3d</code> or <code>material3d</code>

Details

The rectangular prism holding the 3D plot has 12 edges. They are identified using 3 character strings. The first character ('x', 'y', or 'z') selects the direction of the axis. The next two characters are each '-' or '+', selecting the lower or upper end of one of the other coordinates. If only one or

two characters are given, the remaining characters default to '-'. For example `edge = 'x+'` draws an x-axis at the high level of y and the low level of z.

By default, `axes3d` uses the `bbox3d` function to draw the axes. The labels will move so that they do not obscure the data. Alternatively, a vector of arguments as described above may be used, in which case fixed axes are drawn using `axis3d`.

If `pos` is a numeric vector of length 3, `edge` determines the direction of the axis and the tick marks, and the values of the other two coordinates in `pos` determine the position. See the examples.

Value

These functions are called for their side effects. They return the object IDs of objects added to the scene.

Author(s)

Duncan Murdoch

See Also

Classic graphics functions `axis`, `box`, `title`, `mtext`, and `rgl` function `bbox3d`.

Examples

```
open3d()
points3d(rnorm(10), rnorm(10), rnorm(10))

# First add standard axes
axes3d()

# and one in the middle (the NA will be ignored, a number would
# do as well)
axis3d('x', pos = c(NA, 0, 0))

# add titles
title3d('main', 'sub', 'xlab', 'ylab', 'zlab')

rgl.bringtotop()

open3d()
points3d(rnorm(10), rnorm(10), rnorm(10))

# Use fixed axes
axes3d(c('x', 'y', 'z'))

# Put 4 x-axes on the plot
axes3d(c('x--', 'x-+', 'x+-', 'x++'))

axis3d('x', pos = c(NA, 0, 0))
title3d('main', 'sub', 'xlab', 'ylab', 'zlab')
```

 bg3d

Set up Background

Description

Set up the background of the scene.

Usage

```
bg3d(...)
rgl.bg( sphere = FALSE, fogtype = "none", color = c("black", "white"),
back = "lines", ...)
```

Arguments

fogtype	fog type: "none" no fog "linear" linear fog function "exp" exponential fog function "exp2" squared exponential fog function
sphere	logical, if true, an environmental sphere geometry is used for the background decoration.
color	Primary color is used for background clearing and as fog color. Secondary color is used for background sphere geometry. See material3d for details.
back	Specifies the fill style of the sphere geometry. See material3d for details.
...	Material properties. See material3d for details.

Details

If sphere is set to TRUE, an environmental sphere enclosing the whole scene is drawn.

If not, but the material properties include a bitmap as a texture, the bitmap is drawn in the background of the scene. (The bitmap colors modify the general color setting.)

If neither a sphere nor a bitmap background is drawn, the background is filled with a solid color.

Note

The [writeWebGL](#) function only supports solid color backgrounds.

See Also

[material3d](#), [bgplot3d](#) to add a 2D plot as background.

Examples

```
open3d()

# a simple white background

bg3d("white")

# the holo-globe (inspired by star trek):

bg3d(sphere = TRUE, color = c("black", "green"), lit = FALSE, back = "lines" )

# an environmental sphere with a nice texture.

bg3d(sphere = TRUE, texture = system.file("textures/sunsleep.png", package = "rgl"),
      back = "filled" )

# The same texture as a fixed background

open3d()
bg3d(texture = system.file("textures/sunsleep.png", package = "rgl"), col = "white")
```

bgplot3d

Use base graphics for RGL background

Description

Add a 2D plot or a legend in the background of an RGL window.

Usage

```
bgplot3d(expression)
legend3d(...)
```

Arguments

expression	Any plotting commands to produce a plot.
...	Arguments to pass to the legend function.

Details

The `bgplot3d` function opens a [png](#) device and executes `expression`, producing a plot there. This plot is then used as a bitmap background for the current RGL subscene.

The `legend3d` function draws a standard 2D legend to the background of the current subscene by calling `bgplot3d` to open a device, and setting up a plot region there to fill the whole display.

Value

The `bgplot3d` function invisibly returns the ID of the background object that was created, with attribute "value" holding the value returned when the expression was evaluated.

The `legend3d` function does similarly. The "value" attribute is the result of the call to `legend`. The scaling of the coordinates runs from 0 to 1 in X and Y.

Note

Because the background plots are drawn as bitmaps, they do not resize very gracefully. It's best to size your window first, then draw the background at that size.

Author(s)

Duncan Murdoch

See Also

`bg3d` for other background options.

Examples

```
x <- rnorm(100)
y <- rnorm(100)
z <- rnorm(100)
open3d()
# Needs to be a bigger window than the default
par3d(windowRect = c(100, 100, 612, 612))
Sys.sleep(0.1) # Allow sluggish window managers to catch up
parent <- currentSubscene3d()
mfrow3d(2, 2)
plot3d(x, y, z)
next3d(reuse = FALSE)
bgplot3d(plot(y, z))
next3d(reuse = FALSE)
bgplot3d(plot(x, z))
next3d(reuse = FALSE)
legend3d("center", c("2D Points", "3D Points"), pch = c(1, 16))
useSubscene3d(parent)
```

cylinder3d

Create cylindrical or "tube" plots.

Description

This function converts a description of a space curve into a "`mesh3d`" object forming a cylindrical tube around the curve.

Usage

```
cylinder3d(center, radius = 1, twist = 0, e1 = NULL, e2 = NULL, e3 = NULL,
           sides = 8, section = NULL, closed = 0, debug = FALSE, keepVars = FALSE)
```

Arguments

center	An n by 3 matrix whose columns are the x, y and z coordinates of the space curve.
radius	The radius of the cross-section of the tube at each point in the center.
twist	The amount by which the polygon forming the tube is twisted at each point.
e1, e2, e3	The Frenet coordinates to use at each point on the space curve.
sides	The number of sides in the polygon cross section.
section	The polygon cross section as a two-column matrix, or NULL.
closed	Whether to treat the first and last points of the space curve as identical, and close the curve, or put caps on the ends. See the Details.
debug	If TRUE, plot the local Frenet coordinates at each point.
keepVars	If TRUE, return the local variables in attribute "vars".

Details

The number of points in the space curve is determined by the vector lengths in `center`, after using `xyz.coords` to convert it to a list. The other arguments `radius`, `twist`, `e1`, `e2`, and `e3` are extended to the same length.

The `closed` argument controls how the ends of the cylinder are handled. If `closed > 0`, it represents the number of points of overlap in the coordinates. `closed == TRUE` is the same as `closed = 1`. Negative values indicate that caps should be put on the ends of the cylinder. If `closed == -1`, a cap will be put on the end corresponding to `center[1,]`. If `closed == -2`, caps will be put on both ends.

If `section` is NULL (the default), a regular `sides`-sided polygon is used, and `radius` measures the distance from the center of the cylinder to each vertex. If not NULL, `sides` is ignored (and set internally to `nrow(section)`), and `radius` is used as a multiplier to the vertex coordinates. `twist` specifies the rotation of the polygon. Both `radius` and `twist` may be vectors, with values recycled to the number of rows in `center`, while `sides` and `section` are the same at every point along the curve.

The three optional arguments `e1`, `e2`, and `e3` determine the local coordinate system used to create the vertices at each point in `center`. If missing, they are computed by simple numerical approximations. `e1` should be the tangent coordinate, giving the direction of the curve at the point. The cross-section of the polygon will be orthogonal to `e1`. `e2` defaults to an approximation to the normal or curvature vector; it is used as the image of the y axis of the polygon cross-section. `e3` defaults to an approximation to the binormal vector, to which the x axis of the polygon maps. The vectors are orthogonalized and normalized at each point.

Value

A "mesh3d" object holding the cylinder, possibly with attribute "vars" containing the local environment of the function.

Author(s)

Duncan Murdoch

Examples

```
# A trefoil knot
open3d()
theta <- seq(0, 2*pi, len = 25)
knot <- cylinder3d(
  center = cbind(
    sin(theta) + 2*sin(2*theta),
    2*sin(3*theta),
    cos(theta) - 2*cos(2*theta)),
  e1 = cbind(
    cos(theta) + 4*cos(2*theta),
    6*cos(3*theta),
    sin(theta) + 4*sin(2*theta)),
  radius = 0.8,
  closed = TRUE)

shade3d(addNormals(subdivision3d(knot, depth = 2)), col = "green")
```

 ellipse3d

Make an ellipsoid

Description

A generic function and several methods returning an ellipsoid or other outline of a confidence region for three parameters.

Usage

```
ellipse3d(x, ...)
## Default S3 method:
ellipse3d(x, scale = c(1, 1, 1), centre = c(0, 0, 0), level = 0.95,
  t = sqrt(qchisq(level, 3)), which = 1:3, subdivide = 3, smooth = TRUE, ...)
## S3 method for class 'lm'
ellipse3d(x, which = 1:3, level = 0.95, t = sqrt(3 * qf(level,
  3, x$df.residual)), ...)

## S3 method for class 'glm'
ellipse3d(x, which = 1:3, level = 0.95, t, dispersion, ...)
## S3 method for class 'nls'
ellipse3d(x, which = 1:3, level = 0.95, t = sqrt(3 * qf(level,
  3, s$df[2])), ...)
```

Arguments

x	An object. In the default method the parameter x should be a square positive definite matrix at least 3x3 in size. It will be treated as the correlation or covariance of a multivariate normal distribution.
...	Additional parameters to pass to the default method or to qmesh3d .
scale	If x is a correlation matrix, then the standard deviations of each parameter can be given in the scale parameter. This defaults to c(1, 1, 1), so no rescaling will be done.
centre	The centre of the ellipse will be at this position.
level	The confidence level of a simultaneous confidence region. The default is 0.95, for a 95% region. This is used to control the size of the ellipsoid.
t	The size of the ellipse may also be controlled by specifying the value of a t-statistic on its boundary. This defaults to the appropriate value for the confidence region.
which	This parameter selects which variables from the object will be plotted. The default is the first 3.
subdivide	This controls the number of subdivisions (see subdivision3d) used in constructing the ellipsoid. Higher numbers give a smoother shape.
smooth	If TRUE, smooth interpolation of normals is used; if FALSE, a faceted ellipsoid will be displayed.
dispersion	The value of dispersion to use. If specified, it is treated as fixed, and chi-square limits for t are used. If missing, it is taken from <code>summary(x)</code> .

Value

A [mesh3d](#) object representing the ellipsoid.

Examples

```
# Plot a random sample and an ellipsoid of concentration corresponding to a 95%
# probability region for a
# trivariate normal distribution with mean 0, unit variances and
# correlation 0.8.
if (requireNamespace("MASS")) {
  Sigma <- matrix(c(10, 3, 0, 3, 2, 0, 0, 0, 1), 3, 3)
  Mean <- 1:3
  x <- MASS::mvrnorm(1000, Mean, Sigma)

  open3d()

  plot3d(x, box = FALSE)

  plot3d( ellipse3d(Sigma, centre = Mean), col = "green", alpha = 0.5, add = TRUE)
}

# Plot the estimate and joint 90% confidence region for the displacement and cylinder
# count linear coefficients in the mtcars dataset
```



```
data(mtcars)
fit <- lm(mpg ~ disp + cyl , mtcars)

open3d()
plot3d(ellipse3d(fit, level = 0.90), col = "blue", alpha = 0.5, aspect = TRUE)
```

extrude3d *Generate extrusion mesh*

Description

Given a two-dimensional polygon, this generates a three-dimensional extrusion of the shape by triangulating the polygon and creating a cylinder with that shape as the end faces.

Usage

```
extrude3d(x, y = NULL, thickness = 1, smooth = FALSE, ...)
```

Arguments

x, y	A polygon description in one of the forms supported by triangulate .
thickness	The extrusion will have this thickness.
smooth	logical; should normals be added so that the edges of the extrusion appear smooth?
...	Other parameters to pass to tmesh3d when constructing the mesh.

Details

The extrusion is always constructed with the polygon in the xy plane at $z = 0$ and another copy at $z = \text{thickness}$. Use the transformation functions (e.g. [rotate3d](#)) to obtain other orientations and placements.

Value

A mesh object containing a triangulation of the polygon for each face, and quadrilaterals for the sides.

Author(s)

Duncan Murdoch

See Also

[polygon3d](#) for a simple polygon, [triangulate](#) for the triangulation, [turn3d](#) for a solid of rotation.

Examples

```
x <- c(1:10, 10:1)
y <- rev(c(rep(c(0, 2), 5), rep(c(1.5, -0.5), 5)))
plot(x, y, type = "n")
polygon(x, y)
open3d()
shade3d( extrude3d(x, y), col = "red" )
```

GramSchmidt

*The Gram-Schmidt algorithm***Description**

Generate a 3x3 orthogonal matrix using the Gram-Schmidt algorithm.

Usage

```
GramSchmidt(v1, v2, v3, order = 1:3)
```

Arguments

`v1`, `v2`, `v3` Three length 3 vectors (taken as row vectors).
`order` The precedence order for the vectors; see Details.

Details

This function orthogonalizes the matrix `rbind(v1, v2, v3)` using the Gram-Schmidt algorithm. It can handle rank 2 matrices (returning a rank 3 matrix). If the original is rank 1, it is likely to fail.

The order vector determines the precedence of the original vectors. For example, if it is `c(i, j, k)`, then row `i` will be unchanged (other than normalization); row `j` will normally be transformed within the span of rows `i` and `j`. Row `k` will be transformed orthogonally to the span of the others.

Value

A 3x3 matrix whose rows are the orthogonalization of the original row vectors.

Author(s)

Duncan Murdoch

Examples

```
# Proceed through the rows in order
print(A <- matrix(rnorm(9), 3, 3))
GramSchmidt(A[1, ], A[2, ], A[3, ])

# Keep the middle row unchanged
print(A <- matrix(c(rnorm(2), 0, 1, 0, 0, rnorm(3)), 3, 3, byrow = TRUE))
GramSchmidt(A[1, ], A[2, ], A[3, ], order = c(2, 1, 3))
```

<code>grid3d</code>	<i>Add a grid to a 3D plot</i>
---------------------	--------------------------------

Description

This function adds a reference grid to an RGL plot.

Usage

```
grid3d(side, at = NULL, col = "gray", lwd = 1, lty = 1, n = 5)
```

Arguments

<code>side</code>	Where to put the grid; see the Details section.
<code>at</code>	How to draw the grid; see the Details section.
<code>col</code>	The color of the grid lines.
<code>lwd</code>	The line width of the grid lines. (Currently only <code>lty = 1</code> is supported.)
<code>lty</code>	The line type of the grid lines.
<code>n</code>	Suggested number of grid lines; see the Details section.

Details

This function is similar to [grid](#) in classic graphics, except that it draws a 3D grid in the plot.

The grid is drawn in a plane perpendicular to the coordinate axes. The first letter of the `side` argument specifies the direction of the plane: "x", "y" or "z" (or uppercase versions) to specify the coordinate which is constant on the plane.

If `at = NULL` (the default), the grid is drawn at the limit of the box around the data. If the second letter of the `side` argument is "-" or is not present, it is the lower limit; if "+" then at the upper limit. The grid lines are drawn at values chosen by [pretty](#) with `n` suggested locations. The default locations should match those chosen by [axis3d](#) with `nticks = n`.

If `at` is a numeric vector, the grid lines are drawn at those values.

If `at` is a list, then the "x" component is used to specify the x location, the "y" component specifies the y location, and the "z" component specifies the z location. Missing components are handled using the default as for `at = NULL`.

Multiple grids may be drawn by specifying multiple values for `side` or for the component of `at` that specifies the grid location.

Value

A vector or matrix of object ids is returned invisibly.

Note

If the scene is resized, the grid will not be resized; use [abclines3d](#) to draw grid lines that will automatically resize.

Author(s)

Ben Bolker and Duncan Murdoch

See Also

[axis3d](#)

Examples

```
x <- 1:10
y <- 1:10
z <- matrix(outer(x - 5, y - 5) + rnorm(100), 10, 10)
open3d()
persp3d(x, y, z, col = "red", alpha = 0.7, aspect = c(1, 1, 0.5))
grid3d(c("x", "y+", "z"))
```

hook_rgl

*Hook functions to use with **knitr***

Description

These functions allow **rgl** graphics to be embedded in **knitr** documents, either as bitmaps (hook_rgl with format "png"), fixed vector graphics (hook_rgl with format "eps" or "postscript"), or interactive WebGL graphics (hook_webgl).

Usage

```
hook_rgl(before, options, envir)
hook_webgl(before, options, envir)
```

Arguments

before, options, envir
Standard **knitr** hook function arguments.

Value

A string to be embedded into the output, or NULL if called when no output is available.

Author(s)

Originally by Yihui Xie in the **knitr** package; modified by Duncan Murdoch.

See Also

[rgl.Sweave](#) embeds fixed images in Sweave documents.

identify3d	<i>Identify points in plot.</i>
------------	---------------------------------

Description

Identify points in a plot, similarly to the [identify](#) function in base graphics.

Usage

```
identify3d(x, y = NULL, z = NULL, labels = seq_along(x), n = length(x),  
plot = TRUE, adj = c(-0.1, 0.5), tolerance = 20,  
buttons = c("right", "middle"))
```

Arguments

x, y, z	coordinates of points in a scatter plot. Alternatively, any object which defines coordinates (see xyz.coords) can be given as x, and y and z left missing.
labels	an optional character vector giving labels for the points. Will be coerced using as.character , and recycled if necessary to the length of x.
n	the maximum number of points to be identified.
plot	logical: if plot is TRUE, the labels are printed near the points and if FALSE they are omitted.
adj	numeric vector to use as adj parameter to text3d when plotting the labels.
tolerance	the maximal distance (in pixels) for the pointer to be 'close enough' to a point.
buttons	a length 1 or 2 character vector giving the buttons to use for selection and quitting.

Details

If buttons is length 1, the user can quit by reaching n selections, or by hitting the escape key, but the result will be lost if escape is used.

Value

A vector of selected indices.

Author(s)

Duncan Murdoch

See Also

[identify](#) for base graphics, [select3d](#) for selecting regions.

light	<i>add light source</i>
-------	-------------------------

Description

add a light source to the scene.

Usage

```
light3d(theta = 0, phi = 15, x = NULL, ...)  
rgl.light( theta = 0, phi = 0, viewpoint.rel = TRUE, ambient = "#FFFFFF",  
          diffuse = "#FFFFFF", specular = "#FFFFFF", x = NULL, y = NULL, z = NULL)
```

Arguments

theta, phi	polar coordinates, used by default
viewpoint.rel	logical, if TRUE light is a viewpoint light that is positioned relative to the current viewpoint
ambient, diffuse, specular	light color values used for lighting calculation
x, y, z	cartesian coordinates, optional
...	generic arguments passed through to RGL-specific (or other) functions

Details

Up to 8 light sources are supported. They are positioned either in world space or relative to the camera. By providing polar coordinates to theta and phi a directional light source is used. If numerical values are given to x, y and z, a point-like light source with finite distance to the objects in the scene is set up.

If x is non-null, [xyz.coords](#) will be used to form the location values, so all three coordinates can be specified in x.

Value

This function is called for the side effect of adding a light. A light ID is returned to allow [rgl.pop](#) to remove it.

See Also

[rgl.clear](#) [rgl.pop](#)

Examples

```

#
# a lightsource moving through the scene
#
data(volcano)
z <- 2 * volcano # Exaggerate the relief
x <- 10 * (1:nrow(z)) # 10 meter spacing (S to N)
y <- 10 * (1:ncol(z)) # 10 meter spacing (E to W)
zlim <- range(z)
zlen <- zlim[2] - zlim[1] + 1
colorlut <- terrain.colors(zlen) # height color lookup table
col <- colorlut[ z - zlim[1] + 1 ] # assign colors to heights for each point

open3d()
bg3d("gray50")
surface3d(x, y, z, color = col, back = "lines")
r <- max(y) - mean(y)
lightid <- spheres3d(1, 1, 1, alpha = 0)
frame <- function(time) {
  a <- pi*(time - 1)
  save <- par3d(skipRedraw = TRUE)
  clear3d(type = "lights")
  rgl.pop(id = lightid)
  xyz <- matrix(c(r*sin(a) + mean(x), r*cos(a) + mean(y), max(z)), ncol = 3)
  light3d(x = xyz, diffuse = "gray75",
          specular = "gray75", viewpoint.rel = FALSE)
  light3d(diffuse = "gray10", specular = "gray25")
  lightid <-< spheres3d(xyz, emission = "white", radius = 4)
  par3d(save)
  Sys.sleep(0.02)
  NULL
}
play3d(frame, duration = 2)

```

matrices

*Work with homogeneous coordinates***Description**

These functions construct 4x4 matrices for transformations in the homogeneous coordinate system used by OpenGL, and translate vectors between homogeneous and Euclidean coordinates.

Usage

```

identityMatrix()
scaleMatrix(x, y, z)
translationMatrix(x, y, z)
rotationMatrix(angle, x, y, z, matrix)

```

```

asHomogeneous(x)
asEuclidean(x)

scale3d(obj, x, y, z, ...)
translate3d(obj, x, y, z, ...)
rotate3d(obj, angle, x, y, z, matrix, ...)

transform3d(obj, matrix, ...)

```

Arguments

`x`, `y`, `z`, `angle`, `matrix`
 See details

`obj` An object to be transformed

`...` Additional parameters to be passed to methods

Details

OpenGL uses homogeneous coordinates to handle perspective and affine transformations. The homogeneous point (x, y, z, w) corresponds to the Euclidean point $(x/w, y/w, z/w)$. The matrices produced by the functions `scaleMatrix`, `translationMatrix`, and `rotationMatrix` are to be left-multiplied by a row vector of homogeneous coordinates; alternatively, the transpose of the result can be right-multiplied by a column vector. The generic functions `scale3d`, `translate3d` and `rotate3d` apply these transformations to the `obj` argument. The `transform3d` function is a synonym for `rotate3d(obj, matrix = matrix)`.

By default, it is assumed that `obj` is a row vector (or a matrix of row vectors) which will be multiplied on the right by the corresponding matrix, but users may write methods for these generics which operate differently. Methods are supplied for `mesh3d` objects.

To compose transformations, use matrix multiplication. The effect is to apply the matrix on the left first, followed by the one on the right.

`identityMatrix` returns an identity matrix.

`scaleMatrix` scales each coordinate by the given factor. In Euclidean coordinates, (u, v, w) is transformed to $(x*u, y*v, z*w)$.

`translationMatrix` translates each coordinate by the given translation, i.e. (u, v, w) is transformed to $(u + x, v + y, w + z)$.

`rotationMatrix` can be called in three ways. With arguments `angle`, `x`, `y`, `z` it represents a rotation of `angle` radians about the axis `x`, `y`, `z`. If `matrix` is a 3x3 rotation matrix, it will be converted into the corresponding matrix in 4x4 homogeneous coordinates. Finally, if a 4x4 matrix is given, it will be returned unchanged. (The latter behaviour is used to allow `transform3d` to act like a generic function, even though it is not.)

Use `asHomogeneous(x)` to convert the Euclidean vector `x` to homogeneous coordinates, and `asEuclidean(x)` for the reverse transformation.

Value

`identityMatrix`, `scaleMatrix`, `translationMatrix`, and `rotationMatrix` produce a 4x4 matrix representing the requested transformation in homogeneous coordinates.

`scale3d`, `translate3d` and `rotate3d` transform the object and produce a new object of the same class.

Author(s)

Duncan Murdoch

See Also

[par3d](#) for a description of how rgl uses matrices in rendering.

Examples

```
# A 90 degree rotation about the x axis:
rotationMatrix(pi/2, 1, 0, 0)

# Find what happens when you rotate (2, 0, 0) by 45 degrees about the y axis:

x <- asHomogeneous(c(2, 0, 0))
y <- x
asEuclidean(y)

# or more simply...

rotate3d(c(2, 0, 0), pi/4, 0, 1, 0)
```

mesh3d

3D Mesh objects

Description

3D triangle and quadrangle mesh object creation and a collection of sample objects.

Usage

```
qmesh3d(vertices, indices, homogeneous = TRUE, material = NULL,
         normals = NULL, texcoords = NULL)
tmesh3d(vertices, indices, homogeneous = TRUE, material = NULL,
         normals = NULL, texcoords = NULL)

cube3d(trans = identityMatrix(), ...)
tetrahedron3d(trans = identityMatrix(), ...)
octahedron3d(trans = identityMatrix(), ...)
```

```

icosahedron3d(trans = identityMatrix(), ...)
dodecahedron3d(trans = identityMatrix(), ...)
cuboctahedron3d(trans = identityMatrix(), ...)

oh3d(trans = identityMatrix(), ...) # an 'o' object

dot3d(x, ...) # draw dots at the vertices of an object
## S3 method for class 'mesh3d'
dot3d(x, override = TRUE, ...)
wire3d(x, ...) # draw a wireframe object
## S3 method for class 'mesh3d'
wire3d(x, override = TRUE, ...)
shade3d(x, ...) # draw a shaded object
## S3 method for class 'mesh3d'
shade3d(x, override = TRUE, ...)

```

Arguments

<code>x</code>	a mesh3d object (class <code>qmesh3d</code> or <code>tmesh3d</code>)
<code>vertices</code>	3- or 4-component vector of coordinates
<code>indices</code>	4-component vector of vertex indices
<code>homogeneous</code>	logical indicating if homogeneous (four component) coordinates are used.
<code>material</code>	material properties for later rendering
<code>normals</code>	normals at each vertex
<code>texcoords</code>	texture coordinates at each vertex
<code>trans</code>	transformation to apply to objects; see below for defaults
<code>...</code>	additional rendering parameters
<code>override</code>	should the parameters specified here override those stored in the object?

Details

These functions create and work with mesh3d objects, which consist of a matrix of vertex coordinates together with a matrix of indices indicating which vertex is part of which face. Such objects may have triangular faces, planar quadrilateral faces, or both.

The sample objects optionally take a matrix transformation `trans` as an argument. This transformation is applied to all vertices of the default shape. The default is an identity transformation.

The "shape3d" class is a general class for shapes that can be plotted by `dot3d`, `wire3d` or `shade3d`.

The "mesh3d" class is a class of objects that form meshes: the vertices are in member `vb`, as a 3 or 4 by `n` matrix. Meshes with triangular faces will contain `it`, a $3 * n$ matrix giving the indices of the vertices in each face. Quad meshes will have vertex indices in `ib`, a $4 * n$ matrix.

Value

`qmesh3d`, `cube3d`, `oh3d`, `tmesh3d`, `tetrahedron3d`, `octahedron3d`, `icosahedron3d` and `dodecahedron3d` return objects of class `c("mesh3d", "shape3d")`. The first three of these are quad meshes, the rest are triangle meshes.

dot3d, wire3d, and shade3d are called for their side effect of drawing an object into the scene; they return an object ID (or vector of IDs, for some classes) invisibly.

See [rgl.primitive](#) for a discussion of texture coordinates.

See Also

[r3d](#), [par3d](#), [shapelist3d](#) for multiple shapes

Examples

```
# generate a quad mesh object

vertices <- c(
  -1.0, -1.0, 0, 1.0,
  1.0, -1.0, 0, 1.0,
  1.0, 1.0, 0, 1.0,
  -1.0, 1.0, 0, 1.0
)
indices <- c( 1, 2, 3, 4 )

open3d()
wire3d( qmesh3d(vertices, indices) )

# render 4 meshes vertically in the current view

open3d()
bg3d("gray")
l0 <- oh3d(tran = par3d("userMatrix"), color = "green" )
shade3d( translate3d( l0, -6, 0, 0 ) )
l1 <- subdivision3d( l0 )
shade3d( translate3d( l1, -2, 0, 0 ), color = "red", override = FALSE )
l2 <- subdivision3d( l1 )
shade3d( translate3d( l2, 2, 0, 0 ), color = "red", override = TRUE )
l3 <- subdivision3d( l2 )
shade3d( translate3d( l3, 6, 0, 0 ), color = "red" )

# render all of the Platonic solids
open3d()
shade3d( translate3d( tetrahedron3d(col = "red"), 0, 0, 0 ) )
shade3d( translate3d( cube3d(col = "green"), 3, 0, 0 ) )
shade3d( translate3d( octahedron3d(col = "blue"), 6, 0, 0 ) )
shade3d( translate3d( dodecahedron3d(col = "cyan"), 9, 0, 0 ) )
shade3d( translate3d( icosahedron3d(col = "magenta"), 12, 0, 0 ) )
```

Description

The `mfrow3d` and `layout3d` functions provide functionality in **rgl** similar to `par("mfrow")` and `layout` in classic R graphics.

Usage

```
subsceneList(value, window = rgl.cur())

mfrow3d(nr, nc, byrow = TRUE, parent = NA, sharedMouse = FALSE, ...)
layout3d(mat, widths = rep.int(1, ncol(mat)),
         heights = rep.int(1, nrow(mat)),
         parent = NA, sharedMouse = FALSE,
         ...)
next3d(current = NA, clear = TRUE, reuse = TRUE)
clearSubsceneList(delete = currentSubscene3d() %in% subsceneList(),
                  window = rgl.cur())
```

Arguments

<code>value</code>	A new subscene list to set. If missing, return the current one (or NULL).
<code>window</code>	Which window to operate on.
<code>nr, nc</code>	Number of rows and columns of figures.
<code>byrow</code>	Whether figures progress by row (as with <code>par("mfrow")</code>) or by column (as with <code>par("mfcol")</code>).
<code>mat, widths, heights</code>	Layout parameters; see <code>layout</code> for their interpretation.
<code>parent</code>	The parent subscene. NA indicates the current subscene. See Details below.
<code>sharedMouse</code>	Whether to make all subscenes <code>par3d("listeners")</code> to each other.
<code>...</code>	Additional parameters to pass to <code>newSubscene3d</code> as each subscene is created.
<code>current</code>	The subscene to move away from. NA indicates the current subscene.
<code>clear</code>	Whether the newly entered subscene should be cleared upon entry.
<code>reuse</code>	Whether to skip advancing if the current subscene has no objects in it.
<code>delete</code>	If TRUE, delete the subscenes in the current window.

Details

`rgl` can maintain a list of subscenes; the `mfrow3d` and `layout3d` functions create that list. When the list is in place, `next3d` causes `rgl` to move to the next scene in the list, or cycle back to the first one. Unlike the classic R graphics versions of these functions, these functions are completely compatible with each other. You can mix them within a single `rgl` window.

In the default case where `parent` is missing, `mfrow3d` and `layout3d` will call `clearSubsceneList()` at the start.

By default `clearSubsceneList()` checks whether the current subscene is in the current subscene list; if so, it will delete all subscenes in the list, and call `gc3d` to delete any objects that are no longer shown. The subscene list will be set to a previous value if one was recorded, or NULL if not.

If parent is specified in mfrow3d or layout3d (even as NA), the new subscenes will be created within the parent.

Value

mfrow3d and layout3d return a vector of subscene id values that have just been created. If a previous subscene list was in effect and was not automatically cleared, it is attached as an attribute "prev".

Author(s)

Duncan Murdoch

See Also

[newSubscene3d](#), [par](#), [layout](#).

Examples

```
shapes <- list(Tetrahedron = tetrahedron3d(), Cube = cube3d(), Octahedron = octahedron3d(),
             Icosahedron = icosahedron3d(), Dodecahedron = dodecahedron3d(),
             Cuboctahedron = cuboctahedron3d())
col <- rainbow(6)
open3d()
mfrow3d(3, 2)
for (i in 1:6) {
  next3d() # won't advance the first time, since it is empty
  shade3d(shapes[[i]], col = col[i])
}

open3d()
mat <- matrix(1:4, 2, 2)
mat <- rbind(mat, mat + 4, mat + 8)
layout3d(mat, height = rep(c(3, 1), 3), sharedMouse = TRUE)
for (i in 1:6) {
  next3d()
  shade3d(shapes[[i]], col = col[i])
  next3d()
  text3d(0, 0, 0, names(shapes)[i])
}
```

observer3d

Set the observer location.

Description

This function sets the location of the viewer.

Usage

```
observer3d(x, y = NULL, z = NULL, auto = FALSE)
```

Arguments

<code>x, y, z</code>	The location as a 3 vector, using the usual <code>xyz.coords</code> conventions for specification. If <code>x</code> is missing or any coordinate is <code>NA</code> , no change will be made to the location.
<code>auto</code>	If <code>TRUE</code> , the location will be set automatically by rgl to make the whole bounding box visible.

Details

This function sets the location of the viewer relative to the scene, after the model transformations (scaling, rotation) have been done, but before lighting or projection have been applied. (See [par3d](#) for details on the rendering pipeline.)

The coordinate system is a slightly strange one: the `X` coordinate moves the observer location from left to right, and the `Y` coordinate moves up and down. The `Z` coordinate changes the depth from the viewer. All are measured relative to the center of the bounding box (`par("bbox")`) of the subscene. The observer always looks in the positive `Z` direction after the model rotation have been done. The coordinates are in post-scaling units.

Value

Invisibly returns the previous value.

Note

This function is likely to change in future versions of **rgl**, to allow more flexibility in the specification of the observer's location and orientation.

Author(s)

Duncan Murdoch

Examples

```
example(surface3d) # The volcano data
observer3d(0, 0, 440) # Viewed from very close up
```

 par3d *Set or Query RGL Parameters*

Description

par3d can be used to set or query graphical parameters in rgl. Parameters can be set by specifying them as arguments to par3d in tag = value form, or by passing them as a list of tagged values.

Usage

```
par3d(..., no.readonly = FALSE, dev = rgl.cur(),
      subscene = currentSubscene3d(dev))
```

```
open3d(..., params = getr3dDefaults(),
      useNULL = rgl.useNULL())
```

```
getr3dDefaults()
```

```
r3dDefaults
```

Arguments

...	arguments in tag = value form, or a list of tagged values. The tags must come from the graphical parameters described below.
no.readonly	logical; if TRUE and there are no other arguments, only those parameters which can be set by a subsequent par3d() call are returned.
dev	integer; the rgl device.
subscene	integer; the subscene.
params	a list of graphical parameters
useNULL	whether to use the null graphics device

Details

Parameters are queried by giving one or more character vectors to par3d.

par3d() (no arguments) or par3d(no.readonly = TRUE) is used to get *all* the graphical parameters (as a named list).

By default, queries and modifications apply to the current subscene on the current device; specify dev and/or subscene to change this. Some parameters apply to the device as a whole; these are marked in the list below.

open3d opens a new rgl device, and sets the parameters as requested. The r3dDefaults list returned by the getr3dDefaults function will be used as default values for parameters. As installed this sets the point of view to 'world coordinates' (i.e. x running from left to right, y from front to back, z from bottom to top), the mouseMode to (zAxis, zoom, fov), and the field of view to 30 degrees. Users may create their own variable named r3dDefaults in the global environment and it will

override the installed one. If there is a `bg` element in the list or the arguments, it should be a list of arguments to pass to the `bg3d` function to set the background.

The arguments to `open3d` may include `material`, a list of material properties as in `r3dDefaults`, but note that high level functions such as `plot3d` normally use the `r3dDefaults` values in preference to this setting.

If `useNULL` is `TRUE`, `rgl` will use a “null” device. This device records objects as they are plotted, but displays nothing. It is intended for use with `writeWebGL` and similar functions.

Value

When parameters are set, their former values are returned in an invisible named list. Such a list can be passed as an argument to `par3d` to restore the parameter values. Use `par3d(no.readonly = TRUE)` for the full list of parameters that can be restored.

When just one parameter is queried, its value is returned directly. When two or more parameters are queried, the result is a list of values, with the list names giving the parameters.

Note the inconsistency: setting one parameter returns a list, but querying one parameter returns an object.

The `r3dDefaults` variable is a list containing default settings. The `getr3dDefaults` function searches the user’s global environment for `r3dDefaults` and returns the one in the `rgl` namespace if it was not found there. The components of the list may include any settable `par3d` parameter, or “material”, which should include a list of default `material3d` properties, or “bg”, which is a list of defaults to pass to the `bg3d` function.

Parameters

R.O. indicates *read-only arguments*: These may only be used in queries, i.e., they do *not* set anything.

`antialias` ***R.O.*** in `par3d`, may be set in `open3d`. The (requested) number of hardware antialiasing planes to use (with multisample antialiasing). The OpenGL driver may not support the requested number, in which case `par3d("antialias")` will report what was actually set. Applies to the whole device.

`cex` real. The default size for text.

`family` character. The default device independent family name; see `text3d`. Applies to the whole device.

`font` integer. The default font number (from 1 to 5; see `text3d`. Applies to the whole device.

`useFreeType` logical. Should FreeType fonts be used? Applies to the whole device.

`fontname` ***R.O.***; the system-dependent name of the current font. Applies to the whole device.

`FOV` real. The field of view, from 0 to 179 degrees. This controls the degree of parallax in the perspective view. Isometric perspective corresponds to `FOV = 0`.

`ignoreExtent` logical. Set to `TRUE` so that subsequently plotted objects will be ignored in calculating the bounding box of the scene. Applies to the whole device.

`maxClipPlanes` ***R.O.***; an integer giving the maximum number of clip planes that can be defined in the current system. Applies to the whole device.

`modelMatrix` ***R.O.***; a 4 by 4 matrix describing the position of the user data. See the Note below.

- listeners** integer. A vector of subscene id values. If a subscene receives a mouse event (see `mouseMode` just below), the same action will be carried out on all subscenes in this list. (The subscene itself is normally listed as a listener. If it is not listed, it will not respond to its own mouse events.)
- mouseMode** character. A vector of 4 strings describing what the 3 mouse buttons and the mouse wheel do. Partial matching is used. Possible values for the first 3 entries of `mouseMode` (corresponding to the mouse buttons are
- "none" No action for this button.
 - "trackball" Mouse acts as a virtual trackball, rotating the scene.
 - "xAxis" Similar to "trackball", but restricted to X axis rotation.
 - "yAxis" Y axis rotation.
 - "zAxis" Z axis rotation.
 - "polar" Mouse rotates the scene by moving in polar coordinates.
 - "selecting" Mouse is used for selection. This is not normally set by the user, but is used internally by the `select3d` function.
 - "zoom" Mouse is used to zoom the display.
 - "fov" Mouse changes the field of view of the display.
 - "user" Used when a user handler is set by `rgl.setMouseCallbacks`.
- Possible values for the 4th entry corresponding to the mouse wheel are
- "none" No action.
 - "pull" Pulling on the mouse wheel increases magnification, i.e. "pulls the scene closer".
 - "push" Pulling on the mouse wheel decreases magnification, i.e. "pushes the scene away".
 - "user" Used when a user handler is set by `rgl.setWheelCallback`.
- A common default on Mac OSX is to convert a two finger drag on a trackpad to a mouse wheel rotation.
- Applies to the whole device.
- observer** **R.O.**; the position of the observer relative to the model. Set by `observer3d`. See the Note below.
- projMatrix** **R.O.**; a 4 by 4 matrix describing the current projection of the scene.
- scale** real. A vector of 3 values indicating the amount by which to rescale each axis before display. Set by `aspect3d`.
- skipRedraw** whether to update the display. Set to TRUE to suspend updating while making multiple changes to the scene. See `demo(hist3d)` for an example. Applies to the whole device.
- userMatrix** a 4 by 4 matrix describing user actions to display the scene.
- viewport** real. A vector giving the dimensions of the window in pixels. The entries are taken to be `c(x, y, width, height)` where `c(x, y)` are the coordinates in pixels of the lower left corner within the window.
- zoom** real. A positive value indicating the current magnification of the scene.
- bbox** **R.O.**; real. A vector of six values indicating the current values of the bounding box of the scene (`xmin, xmax, ymin, ymax, zmin, zmax`)
- windowRect** integer. A vector of four values indicating the left, top, right and bottom of the displayed window (in pixels). Applies to the whole device.

Rendering

The parameters returned by `par3d` are sufficient to determine where `rgl` would render a point on the screen. Given a column vector (x, y, z) in a subscene `s`, it performs the equivalent of the following operations:

1. It converts the point to homogeneous coordinates by appending $w = 1$, giving the vector $v = (x, y, z, 1)$.
2. It calculates the $M = \text{par3d}(\text{"modelMatrix"})$ as a product from right to left of the following matrices:
 - A matrix to translate the centre of the bounding box to the origin.
 - A matrix to rescale according to `par3d("scale")`.
 - The `par3d("userMatrix")` as set by the user.
 - A matrix which may be set by mouse movements.
 - If `s` has the "model" set to "modify", a similar collection of matrices using parameters from the parent subscene.
3. It multiplies the point by M giving $u = M \%*\% v$.
4. It multiplies that point by a matrix based on the observer position to translate the origin to the centre of the viewing region.
5. Using this location and information on the normals (which have been similarly transformed), it performs lighting calculations.
6. It obtains the projection matrix $P = \text{par3d}(\text{"projMatrix"})$ and multiplies the point by it giving $P \%*\% u = (x2, y2, z2, w2)$.
7. It converts back to Euclidean coordinates by dividing the first 3 coordinates by $w2$.
8. The new value $z2/w2$ represents the depth into the scene of the point. Depending on what has already been plotted, this depth might be obscured, in which case nothing more is plotted.
9. If the point is not culled due to depth, the $x2$ and $y2$ values are used to determine the point in the image. The `par3d("viewport")` values are used to translate from the range $(-1, 1)$ to pixel locations, and the point is plotted.
10. If hardware antialiasing is enabled, then the whole process is repeated multiple times (at least conceptually) with different locations in each pixel sampled to determine what is plotted there, and then the images are combined into what is displayed.

See [?matrices](#) for more information on homogeneous and Euclidean coordinates.

Note that many of these calculations are done on the graphics card using single precision; you will likely see signs of rounding error if your scene requires more than 4 or 5 digit precision to distinguish values in any coordinate.

Note

The "xAxis", "yAxis" and "zAxis" mouse modes rotate relative to the coordinate system of the data, regardless of the current orientation of the scene.

When multiple parameters are set, they are set in the order given. In some cases this may lead to warnings and ignored values; for example, some font families only support `cex = 1`, so changing both `cex` and `family` needs to be done in the right order. For example, when using the "bitmap"

family on Windows, `par3d(family = "sans", cex = 2)` will work, but `par3d(cex = 2, family = "sans")` will leave `cex` at 1 (with a warning that the "bitmap" family only supports that size).

Although `par3d("viewport")` names the entries of the reported vector, names are ignored when setting the viewport and entries must be specified in the standard order.

In **rgl** versions 0.94.x the `modelMatrix` entry had a changed meaning; before and after that it contains a copy of the OpenGL MODELVIEW matrix.

References

OpenGL Architecture Review Board (1997). OpenGL Programming Guide. Addison-Wesley.

See Also

[rgl.viewpoint](#) to set FOV and zoom.

[rgl.useNULL](#) for default usage of null device.

Examples

```
r3dDefaults
open3d()
shade3d(cube3d(color = rep(rainbow(6), rep(4, 6))))
save <- par3d(userMatrix = rotationMatrix(90*pi/180, 1, 0, 0))
save
par3d("userMatrix")
par3d(save)
par3d("userMatrix")
```

par3dinterp

Interpolator for par3d parameters

Description

Returns a function which interpolates `par3d` parameter values, suitable for use in animations.

Usage

```
par3dinterp(times = NULL, userMatrix, scale, zoom, FOV,
            method = c("spline", "linear"),
            extrapolate = c("oscillate", "cycle", "constant", "natural"),
            dev = rgl.cur(), subscene = currentSubscene3d(dev))
```

Arguments

<code>times</code>	Times at which values are recorded or a list; see below
<code>userMatrix</code>	Values of <code>par3d("userMatrix")</code>
<code>scale</code>	Values of <code>par3d("scale")</code>
<code>zoom</code>	Values of <code>par3d("zoom")</code>

FOV	Values of <code>par3d("FOV")</code>
method	Method of interpolation
extrapolate	How to extrapolate outside the time range
dev	Which rgl device to use
subscene	Which subscene to use

Details

This function is intended to be used in constructing animations. It produces a function that returns a list suitable to pass to `par3d`, to set the viewpoint at a given point in time.

All of the parameters are optional. Only those `par3d` parameters that are specified will be returned.

The input values other than `times` may each be specified as lists, giving the parameter value settings at a fixed time, or as matrices or arrays. If not lists, the following formats should be used: `userMatrix` can be a $4 \times 4 \times n$ array, or a $4 \times 4n$ matrix; `scale` should be an $n \times 3$ matrix; `zoom` and `FOV` should be length n vectors.

An alternative form of input is to put all of the above arguments into a list (i.e. a list of lists, or a list of arrays/matrices/vectors), and pass it as the first argument. This is the most convenient way to use this function with the `tkrgl` function `par3dsave`.

Interpolation is by cubic spline or linear interpolation in an appropriate coordinate-wise fashion. Extrapolation may oscillate (repeat the sequence forward, backward, forward, etc.), cycle (repeat it forward), be constant (no repetition outside the specified time range), or be natural (linear on an appropriate scale). In the case of cycling, the first and last specified values should be equal, or the last one will be dropped. Natural extrapolation is only supported with spline interpolation.

Value

A function is returned. The function takes one argument, and returns a list of `par3d` settings interpolated to that time.

Author(s)

Duncan Murdoch

See Also

`play3d` to play the animation.

Examples

```
f <- par3dinterp( zoom = c(1, 2, 3, 1) )
f(0)
f(1)
f(0.5)
## Not run:
play3d(f)

## End(Not run)
```

persp3d

*Surface plots***Description**

This function draws plots of surfaces in 3-space. `persp3d` is a generic function.

Usage

```
persp3d(x, ...)

## Default S3 method:
persp3d(x = seq(0, 1, len = nrow(z)), y = seq(0, 1, len = ncol(z)), z,
        xlim = NULL, ylim = NULL, zlim = NULL,
        xlab = NULL, ylab = NULL, zlab = NULL, add = FALSE, aspect = !add,
        forceClipregion = FALSE, ...)
```

Arguments

<code>x, y</code>	locations of grid lines at which the values in <code>z</code> are measured. These may be given as vectors or matrices. If vectors, they must be in ascending order. Either one or both may be matrices. If <code>x</code> is a list, its components <code>x\$x</code> and <code>x\$y</code> are used for <code>x</code> and <code>y</code> , respectively.
<code>z</code>	a matrix containing the values to be plotted. Note that <code>x</code> can be used instead of <code>z</code> for convenience.
<code>xlim, ylim, zlim</code>	<code>x</code> -, <code>y</code> - and <code>z</code> -limits. If present, the plot is clipped to this region.
<code>xlab, ylab, zlab</code>	titles for the axes. N.B. These must be character strings; expressions are not accepted. Numbers will be coerced to character strings.
<code>add</code>	whether to add the points to an existing plot.
<code>aspect</code>	either a logical indicating whether to adjust the aspect ratio, or a new ratio.
<code>forceClipregion</code>	force a clipping region to be used, whether or not limits are given.
<code>...</code>	additional material parameters to be passed to surface3d and decorate3d .

Details

This is similar to [persp](#) with user interaction. See [plot3d](#) for more general details.

One difference from [persp](#) is that colors are specified on each vertex, rather than on each facet of the surface. To emulate the [persp](#) color handling, you need to do the following. First, convert the color vector to an $(n_x - 1)$ by $(n_y - 1)$ matrix; then add an extra row before row 1, and an extra column after the last column, to convert it to n_x by n_y . (These extra colors will not be used). For example, `col <- rbind(1, cbind(matrix(col, n_x - 1, n_y - 1), 1))`. Finally, call `persp3d` with material property `smooth = FALSE`.

If the `x` or `y` argument is a matrix, then it must be of the same dimension as `z`, and the values in the matrix will be used for the corresponding coordinates. This is used to plot shapes such as spheres or cylinders where `z` is not a function of `x` and `y`. See the fourth and fifth examples below.

See the “Clipping” section in [plot3d](#) for more details on `xlim`, `ylim`, `zlim` and `forceClipregion`.

Value

This function is called for the side effect of drawing the plot. A vector of shape IDs is returned invisibly.

Author(s)

Duncan Murdoch

See Also

[plot3d](#), [persp](#). There is a [persp3d.function](#) method for drawing functions.

Examples

```
# (1) The Obligatory Mathematical surface.
#   Rotated sinc function.

x <- seq(-10, 10, length = 30)
y <- x
f <- function(x, y) { r <- sqrt(x^2 + y^2); 10 * sin(r)/r }
z <- outer(x, y, f)
z[is.na(z)] <- 1
open3d()
bg3d("white")
material3d(col = "black")
persp3d(x, y, z, aspect = c(1, 1, 0.5), col = "lightblue",
        xlab = "X", ylab = "Y", zlab = "Sinc( r )")

# (2) Add to existing persp plot:

xE <- c(-10, 10); xy <- expand.grid(xE, xE)
points3d(xy[, 1], xy[, 2], 6, col = "red")
lines3d(x, y = 10, z = 6 + sin(x), col = "green")

phi <- seq(0, 2*pi, len = 201)
r1 <- 7.725 # radius of 2nd maximum
xr <- r1 * cos(phi)
yr <- r1 * sin(phi)
lines3d(xr, yr, f(xr, yr), col = "pink", lwd = 2)

# (3) Visualizing a simple DEM model

z <- 2 * volcano           # Exaggerate the relief
x <- 10 * (1:nrow(z))     # 10 meter spacing (S to N)
y <- 10 * (1:ncol(z))     # 10 meter spacing (E to W)
```

```

open3d()
bg3d("slategray")
material3d(col = "black")
persp3d(x, y, z, col = "green3", aspect = "iso",
        axes = FALSE, box = FALSE)

# (4) A globe

lat <- matrix(seq(90, -90, len = 50)*pi/180, 50, 50, byrow = TRUE)
long <- matrix(seq(-180, 180, len = 50)*pi/180, 50, 50)

r <- 6378.1 # radius of Earth in km
x <- r*cos(lat)*cos(long)
y <- r*cos(lat)*sin(long)
z <- r*sin(lat)

open3d()
persp3d(x, y, z, col = "white",
        texture = system.file("textures/worldsmall.png", package = "rgl"),
        specular = "black", axes = FALSE, box = FALSE, xlab = "", ylab = "", zlab = "",
        normal_x = x, normal_y = y, normal_z = z)
if (!rgl.useNULL())
  play3d(spin3d(axis = c(0, 0, 1), rpm = 16), duration = 2.5)

## Not run:
# This looks much better, but is slow because the texture is very big
persp3d(x, y, z, col = "white",
        texture = system.file("textures/world.png", package = "rgl"),
        specular = "black", axes = FALSE, box = FALSE, xlab = "", ylab = "", zlab = "",
        normal_x = x, normal_y = y, normal_z = z)

## End(Not run)

```

persp3d.function *Plot a function of two variables*

Description

Plot a function $z(x, y)$ or a parametric function $(x(s, t), y(s, t), z(s, t))$.

Usage

```

## S3 method for class 'function'
persp3d(x,
        xlim = c(0, 1), ylim = c(0, 1),
        slim = NULL, tlim = NULL,
        n = 101,
        xvals = seq.int(min(xlim), max(xlim), length.out = n[1]),
        yvals = seq.int(min(ylim), max(ylim), length.out = n[2]),

```

```

svals = seq.int(min(slim), max(slim), length.out = n[1]),
tvals = seq.int(min(tlim), max(tlim), length.out = n[2]),
xlab, ylab, zlab,
col = "gray", otherargs = list(),
normal = NULL, texture = NULL, ...)
## S3 method for class 'function'
plot3d(x, ...)

```

Arguments

<code>x</code>	A function of two arguments. See the details below.
<code>xlim, ylim</code>	By default, the range of <code>x</code> and <code>y</code> values. For a parametric surface, if these are not missing, they are used as limits on the displayed <code>x</code> and <code>y</code> values.
<code>slim, tlim</code>	If not <code>NULL</code> , these give the range of <code>s</code> and <code>t</code> in the parametric specification of the surface. If only one is given, the other defaults to <code>c(0, 1)</code> .
<code>n</code>	A one or two element vector giving the number of steps in the <code>x</code> and <code>y</code> (or <code>s</code> and <code>t</code>) grid.
<code>xvals, yvals</code>	The values at which to evaluate <code>x</code> and <code>y</code> . Ignored for a parametric surface. If used, <code>xlim</code> and/or <code>ylim</code> are ignored.
<code>svals, tvals</code>	The values at which to evaluate <code>s</code> and <code>t</code> for a parametric surface. Only used if <code>slim</code> or <code>tlim</code> is not <code>NULL</code> . As with <code>xvals</code> and <code>yvals</code> , these override the corresponding <code>slim</code> or <code>tlim</code> specification.
<code>xlab, ylab, zlab</code>	The axis labels. See the details below for the defaults.
<code>col</code>	The color to use for the plot. See the details below.
<code>otherargs</code>	Additional arguments to pass to the function.
<code>normal, texture</code>	Functions to set surface normals or texture coordinates. See the details below.
<code>...</code>	Additional arguments to pass to persp3d .

Details

The "function" method for `plot3d` simply passes all arguments to `persp3d`. Thus this description applies to both.

The first argument `x` is required to be a function. It is named `x` only because of the requirements of the S3 system; in the remainder of this help page, we will assume that the assignment `f <- x` has been made, and will refer to the function `f()`.

`persp3d.function` evaluates `f()` on a two-dimensional grid of values, and displays the resulting surface. The values on the grid will be passed in as vectors in the first two arguments to the function, so `f()` needs to be vectorized. Other optional arguments to `f()` can be specified in the `otherargs` list.

In the default form where `slim` and `tlim` are both `NULL`, it is assumed that `f(x, y)` returns heights, which will be plotted in the `z` coordinate. The default axis labels will be taken from the argument names to `f()` and the expression passed as argument `x` to this function.

If `slim` or `tlim` is specified, a parametric surface is plotted. The function $f(s, t)$ must return a 3-column matrix, giving x , y and z coordinates of points on the surface. The default axis labels will be the column names if those are present. In this case `xlim`, `ylim` and `zlim` are used to define a clipping region only if specified; the defaults are ignored.

The color of the surface may be specified as the name of a color, or a vector or matrix of color names. In this case the colors will be recycled across the points on the grid of values.

Alternatively, a function may be given: it should be a function like `rainbow` that takes an integer argument and returns a vector of colors. In this case the colors are mapped to z values.

The `normal` argument allows specification of a function to compute normal vectors to the surface. This function is passed the same arguments as $f()$ (including `otherargs` if present), and should produce a 3-column matrix containing the x , y and z coordinates of the normals.

The `texture` argument is a function similar to `normal`, but it produces a 2-column matrix containing texture coordinates.

Both `normal` and `texture` may also contain matrices, with 3 and 2 columns respectively, and rows corresponding to the points that were passed to $f()$.

Value

This function constructs a call to `persp3d` and returns the value from that function.

Author(s)

Duncan Murdoch

See Also

The `curve` function in base graphics does something similar for functions of one variable. See the example below for space curves.

Examples

```
# (1) The Obligatory Mathematical surface.
#   Rotated sinc function, with colors

f <- function(x, y) {
  r <- sqrt(x^2 + y^2)
  ifelse(r == 0, 10, 10 * sin(r)/r)
}
open3d()
plot3d(f, col = colorRampPalette(c("blue", "white", "red")),
       xlab = "X", ylab = "Y", zlab = "Sinc( r )",
       xlim = c(-10, 10), ylim = c(-10, 10),
       aspect = c(1, 1, 0.5))

# (2) A cylindrical plot

f <- function(s, t) {
  r <- 1 + exp( -pmin( (s - t)^2,
                     (s - t - 1)^2,
```

```

                                (s - t + 1)^2 )/0.01 )
  cbind(r*cos(t*2*pi), r*sin(t*2*pi), s)
}

open3d()
plot3d(f, slim = c(0, 1), tlim = c(0, 1), col = "red", alpha = 0.8)

# Add a curve to the plot, fixing s at 0.5.

plot3d(f(0.5, seq.int(0, 1, length.out = 100)), type = "l", add = TRUE,
      lwd = 3, depth_test = "lequal")

```

planes3d

add planes

Description

planes3d and rgl.planes add mathematical planes to a scene. Their intersection with the current bounding box will be drawn. clipplanes3d and rgl.clipplanes add clipping planes to a scene.

Usage

```

planes3d(a, b = NULL, c = NULL, d = 0, ...)
rgl.planes(a, b = NULL, c = NULL, d = 0, ...)
clipplanes3d(a, b = NULL, c = NULL, d = 0)
rgl.clipplanes(a, b = NULL, c = NULL, d = 0)

```

Arguments

a, b, c	Coordinates of the normal to the plane. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
d	Coordinates of the "offset". See the details.
...	Material properties. See rgl.material for details.

Details

planes3d and rgl.planes draw planes using the parametrization $ax + by + cz + d = 0$. Multiple planes may be specified by giving multiple values for any of a, b, c, d; the other values will be recycled as necessary.

clipplanes3d and rgl.clipplanes define clipping planes using the same equations. Clipping planes suppress the display of other objects (or parts of them) in the subscene, based on their coordinates. Points (or parts of lines or surfaces) where the coordinates x, y, z satisfy $ax + by + cz + d < 0$ will be suppressed.

The number of clipping planes supported by the OpenGL driver is implementation dependent; use `par3d("maxClipPlanes")` to find the limit.

Value

A shape ID of the planes or clipplanes object is returned invisibly.

See Also

[abclines3d](#), [rgl.abclines](#) for mathematical lines.

[triangles3d](#), [rgl.triangles](#) or the corresponding functions for quadrilaterals may be used to draw sections of planes that do not adapt to the bounding box.

The example in [subscene3d](#) shows how to combine clipping planes to suppress complex shapes.

Examples

```
# Show regression plane with z as dependent variable

open3d()
x <- rnorm(100)
y <- rnorm(100)
z <- 0.2*x - 0.3*y + rnorm(100, sd = 0.3)
fit <- lm(z ~ x + y)
plot3d(x, y, z, type = "s", col = "red", size = 1)

coefs <- coef(fit)
a <- coefs["x"]
b <- coefs["y"]
c <- -1
d <- coefs["(Intercept)"]
planes3d(a, b, c, d, alpha = 0.5)

open3d()
ids <- plot3d(x, y, z, type = "s", col = "red", size = 1, forceClipregion = TRUE)
useSubscene3d(ids["clipregion"])
clipplanes3d(a, b, c, d)
```

play3d

Play animation of rgl scene

Description

play3d calls a function repeatedly, passing it the elapsed time in seconds, and using the result of the function to reset the viewpoint. movie3d does the same, but records each frame to a file to make a movie.

Usage

```

play3d(f, duration = Inf, dev = rgl.cur(), ..., startTime = 0)
movie3d(f, duration, dev = rgl.cur(), ..., fps = 10,
        movie = "movie", frames = movie, dir = tempdir(),
        convert = TRUE, clean = TRUE, verbose = TRUE,
        top = TRUE, type = "gif", startTime = 0)

```

Arguments

<code>f</code>	A function returning a list that may be passed to par3d
<code>duration</code>	The duration of the animation
<code>dev</code>	Which rgl device to select
<code>...</code>	Additional parameters to pass to <code>f</code> .
<code>startTime</code>	Initial time at which to start the animation
<code>fps</code>	Number of frames per second
<code>movie</code>	The base of the output filename, not including <code>.gif</code>
<code>frames</code>	The base of the name for each frame
<code>dir</code>	A directory in which to create temporary files for each frame of the movie
<code>convert</code>	Whether to try to convert the frames to a single GIF movie, or a command to do so
<code>clean</code>	If <code>convert</code> is TRUE, whether to delete the individual frames
<code>verbose</code>	Whether to report the <code>convert</code> command and the output filename
<code>top</code>	Whether to call rgl.bringtotop before each frame
<code>type</code>	What type of movie to create. See Details.

Details

The function `f` will be called in a loop with the first argument being the `startTime` plus the time in seconds since the start (where the start is measured after all arguments have been evaluated).

`play3d` is likely to place a high load on the CPU; if this is a problem, calls to [Sys.sleep](#) should be made within the function to release time to other processes.

`play3d` will run for the specified `duration` (in seconds), but can be interrupted by pressing ESC while the rgl window has the focus.

`movie3d` saves each frame to disk in a filename of the form `'framesXXX.png'`, where XXX is the frame number, starting from 0. If `convert` is TRUE, it uses ImageMagick to convert them to a single file, by default an animated GIF. The `type` argument will be passed to ImageMagick to use as a file extension to choose the file type.

Alternatively, `convert` can be a template for a command to execute in the standard shell (wildcards are allowed). The template is converted to a command using

```
sprintf(convert, fps, frames, movie, type, dir, duration)
```

For example, `code = TRUE` uses the template `"convert -delay 1x%d %s*.png %s.%s"`. All work

is done in the directory `dir`, so paths should not be needed in the command. (Note that `sprintf` does not require all arguments to be used, and supports formats that use them in an arbitrary order.)

The `top = TRUE` default is designed to work around an OpenGL limitation: in some implementations, `rgl.snapshot` will fail if the window is not topmost.

As of `rgl` version 0.94, the `dev` argument is not needed: the function `f` can specify its device, as `spin3d` does, for example. However, if `dev` is specified, it will be selected as the current device as each update is played.

Value

This function is called for the side effect of its repeated calls to `f`. It returns `NULL` invisibly.

Author(s)

Duncan Murdoch, based on code by Michael Friendly

See Also

`spin3d` and `par3dinterp` return functions suitable to use as `f`. See `demo(flag)` for an example that modifies the scene in `f`.

Examples

```
open3d()
plot3d( cube3d(col = "green") )
M <- par3d("userMatrix")
if (!rgl.useNULL())
  play3d( par3dinterp(time = (0:2)*0.75, userMatrix = list(M,
                                                         rotate3d(M, pi/2, 1, 0, 0),
                                                         rotate3d(M, pi/2, 0, 1, 0) ) ),
         duration = 3 )
## Not run:
movie3d( spin3d(), duration = 5 )

## End(Not run)
```

plot3d

3D Scatterplot

Description

Draws a 3D scatterplot.

Usage

```

plot3d(x, ...)
## Default S3 method:
plot3d(x, y, z,
       xlab, ylab, zlab, type = "p", col,
       size, lwd, radius,
       add = FALSE, aspect = !add,
       xlim = NULL, ylim = NULL, zlim = NULL,
       forceClipregion = FALSE, ...)
## S3 method for class 'mesh3d'
plot3d(x, xlab = "x", ylab = "y", zlab = "z", type = c("shade", "wire", "dots"),
       add = FALSE, ...)
decorate3d(xlim, ylim, zlim,
           xlab = "x", ylab = "y", zlab = "z",
           box = TRUE, axes = TRUE, main = NULL, sub = NULL,
           top = TRUE, aspect = FALSE, expand = 1.03,
           ...)

```

Arguments

<code>x, y, z</code>	vectors of points to be plotted. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
<code>xlab, ylab, zlab</code>	labels for the coordinates.
<code>type</code>	For the default method, a single character indicating the type of item to plot. Supported types are: 'p' for points, 's' for spheres, 'l' for lines, 'h' for line segments from $z = 0$, and 'n' for nothing. For the mesh3d method, one of 'shade', 'wire', or 'dots'. Partial matching is used.
<code>col</code>	the color to be used for plotted items.
<code>size</code>	the size for plotted points.
<code>lwd</code>	the line width for plotted items.
<code>radius</code>	the radius of spheres: see Details below.
<code>add</code>	whether to add the points to an existing plot.
<code>aspect</code>	either a logical indicating whether to adjust the aspect ratio, or a new ratio.
<code>expand</code>	how much to expand the box around the data, if it is drawn.
<code>xlim, ylim, zlim</code>	In plot3d, if not NULL, set clipping limits for the plot. In decorate3d, these are used for the labels.
<code>forceClipregion</code>	Force a clipping region to be used, whether or not limits are given.
<code>...</code>	additional parameters which will be passed to par3d , material3d or decorate3d .
<code>box, axes</code>	whether to draw a box and axes.
<code>main, sub</code>	main title and subtitle.
<code>top</code>	whether to bring the window to the top when done.

Details

plot3d is a partial 3D analogue of plot.default.

Missing values in the data are skipped, as in standard graphics.

If aspect is TRUE, aspect ratios of $c(1, 1, 1)$ are passed to [aspect3d](#). If FALSE, no aspect adjustment is done. In other cases, the value is passed to [aspect3d](#).

With `type = "s"`, spheres are drawn centered at the specified locations. The radius may be controlled by `size` (specifying the size relative to the plot display, with the default `size = 3` giving a radius about 1/20 of the plot region) or `radius` (specifying it on the data scale if an isometric aspect ratio is chosen, or on an average scale if not).

Value

plot3d is called for the side effect of drawing the plot; a vector of object IDs is returned.

decorate3d adds the usual decorations to a plot: labels, axes, etc.

Clipping

If any of `xlim`, `ylim` or `zlim` are specified, they should be length two vectors giving lower and upper clipping limits for the corresponding coordinate. NA limits will be ignored.

If any clipping limits are given, then the data will be plotted in a newly created subscene within the current one; otherwise plotting will take place directly in the current subscene. This subscene is named "clipregion" in the results.

Use `forceClipregion = TRUE` to force creation of this subscene even without specifying limits.

Author(s)

Duncan Murdoch

See Also

[plot.default](#), [open3d](#), [par3d](#). There is a [plot3d.function](#) method for plotting surfaces.

Examples

```
open3d()
x <- sort(rnorm(1000))
y <- rnorm(1000)
z <- rnorm(1000) + atan2(x, y)
plot3d(x, y, z, col = rainbow(1000))
```

points3d

add primitive set shape

Description

Adds a shape node to the current scene

Usage

```
points3d(x, y = NULL, z = NULL, ...)
lines3d(x, y = NULL, z = NULL, ...)
segments3d(x, y = NULL, z = NULL, ...)
triangles3d(x, y = NULL, z = NULL, ...)
quads3d(x, y = NULL, z = NULL, ...)
```

Arguments

<code>x, y, z</code>	coordinates. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
<code>...</code>	Material properties (see rgl.material). For normals use <code>normals</code> and for texture coordinates use <code>texcoords</code> ; see rgl.primitive for details.

Details

The functions `points3d`, `lines3d`, `segments3d`, `triangles3d` and `quads3d` add points, joined lines, line segments, filled triangles or quadrilaterals to the plots. They correspond to the OpenGL types `GL_POINTS`, `GL_LINE_STRIP`, `GL_LINES`, `GL_TRIANGLES` and `GL_QUADS` respectively.

Points are taken in pairs by `segments3d`, triplets as the vertices of the triangles, and quadruplets for the quadrilaterals. Colors are applied vertex by vertex; if different at each end of a line segment, or each vertex of a polygon, the colors are blended over the extent of the object. Quadrilaterals must be entirely in one plane and convex, or the results are undefined.

These functions call the lower level functions [rgl.points](#), [rgl.linestrips](#), and so on, and are provided for convenience.

The appearance of the new objects are defined by the material properties. See [rgl.material](#) for details.

The two principal differences between the `rgl.*` functions and the `*3d` functions are that the former set all unspecified material properties to defaults, whereas the latter use current values as defaults; the former make persistent changes to material properties with each call, whereas the latter make temporary changes only for the duration of the call.

Value

Each function returns the integer object ID of the shape that was added to the scene. These can be passed to [rgl.pop](#) to remove the object from the scene.

Author(s)

Ming Chen and Duncan Murdoch

Examples

```

# Show 12 random vertices in various ways.

M <- matrix(rnorm(36), 3, 12, dimnames = list(c('x', 'y', 'z'),
                                             rep(LETTERS[1:4], 3)))

# Force 4-tuples to be convex in planes so that quads3d works.

for (i in c(1, 5, 9)) {
  quad <- as.data.frame(M[, i + 0:3])
  coeffs <- runif(2, 0, 3)
  if (mean(coeffs) < 1) coeffs <- coeffs + 1 - mean(coeffs)
  quad$C <- with(quad, coeffs[1]*(B - A) + coeffs[2]*(D - A) + A)
  M[, i + 0:3] <- as.matrix(quad)
}

open3d()

# Rows of M are x, y, z coords; transpose to plot

M <- t(M)
shift <- matrix(c(-3, 3, 0), 12, 3, byrow = TRUE)

points3d(M)
lines3d(M + shift)
segments3d(M + 2*shift)
triangles3d(M + 3*shift, col = 'red')
quads3d(M + 4*shift, col = 'green')
text3d(M + 5*shift, texts = 1:12)

# Add labels

shift <- outer(0:5, shift[, 1, ])
shift[, 1] <- shift[, 1] + 3
text3d(shift,
        texts = c('points3d', 'lines3d', 'segments3d',
                  'triangles3d', 'quads3d', 'text3d'),
        adj = 0)
rgl.bringtotop()

```

polygon3d

Triangulate and draw a polygon in three dimensions.

Description

This function takes a description of a flat polygon in x, y and z coordinates, and draws it in three dimensions.

Usage

```

polygon3d(x, y = NULL, z = NULL, fill = TRUE, plot = TRUE,
          coords = 1:2, random = TRUE, ...)

```

Arguments

x, y, z	Vertices of the polygon in a form accepted by xyz.coords .
fill	logical; should the polygon be filled?
plot	logical; should the polygon be displayed?
coords	Which two coordinates (x = 1, y = 2, z = 3) describe the polygon.
random	Should a random triangulation be used?
...	Other parameters to pass to lines3d or shade3d if plot = TRUE.

Details

The function triangulates the two dimensional polygon described by `coords`, then applies the triangulation to all three coordinates. No check is made that the polygon is actually all in one plane, but the results may be somewhat unpredictable (especially if `random = TRUE`) if it is not.

Polygons need not be simple; use NA to indicate separate closed pieces. For `fill = FALSE` there are no other restrictions on the pieces, but for `fill = TRUE` the resulting two-dimensional polygon needs to be one that [triangulate](#) can handle.

Value

If `plot = TRUE`, the id number of the lines (for `fill = FALSE`) or triangles (for `fill = TRUE`) that have been plotted.

If `plot = FALSE`, then for `fill = FALSE`, a vector of indices into the XYZ matrix that could be used to draw the polygon. For `fill = TRUE`, a triangular mesh object representing the triangulation.

Author(s)

Duncan Murdoch

See Also

[extrude3d](#) for a solid extrusion of a polygon, [triangulate](#) for the triangulation.

Examples

```

theta <- seq(0, 4*pi, len = 50)
r <- theta + 1
r <- c(r[-50], rev(theta*0.8) + 1)
theta <- c(theta[-50], rev(theta))
x <- r*cos(theta)
y <- r*sin(theta)
plot(x, y, type = "n")
polygon(x, y)
polygon3d(x, y, x + y, col = "blue")

```

propertySetter *Write HTML/Javascript code to control a WebGL display.*

Description

propertySlider writes out HTML code to control WebGL displays on the same page via a slider; par3dinterpSetter and propertySetter return Javascript code to be used in HTML controls.

Usage

```
propertySlider(setter = propertySetter,
               minS = min(param), maxS = max(param), step = 1, init = minS,
               labels = displayVals(sliderVals),
               id = basename(tempfile("input")), name = id,
               outputid = paste0(id, "text"),
               ...)

propertySetter(values, entries, properties, objids, prefixes = "",
               param = seq_len(NROW(values)), interp = TRUE, digits = 7)

par3dinterpSetter(fn, from, to, steps, subscene, omitConstant = TRUE, ...)
```

Arguments

setter	A function to write Javascript code, or its output, or a list containing several of these.
minS, maxS, step, init	Slider values to be displayed.
labels	Labels to display for each slider value. The defaults are calculated using internal variables. If NULL, no labels will be shown.
id	The id of the input control that will be generated.
name	The name of the input control that will be generated.
outputid	The id of the output control that will display the slider value, or NULL for none.
...	See Details below.
values	An array of values; rows correspond to slider positions.
entries, properties, objids, prefixes	Vectors describing the columns of values. See the details below.
param	Parameter values corresponding to each row of values.
interp	Whether to interpolate values. If FALSE, the Javascript function will expect non-negative integer values.
digits	How many significant digits to emit in the Javascript code.
fn	A function returned from par3dinterp .
from, to, steps	Values where fn should be evaluated.

subscene	Which subscene's properties should be modified?
omitConstant	If TRUE, do not set values that are constant across the range.

Details

The ... parameters to `propertySlider` will be passed to `setter` if the latter is a function, otherwise ignored.

The ... parameters to `par3dinterpSetter` will be passed to `propertySetter`.

`propertySetter` is a low-level general purpose function for modifying properties of objects in the scene. It is mainly for internal use. `propertySlider` uses it to generate Javascript for a slider control to manipulate those properties. `par3dinterpSetter` uses it to set parameters corresponding to values produced by the result of `par3dinterp`.

The rows of the values matrix correspond to different settings for numeric properties. The columns are values to insert into those properties.

Argument `entries` gives the numeric (zero based) index into the Javascript property named by `properties`, for the object id `objids`, in the display with prefix `prefixes`. All of these may be vectors, corresponding to the columns of values. All but `entries` will be recycled to the appropriate length; its length needs to match the number of columns in values.

There are two modes for determining the values to substitute. In the simplest mode (`interp = FALSE` in `propertySetter`), each row of values corresponds to a location for the slider, and the values are simply copied into place. This requires that `param`, `min`, `max` and `step` take on their default values.

In other cases, linear interpolation is used between successive rows of values, with extrapolation outside the range of `param` repeating the first or last row. `param` should then contain the values that correspond to exact rows.

In both cases, `param` must be a strictly increasing vector.

Value

`propertySlider` prints the full code to generate the control, and returns the id of the control that was generated.

`propertySetter` returns a single element character vector containing the Javascript source for a function to set the appropriate properties. It does not assign the function to a variable or include any of the HTML wrapper text that `propertySlider` adds.

The character vector has class `"propertySetter"`, and an attribute named `"env"` which gives access to the local environment where it was created, so for example `attr(value, "env")$prefixes` will give access to the `prefixes` argument if `value` was produced by `"propertySetter"`.

Author(s)

Duncan Murdoch

See Also

[writeWebGL.clipplaneSlider](#) makes use of `propertySlider`.

[ageSetter](#) can be used as the `setter` argument to `propertySlider` to modify objects according to a linear (age) scale.

Examples

```
# Just the setter function
cat(propertySetter(1:4, entries = 12, properties = "values", objids = 13))

# A 4-position slider
propertySlider(values = 1:4, entries = 12, properties = "values", objids = 13, interp = FALSE)

# A 10-position slider interpolating the 4-position slider
propertySlider(values = 1:4, entries = 12, properties = "values", objids = 13,
               step = (4-1)/9)

# The userMatrix interpolation from example(play3d)
M <- r3dDefaults$userMatrix
fn <- par3dinterp(time = (0:2)*0.75, userMatrix = list(M,
                                                       rotate3d(M, pi/2, 1, 0, 0),
                                                       rotate3d(M, pi/2, 0, 1, 0) ) )
cat(par3dinterpSetter(fn, 0, 3, steps=10))
```

r3d

Generic 3D interface

Description

Generic 3D interface for 3D rendering and computational geometry.

Details

R3d is a design for an interface for 3d rendering and computation without dependency on a specific rendering implementation. R3d includes a collection of 3D objects and geometry algorithms. All r3d interface functions are named *3d. They represent generic functions that delegate to implementation functions.

The interface can be grouped into 8 categories: Scene Management, Primitive Shapes, High-level Shapes, Geometry Objects, Visualization, Interaction, Transformation, Subdivision.

The rendering interface gives an abstraction to the underlying rendering model. It can be grouped into four categories:

Scene Management: A 3D scene consists of shapes, lights and background environment.

Primitive Shapes: Generic primitive 3D graphics shapes such as points, lines, triangles, quadrangles and texts.

High-level Shapes: Generic high-level 3D graphics shapes such as spheres, sprites and terrain.

Interaction: Generic interface to select points in 3D space using the pointer device.

In this package we include an implementation of r3d using the underlying rgl.* functions.

3D computation is supported through the use of object structures that live entirely in R.

Geometry Objects: Geometry and mesh objects allow to define high-level geometry for computational purpose such as triangle or quadrangle meshes (see [mesh3d](#)).

Transformation: Generic interface to transform 3d objects.

Visualization: Generic rendering of 3d objects such as dotted, wired or shaded.

Computation: Generic subdivision of 3d objects.

At present, the main practical differences between the r3d functions and the rgl.* functions are as follows.

The r3d functions call `open3d` if there is no device open, and the rgl.* functions call `rgl.open`. By default `open3d` sets the initial orientation of the coordinate system in 'world coordinates', i.e. a right-handed coordinate system in which the x-axis increases from left to right, the y-axis increases with depth into the scene, and the z-axis increases from bottom to top of the screen. rgl.* functions, on the other hand, use a right-handed coordinate system similar to that used in OpenGL. The x-axis matches that of r3d, but the y-axis increases from bottom to top, and the z-axis decreases with depth into the scene. Since the user can manipulate the scene, either system can be rotated into the other one.

The r3d functions also preserve the `rgl.material` setting across calls (except for texture elements, in the current implementation), whereas the rgl.* functions leave it as set by the last call.

The example code below illustrates the two coordinate systems.

See Also

[points3d](#), [lines3d](#), [segments3d](#), [triangles3d](#), [quads3d](#), [text3d](#), [spheres3d](#), [sprites3d](#), [terrain3d](#), [select3d](#), [dot3d](#), [wire3d](#), [shade3d](#), [transform3d](#), [rotate3d](#), [subdivision3d](#), [mesh3d](#), [cube3d](#), [rgl](#)

Examples

```
x <- c(0, 1, 0, 0)
y <- c(0, 0, 1, 0)
z <- c(0, 0, 0, 1)
labels <- c("Origin", "X", "Y", "Z")
i <- c(1, 2, 1, 3, 1, 4)

# rgl.* interface

rgl.open()
rgl.texts(x, y, z, labels)
rgl.texts(1, 1, 1, "rgl.* coordinates")
rgl.lines(x[i], y[i], z[i])

# *3d interface

open3d()
text3d(x, y, z, labels)
text3d(1, 1, 1, "*3d coordinates")
segments3d(x[i], y[i], z[i])
```

readSTL	<i>Read and write STL (stereolithography) format files</i>
---------	--

Description

These functions read and write STL files. This is a simple file format that is commonly used in 3D printing. It does not represent text, only triangles. The `writeSTL` function converts some RGL object types to triangles.

Usage

```
readSTL(con, ascii = FALSE, plot = TRUE, ...)
writeSTL(con, ascii = FALSE,
         pointRadius = 0.005,
         pointShape = icosahedron3d(),
         lineRadius = pointRadius,
         lineSides = 20,
         ids = NULL)
```

Arguments

<code>con</code>	A connection or filename.
<code>ascii</code>	Whether to use the ASCII format or the binary format.
<code>plot</code>	On reading, should the object be plotted?
<code>...</code>	If plotting, other parameters to pass to triangles3d
<code>pointRadius</code> , <code>lineRadius</code>	The radius of points and lines relative to the overall scale of the figure.
<code>pointShape</code>	A mesh shape to use for points. It is scaled by the <code>pointRadius</code> .
<code>lineSides</code>	Lines are rendered as cylinders with this many sides.
<code>ids</code>	The identifiers (from rgl.ids) of the objects to write. If NULL, try to write everything.

Details

The current implementation is limited. For reading, it ignores normals and color information. For writing, it only outputs triangles, quads, planes, spheres, points, line segments, line strips and surfaces, and does not write color information. Lines and points are rendered in an isometric scale: if your data scales vary, they will look strange.

Since the STL format only allows one object per file, all RGL objects are combined into a single object when output.

The output file is readable by Blender and Meshlab; the latter can write in a number of other formats, including U3D, suitable for import into a PDF document.

Value

readSTL invisibly returns the object id if plot = TRUE, or (visibly) a matrix of vertices of the triangles if not.

writeSTL invisibly returns the name of the connection to which the data was written.

Author(s)

Duncan Murdoch

References

The file format was found on Wikipedia on October 25, 2012. I learned about the STL file format from David Smith's blog reporting on Ian Walker's r2stl function.

See Also

[scene3d](#) saves a copy of a scene to an R variable; [writeWebGL](#), [writePLY](#), [writeOBJ](#) and [writeSTL](#) write the scene to a file in various other formats.

Examples

```
filename <- tempfile(fileext = ".stl")
open3d()
shade3d( icosahedron3d(col = "magenta") )
writeSTL(filename)
open3d()
readSTL(filename, col = "red")
```

rgl.attrib

Get information about shapes

Description

Retrieves information about the shapes in a scene.

Usage

```
rgl.attrib.count(id, attrib)
rgl.attrib(id, attrib, first = 1,
last = rgl.attrib.count(id, attrib))
```

Arguments

id	A shape identifier, as returned by rgl.ids .
attrib	An attribute of a shape. Currently supported: one of "vertices", "normals", "colors", "texcoords", "dim", "texts", "cex", "adj", "radii", "centers", "ids", "usermatrix", "types", "flags" or unique prefixes to one of those.
first, last	Specify these to retrieve only those rows of the result.

Details

If the identifier is not found or is not a shape that has the given attribute, zero will be returned by `rgl.attrib.count`, and an empty matrix will be returned by `rgl.attrib`.

The first four `attrib` names correspond to the usual OpenGL properties; "dim" is used just for surfaces, defining the rows and columns in the rectangular grid; "cex" and "adj" apply only to text objects.

Value

`rgl.attrib.count` returns the count of the requested attribute. `rgl.attrib` returns the values of the attribute. Attributes are mostly real-valued, with the following sizes:

"vertices"	3 values	x, y, z
"normals"	3 values	x, y, z
"centers"	3 values	x, y, z
"colors"	4 values	r, g, b, a
"texcoords"	2 values	s, t
"dim"	2 values	r, c
"cex"	1 value	cex
"adj"	2 values	x, y
"radii"	1 value	r
"ids"	1 value	id
"usermatrix"	4 values	x, y, z, w
"texts"	1 value	text
"types"	1 value	type
"flags"	1 value	flag

The "texts" and "types" attributes are character-valued; the flags attribute is logical valued, with named rows.

These are returned as matrices with the row count equal to the count for the attribute, and the columns as listed above.

Author(s)

Duncan Murdoch

See Also

[rgl.ids](#)

Examples

```
p <- plot3d(rnorm(100), rnorm(100), rnorm(100), type = "s", col = "red")
rgl.attrib.count(p["data"], "vertices")
rgl.attrib(p["data"], "vertices", last = 10)
```

 rgl.bbox

 Set up Bounding Box decoration

Description

Set up the bounding box decoration.

Usage

```
rgl.bbox(
  xat = NULL, xlab = NULL, xunit = 0, xlen = 5,
  yat = NULL, ylab = NULL, yunit = 0, ylen = 5,
  zat = NULL, zlab = NULL, zunit = 0, zlen = 5,
  marklen = 15.0, marklen.rel = TRUE, expand = 1,
  draw_front = FALSE, ...)
bbox3d(xat = NULL, yat = NULL, zat = NULL,
  xunit = "pretty", yunit = "pretty", zunit = "pretty",
  expand = 1.03, nticks = 5,
  draw_front = FALSE, ...)
```

Arguments

xat, yat, zat	vector specifying the tickmark positions
xlab, ylab, zlab	character vector specifying the tickmark labeling
xunit, yunit, zunit	value specifying the tick mark base for uniform tick mark layout
xlen, ylen, zlen	value specifying the number of tickmarks
marklen	value specifying the length of the tickmarks
marklen.rel	logical, if TRUE tick mark length is calculated using $1/\text{marklen} * \text{axis length}$, otherwise tick mark length is marklen in coordinate space
expand	value specifying how much to expand the bounding box around the data
nticks	suggested number of ticks to use on axes
draw_front	draw the front faces of the bounding box
...	Material properties (or other rgl.bbox parameters in the case of bbox3d). See rgl.material for details.

Details

Four different types of tick mark layouts are possible. If `at` is not NULL, the ticks are set up at custom positions. If `unit` is numeric but not zero, it defines the tick mark base. If it is "pretty" (the default in `bbox3d`), ticks are set at [pretty](#) locations. If `length` is not zero, it specifies the number of ticks that are automatically specified. The first color specifies the bounding box, while the second one specifies the tick mark and font color.

bbox3d defaults to [pretty](#) locations for the axis labels and a slightly larger box, whereas `rgl.bbox` covers the exact range.

[axes3d](#) offers more flexibility in the specification of the axes, but they are static, unlike those drawn by `rgl.bbox` and `bbox3d`.

Value

This function is called for the side effect of setting the bounding box decoration. A shape ID is returned to allow `rgl.pop` to delete it.

See Also

[rgl.material](#), [axes3d](#)

Examples

```
rgl.open()
rgl.points(rnorm(100), rnorm(100), rnorm(100))
rgl.bbox(color = c("#333377", "white"), emission = "#333377",
         specular = "#3333FF", shininess = 5, alpha = 0.8 )

open3d()
points3d(rnorm(100), rnorm(100), rnorm(100))
bbox3d(color = c("#333377", "black"), emission = "#333377",
       specular = "#3333FF", shininess = 5, alpha = 0.8)
```

<code>rgl.bringtotop</code>	<i>Assign focus to an RGL window</i>
-----------------------------	--------------------------------------

Description

'`rgl.bringtotop`' brings the current RGL window to the front of the window stack (and gives it focus).

Usage

```
rgl.bringtotop(stay = FALSE)
```

Arguments

`stay` whether to make the window stay on top.

Details

If `stay` is TRUE, then the window will stay on top of normal windows.

Note

not completely implemented for X11 graphics (`stay` not implemented; window managers such as KDE may block this action (set "Focus stealing prevention level" to None in Control Center/Window Behavior/Advanced)). Not currently implemented under OS/X.

Author(s)

Ming Chen/Duncan Murdoch

Examples

```
rgl.open()
rgl.points(rnorm(1000), rnorm(1000), rnorm(1000), color = heat.colors(1000))
rgl.bringtotop(stay = TRUE)
```

rgl.material

Generic Appearance setup

Description

Set material properties for geometry appearance.

Usage

```
rgl.material(
  color      = c("white"),
  alpha      = c(1.0),
  lit        = TRUE,
  ambient    = "black",
  specular   = "white",
  emission   = "black",
  shininess  = 50.0,
  smooth     = TRUE,
  texture    = NULL,
  textype    = "rgb",
  texmipmap  = FALSE,
  texminfilter = "linear",
  texmagfilter = "linear",
  texenvmap  = FALSE,
  front      = "fill",
  back       = "fill",
  size       = 3.0,
  lwd        = 1.0,
  fog        = TRUE,
  point_antialias = FALSE,
  line_antialias = FALSE,
  depth_mask = TRUE,
  depth_test = "less",
  ...
)
```

material3d(...)

Arguments

color	vector of R color characters. Represents the diffuse component in case of lighting calculation (lit = TRUE), otherwise it describes the solid color characteristics.
lit	logical, specifying if lighting calculation should take place on geometry
ambient, specular, emission, shininess	properties for lighting calculation. ambient, specular, emission are R color character string values; shininess represents a numerical.
alpha	vector of alpha values between 0.0 (fully transparent) .. 1.0 (opaque).
smooth	logical, specifying whether Gouraud shading (smooth) or flat shading should be used.
texture	path to a texture image file. Supported formats: png.
texture	specifies what is defined with the pixmap "alpha" alpha values "luminance" luminance "luminance.alpha" luminance and alpha "rgb" color "rgba" color and alpha texture
texmipmap	Logical, specifies if the texture should be mipmapped.
texmagfilter	specifies the magnification filtering type (sorted by ascending quality): "nearest" texel nearest to the center of the pixel "linear" weighted linear average of a 2x2 array of texels
texminfilter	specifies the minification filtering type (sorted by ascending quality): "nearest" texel nearest to the center of the pixel "linear" weighted linear average of a 2x2 array of texels "nearest.mipmap.nearest" low quality mipmapping "nearest.mipmap.linear" medium quality mipmapping "linear.mipmap.nearest" medium quality mipmapping "linear.mipmap.linear" high quality mipmapping
texenvmap	logical, specifies if auto-generated texture coordinates for environment-mapping should be performed on geometry.
front, back	Determines the polygon mode for the specified side: "fill" filled polygon "line" wireframed polygon "points" point polygon "cull" culled (hidden) polygon
size	numeric, specifying the size of points in pixels
lwd	numeric, specifying the line width in pixels
fog	logical, specifying if fog effect should be applied on the corresponding shape
point_antialias, line_antialias	logical, specifying if points and lines should be antialiased

depth_mask	logical, specifying whether the object's depth should be stored.
depth_test	Determines which depth test is used to see if this object is visible, depending on its apparent depth in the scene compared to the stored depth. Possible values are "never", "less" (the default), "equal", "lequal" (less than or equal), "greater", "notequal", "gequal" (greater than or equal), "always".
...	Any of the arguments above; see Details below.

Details

Only one side at a time can be culled.

material3d is an alternate interface to the material properties, modelled after [par3d](#): rather than setting defaults for parameters that are not specified, they will be left unchanged. material3d may also be used to query the material properties; see the examples below.

The current implementation does not return parameters for textures.

If point_antialias is TRUE, points will be drawn as circles; otherwise, they will be drawn as squares. Lines tend to appear heavier with line_antialias == TRUE.

The material member of the [r3dDefaults](#) list may be used to set default values for material properties.

The ... parameter to rgl.material is ignored.

Value

rgl.material() is called for the side effect of setting the material properties. It returns a value invisibly which is not intended for use by the user.

Users should use material3d() to query material properties. It returns values similarly to [par3d](#) as follows: When setting properties, it returns the previous values in a named list. A named list is also returned when more than one value is queried. When a single value is queried it is returned directly.

See Also

[rgl.primitive](#), [rgl.bbox](#), [rgl.bg](#), [rgl.light](#)

Examples

```
save <- material3d("color")
material3d(color = "red")
material3d("color")
material3d(color = save)

# this illustrates the effect of depth_test
x <- c(1:3); xmid <- mean(x)
y <- c(2, 1, 3); ymid <- mean(y)
z <- 1
open3d()
tests <- c("never", "less", "equal", "lequal", "greater",
           "notequal", "gequal", "always")
for (i in 1:8) {
```

```

    triangles3d(x, y, z + i, col = heat.colors(8)[i])
    texts3d(xmid, ymid, z + i, paste(i, tests[i], sep = ". "), depth_test = tests[i])
  }

```

rgl.open	<i>3D visualization device system</i>
----------	---------------------------------------

Description

3D real-time rendering system.

Usage

```

# Low level rgl.* interface
rgl.open(useNULL = rgl.useNULL()) # open new device
rgl.close() # close current device
rgl.cur() # returns active device ID
rgl.dev.list() # returns all device IDs
rgl.set(which, silent = FALSE) # set device as active
rgl.quit() # shutdown rgl device system
rgl.init(initValue = 0, onlyNULL = FALSE) # re-initialize rgl

```

Arguments

useNULL	whether to open the “null” device
which	device ID
silent	whether to suppress update of window titles
initValue	value for internal use only
onlyNULL	only initialize the null (no display) device

Details

The **rgl** device design is oriented towards the R device metaphor. If you send scene management instructions, and there’s no device open, it will be opened automatically. Opened devices automatically get the current device focus. The focus may be changed by using `rgl.set()`. `rgl.quit()` shuts down the rgl subsystem and all open devices, detaches the package including the shared library and additional system libraries.

The `rgl.open()` function attempts to open a new RGL window. If the `"rgl.antialias"` option is set, it will be used to select the requested antialiasing. (See [open3d](#) for more description of antialiasing and an alternative way to set the value.)

If `useNULL` is `TRUE`, **rgl** will use a “null” device. This device records objects as they are plotted, but displays nothing. It is intended for use with [writeWebGL](#) and similar functions.

If `rgl.open()` fails (e.g. because X windows is not running, or its `DISPLAY` variable is not set properly), then you can retry the initialization by calling `rgl.init()`. Do not do this when windows have already been successfully opened: they will be orphaned, with no way to remove them other

than closing R. In fact, it's probably a good idea not to do this at all: quitting R and restarting it is a better solution.

This package also includes a higher level interface which is described in the [r3d](#) help topic. That interface is designed to act more like classic 2D R graphics. We recommend that you avoid mixing `rgl.*` and `*3d` calls.

See the first example below to display the ChangeLog.

Value

`rgl.open`, `rgl.close` and `rgl.set` are called for their side effects and return no useful value. Similarly `rgl.init` and `rgl.quit` are not designed to return useful values; in fact, users shouldn't call them at all!

`rgl.cur` returns the currently active devices, or `0` if none is active; `rgl.dev.list` returns a vector of all open devices. Both functions name the items according to the type of device: `null` for a hidden null device, `wgl` for a Windows device, `glX` for an X windows device, and `NSOpenGL` for a Cocoa device on OSX.

See Also

[r3d](#), [rgl.clear](#), [rgl.pop](#), [rgl.viewpoint](#), [rgl.light](#), [rgl.bg](#), [rgl.bbox](#), [rgl.points](#), [rgl.lines](#), [rgl.triangles](#), [rgl.quads](#), [rgl.texts](#), [rgl.surface](#), [rgl.spheres](#), [rgl.sprites](#), [rgl.snapshot](#), [rgl.useNULL](#)

`rgl.pixels`

Extract pixel information from window

Description

This function extracts single components of the pixel information from the topmost window.

Usage

```
rgl.pixels(component = c("red", "green", "blue"),
           viewport = par3d("viewport"), top = TRUE)
```

Arguments

<code>component</code>	Which component(s)?
<code>viewport</code>	Lower left corner and size of desired region.
<code>top</code>	Whether to bring window to top before reading.

Details

The possible components are "red", "green", "blue", "alpha", "depth", and "luminance" (the sum of the three colors). All are scaled from 0 to 1.

Note that the luminance is kept below 1 by truncating the sum; this is the definition used for the `GL_LUMINANCE` component in OpenGL.

Value

A vector, matrix or array containing the desired components. If one component is requested, a vector or matrix will be returned depending on the size of block requested (length 1 dimensions are dropped); if more, an array, whose last dimension is the list of components.

Author(s)

Duncan Murdoch

See Also

[rgl.snapshot](#) to write a copy to a file, `demo("stereo")` for functions that make use of this to draw a random dot stereogram and an anaglyph.

Examples

```
example(surface3d)
depth <- rgl.pixels(component = "depth")
if (length(depth) && is.matrix(depth)) # Protect against empty or single pixel windows
  contour(depth)
```

`rgl.postscript` *export screenshot*

Description

Saves the screenshot to a file in PostScript or other vector graphics format.

Usage

```
rgl.postscript( filename, fmt = "eps", drawText = TRUE )
```

Arguments

<code>filename</code>	full path to filename.
<code>fmt</code>	export format, currently supported: ps, eps, tex, pdf, svg, pgf
<code>drawText</code>	logical, whether to draw text

Details

Animations can be created in a loop modifying the scene and saving a screenshot to a file. (See example below)

This function is a wrapper for the GL2PS library by Christophe Geuzaine, and has the same limitations as that library: not all OpenGL features are supported, and some are only supported in some formats. See the reference for full details.

Author(s)

Christophe Geuzaine / Albrecht Gebhardt

References

GL2PS: an OpenGL to PostScript printing library by Christophe Geuzaine, <http://www.geuz.org/gl2ps/>, version 1.3.8.

See Also

[rgl.viewpoint](#), [rgl.snapshot](#)

Examples

```
x <- y <- seq(-10, 10, length = 20)
z <- outer(x, y, function(x, y) x^2 + y^2)
persp3d(x, y, z, col = 'lightblue')

title3d("Using LaTeX text", col = 'red', line = 3)
rgl.postscript("persp3da.ps", "ps", drawText = FALSE)
rgl.postscript("persp3da.pdf", "pdf", drawText = FALSE)
rgl.postscript("persp3da.tex", "tex")
rgl.pop()
title3d("Using ps/pdf text", col = 'red', line = 3)
rgl.postscript("persp3db.ps", "ps")
rgl.postscript("persp3db.pdf", "pdf")
rgl.postscript("persp3db.tex", "tex", drawText = FALSE)

## Not run:

#
# create a series of frames for an animation
#

rgl.open()
shade3d(oh3d(), color = "red")
rgl.viewpoint(0, 20)

for (i in 1:45) {
  rgl.viewpoint(i, 20)
  filename <- paste("pic", formatC(i, digits = 1, flag = "0"), ".eps", sep = "")
  rgl.postscript(filename, fmt = "eps")
}

## End(Not run)
```

rgl.primitive	<i>add primitive set shape</i>
---------------	--------------------------------

Description

Adds a shape node to the current scene

Usage

```

rgl.points(x, y = NULL, z = NULL, ... )
rgl.lines(x, y = NULL, z = NULL, ... )
rgl.linestrips(x, y = NULL, z = NULL, ...)
rgl.triangles(x, y = NULL, z = NULL, normals = NULL, texcoords = NULL, ... )
rgl.quads(x, y = NULL, z = NULL, normals = NULL, texcoords = NULL, ... )

```

Arguments

x, y, z	coordinates. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
normals	Normals at each point.
texcoords	Texture coordinates at each point.
...	Material properties. See rgl.material for details.

Details

Adds a shape node to the scene. The appearance is defined by the material properties. See [rgl.material](#) for details.

The names of these functions correspond to OpenGL primitives. They all take a sequence of vertices in x, y, z. The only non-obvious ones are `rgl.lines` which draws line segments based on pairs of vertices, and `rgl.linestrips` which joins the vertices.

For triangles and quads, the normals at each vertex may be specified using `normals`. These may be given in any way that would be acceptable as a single argument to [xyz.coords](#). These need not match the actual normals to the polygon: curved surfaces can be simulated by using other choices of normals.

Texture coordinates may also be specified. These may be given in any way that would be acceptable as a single argument to [xy.coords](#), and are interpreted in terms of the bitmap specified as the material texture, with (0, 0) at the lower left, (1, 1) at the upper right. The texture is used to modulate the color of the polygon.

These are the lower level functions called by [points3d](#), [segments3d](#), [lines3d](#), etc. The two principal differences between the `rgl.*` functions and the `*3d` functions are that the former set all unspecified material properties to defaults, whereas the latter use current values as defaults; the former make persistent changes to material properties with each call, whereas the latter make temporary changes only for the duration of the call.

Value

Each primitive function returns the integer object ID of the shape that was added to the scene. These can be passed to [rgl.pop](#) to remove the object from the scene.

See Also

[rgl.material](#), [rgl.spheres](#), [rgl.texts](#), [rgl.surface](#), [rgl.sprites](#)

Examples

```
rgl.open()
rgl.points(rnorm(1000), rnorm(1000), rnorm(1000), color = heat.colors(1000))
```

`rgl.select`

Switch to select mode, and return the mouse position selected.

Description

Mostly for internal use, this function temporarily installs a handler on a button of the mouse that will return the mouse coordinates of one click and drag rectangle.

Usage

```
rgl.select(button = c("left", "middle", "right"))
```

Arguments

`button` Which button to use?

Value

A vector of four coordinates: the X and Y coordinates of the start and end of the dragged rectangle.

Author(s)

Duncan Murdoch

See Also

[rgl.select3d](#), a version that allows the selection region to be used to select points in the scene.

rgl.setMouseCallbacks *User callbacks on mouse events*

Description

Set and get user callbacks on mouse events.

Usage

```
rgl.setMouseCallbacks(button, begin = NULL, update = NULL, end = NULL)
rgl.getMouseCallbacks(button)
rgl.setWheelCallback(rotate)
rgl.getWheelCallback()
```

Arguments

button	Which button?
begin	Called when mouse down event occurs
update	Called when mouse moves
end	Called when mouse is released
rotate	Called when mouse wheel is rotated

Details

The set functions set event handlers on mouse events that occur within the current rgl window. The begin and update events should be functions taking two arguments; these will be the mouse coordinates when the event occurs. The end event handler takes no arguments. The rotate event takes a single argument, which will be equal to 1 if the user pushes the wheel away by one click, and 2 if the user pulls the wheel by one click.

Alternatively, the handlers may be set to NULL, the default value, in which case no action will occur.

If a subscene has multiple listeners, the user action will still only be called for the subscene that received the mouse event. It should consult [par3d\("listeners"\)](#) if it makes sense to take action on the whole group of subscenes.

The get function retrieves the callbacks that are currently set.

Value

The set functions are called for the side effect of setting the mouse event handlers.

The rgl.getMouseCallbacks function returns a list containing the callback functions or NULL if no user callback is set. The rgl.getWheelCallback returns the callback function or NULL.

Author(s)

Duncan Murdoch

See Also

[par3d](#) to set built-in handlers

Examples

```
## Not quite right --- this doesn't play well with rescaling

pan3d <- function(button) {
  start <- list()

  begin <- function(x, y) {
    start$userMatrix <<- par3d("userMatrix")
    start$viewport <<- par3d("viewport")
    start$scale <<- par3d("scale")
    start$projection <<- rgl.projection()
    start$pos <<- rgl.window2user( x/start$viewport[3], 1 - y/start$viewport[4], 0.5,
                                projection = start$projection)
  }

  update <- function(x, y) {
    xlat <- (rgl.window2user( x/start$viewport[3], 1 - y/start$viewport[4], 0.5,
                            projection = start$projection) - start$pos)*start$scale
    mouseMatrix <- translationMatrix(xlat[1], xlat[2], xlat[3])
    par3d(userMatrix = start$userMatrix %%% t(mouseMatrix) )
  }

  rgl.setMouseCallbacks(button, begin, update)
  cat("Callbacks set on button", button, "of rgl device", rgl.cur(), "\n")
}
pan3d(3)
```

rgl.snapshot

export screenshot

Description

Saves the screenshot as png file.

Usage

```
rgl.snapshot( filename, fmt = "png", top = TRUE )
snapshot3d( ... )
```

Arguments

filename	full path to filename.
fmt	image export format, currently supported: png
top	whether to call rgl.bringtotop
...	arguments to pass to <code>rgl.snapshot</code>

Details

Animations can be created in a loop modifying the scene and saving each screenshot to a file. Various graphics programs (e.g. ImageMagick) can put these together into a single animation. (See [movie3d](#) or the example below.)

Note

On some systems, the snapshot will include content from other windows if they cover the active rgl window. Setting `top = TRUE` (the default) will use [rgl.bringtotop](#) before the snapshot to avoid this. (See <http://www.opengl.org/resources/faq/technical/rasterization.htm#rast0070> for more details.)

See Also

[movie3d](#), [rgl.viewpoint](#)

Examples

```
## Not run:

#
# create animation
#

shade3d(oh3d(), color = "red")
rgl.bringtotop()
rgl.viewpoint(0, 20)

setwd(tempdir())
for (i in 1:45) {
  rgl.viewpoint(i, 20)
  filename <- paste("pic", formatC(i, digits = 1, flag = "0"), ".png", sep = "")
  rgl.snapshot(filename)
}
## Now run ImageMagick command:
##   convert -delay 10 *.png -loop 0 pic.gif

## End(Not run)
```

rgl.surface

add height-field surface shape

Description

Adds a surface to the current scene. The surface is defined by a matrix defining the height of each grid point and two vectors defining the grid.

Usage

```
rgl.surface(x, z, y, coords = 1:3, ...,
           normal_x = NULL, normal_y = NULL, normal_z = NULL,
           texture_s = NULL, texture_t = NULL)
```

Arguments

x	values corresponding to rows of y, or matrix of x coordinates
y	matrix of height values
z	values corresponding to columns of y, or matrix of z coordinates
coords	See details
...	Material and texture properties. See rgl.material for details.
normal_x, normal_y, normal_z	matrices of the same dimension as y giving the coordinates of normals at each grid point
texture_s, texture_t	matrices of the same dimension as z giving the coordinates within the current texture of each grid point

Details

Adds a surface mesh to the current scene. The surface is defined by the matrix of height values in y, with rows corresponding to the values in x and columns corresponding to the values in z.

The coords parameter can be used to change the geometric interpretation of x, y, and z. The first entry of coords indicates which coordinate (1 = X, 2 = Y, 3 = Z) corresponds to the x parameter. Similarly the second entry corresponds to the y parameter, and the third entry to the z parameter. In this way surfaces may be defined over any coordinate plane.

If the normals are not supplied, they will be calculated automatically based on neighbouring points.

Texture coordinates run from 0 to 1 over each dimension of the texture bitmap. If texture coordinates are not supplied, they will be calculated to render the texture exactly once over the grid. Values greater than 1 can be used to repeat the texture over the surface.

`rgl.surface` always draws the surface with the 'front' upwards (i.e. towards higher y values). This can be used to render the top and bottom differently; see [rgl.material](#) and the example below.

If the x or z argument is a matrix, then it must be of the same dimension as y, and the values in the matrix will be used for the corresponding coordinates. This is used to plot shapes such as cylinders where y is not a function of x and z.

NA values in the height matrix are not drawn.

Value

The object ID of the displayed surface is returned invisibly.

See Also

[rgl.material](#), [surface3d](#), [terrain3d](#). See [persp3d](#) for a higher level interface.

Examples

```
#
# volcano example taken from "persp"
#

data(volcano)

y <- 2 * volcano      # Exaggerate the relief

x <- 10 * (1:nrow(y)) # 10 meter spacing (S to N)
z <- 10 * (1:ncol(y)) # 10 meter spacing (E to W)

ylim <- range(y)
ylen <- ylim[2] - ylim[1] + 1

colorlut <- terrain.colors(ylen) # height color lookup table

col <- colorlut[ y - ylim[1] + 1 ] # assign colors to heights for each point

rgl.open()
rgl.surface(x, z, y, color = col, back = "lines")
```

rgl.Sweave

Integrating rgl with Sweave

Description

As of R 2.13.0, it is possible to include rgl graphics into a [Sweave](#) document. These functions support that integration.

Usage

```
Sweave.snapshot()
rgl.Sweave(name, width, height, options, ...)
rgl.Sweave.off()
```

Arguments

name, width, height, options, ...

These arguments are passed by [Sweave](#) to rgl.Sweave when it opens the device.

Details

The rgl.Sweave function is not normally called by the user. The user specifies it as the graphics driver when opening the code chunk, e.g. by using

```
<<fig = TRUE, pdf = FALSE, grdevice = rgl.Sweave, resolution = 100>>=
```

When the `rgl` device is closed at the end of the code chunk, `rgl.Sweave.off()` will be called automatically. It will save a snapshot of the last image (by default in `.png` format) for inclusion in the Sweave document and (by default) close the device. Alternatively, the `Sweave.snapshot()` function can be called to save the image before the end of the chunk. Only one snapshot will be taken per chunk.

Several chunk options are used by the `rgl.Sweave` device:

stayopen (default FALSE). If TRUE then the `rgl` device will *not* be closed at the end of the chunk, instead a call to `Sweave.snapshot()` will be used if it has not been called explicitly. Subsequent chunks can add to the scene.

outputtype (default png). The output may be specified as `outputtype = pdf` or `outputtype = eps` instead, in which case the `rgl.postscript` function will be used to write output in the specified format. Note that `rgl.postscript` has limitations and does not always render scenes correctly.

delay (default 0.1). After creating the display window, `Sys.sleep` will be called to delay this many seconds, to allow the display system to initialize. This is needed in X11 systems which open the display asynchronously. If the default time is too short, `rgl.Sweave` may falsely report that the window is too large to open.

Value

These functions are called for their side effects.

Note

We recommend turning off all other graphics drivers in a chunk that uses `grdevice = rgl.Sweave`. The `rgl` functions do not write to a standard graphics device.

Note

The `rgl` package relies on your graphics hardware to render OpenGL scenes, and the default `.png` output copies a bitmap from the hardware device. All such devices have limitations on the size of the bitmap, but they do not always signal these limitations in a way that `rgl` will detect. If you find that images are not being produced properly, try reducing the size using the `resolution`, `width` or `height` chunk options.

Author(s)

Duncan Murdoch

See Also

[RweaveLatex](#) for a description of alternate graphics drivers in Sweave, and standard options that can be used in code chunks.

[hook_rgl](#) and [hook_webgl](#) allow fixed or interactive **rgl** scenes to be embedded in **knitr** documents.

rgl.useNULL	<i>Report default use of null device.</i>
-------------	---

Description

This function checks the "rgl.useNULL" option if present, or the RGL_USE_NULL environment variable if it is not. If the value is TRUE or a string which matches "yes" or "true" in a case-insensitive test, TRUE is returned.

Usage

```
rgl.useNULL()
```

Value

A logical value indicating the current default for use of the null device.

Note

This function is checked by the initialization code when **rgl** is loaded. Thus if you want to run **rgl** on a system where there is no graphics support, you should run `options(rgl.useNULL = TRUE)` or set the environment variable `RGL_USE_NULL=TRUE` *before* calling `library(rgl)` (or other code that loads **rgl**), and it will not fail in its attempt at initialization.

Author(s)

Duncan Murdoch

See Also

[open3d](#) and [rgl.open](#).

Examples

```
rgl.useNULL()
```

rgl.user2window	<i>Convert between rgl user and window coordinates</i>
-----------------	--

Description

This function converts from 3-dimensional user coordinates to 3-dimensional window coordinates.

Usage

```

rgl.user2window(x, y = NULL, z = NULL, projection = rgl.projection())
rgl.window2user(x, y = NULL, z = 0, projection = rgl.projection())
rgl.projection()

```

Arguments

x, y, z	Input coordinates. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
projection	The rgl projection to use

Details

These functions convert between user coordinates and window coordinates.

Window coordinates run from 0 to 1 in X, Y, and Z. X runs from 0 on the left to 1 on the right; Y runs from 0 at the bottom to 1 at the top; Z runs from 0 foremost to 1 in the background. `rgl` does not currently display vertices plotted outside of this range, but in normal circumstances will automatically resize the display to show them. In the example below this has been suppressed.

Value

The coordinate conversion functions produce a matrix with columns corresponding to the X, Y, and Z coordinates.

`rgl.projection()` returns a list containing the following components:

model	the modelview matrix
projection	the projection matrix
viewport	the viewport vector

See [par3d](#) for more details.

Author(s)

Ming Chen / Duncan Murdoch

See Also

[select3d](#)

Examples

```

open3d()
points3d(rnorm(100), rnorm(100), rnorm(100))
if (interactive() || !.Platform$OS == "unix") {
# Calculate a square in the middle of the display and plot it
square <- rgl.window2user(c(0.25, 0.25, 0.75, 0.75, 0.25),
                        c(0.25, 0.75, 0.75, 0.25, 0.25), 0.5)
par3d(ignoreExtent = TRUE)
lines3d(square)

```

```
par3d(ignoreExtent = FALSE)
}
```

scene	<i>scene management</i>
-------	-------------------------

Description

Clear shapes, lights, bbox

Usage

```
clear3d( type = c("shapes", "bboxdeco", "material"), defaults, subscene = 0 )
rgl.clear( type = "shapes", subscene = 0 )
pop3d( ... )
rgl.pop( type = "shapes", id = 0 )
rgl.ids( type = "shapes", subscene = NA )
```

Arguments

type	Select subtype(s): "shapes" shape stack "lights" light stack "bboxdeco" bounding box "userviewpoint" user viewpoint "modelviewpoint" model viewpoint "material" material properties "background" scene background "subscene" subscene list "all" all of the above
defaults	default values to use after clearing
subscene	which subscene to work with. NA means the current one, 0 means the whole scene
id	vector of ID numbers of items to remove
...	generic arguments passed through to RGL-specific (or other) functions

Details

RGL holds several lists of objects in each scene. There are lists for shapes, lights, bounding box decorations, subscenes, etc. `clear3d` and `rgl.clear` clear the specified stack, or restore the defaults for the bounding box (not visible) or viewpoint. With `id = 0` `rgl.pop` removes the last added node on the list (except for subscenes: there it removes the active subscene). The `id` argument may be used to specify arbitrary item(s) to remove; if `id != 0`, the `type` argument is ignored.

`rgl.clear` and `clear3d` may also be used to clear material properties back to their defaults.

`clear3d` has an optional `defaults` argument, which defaults to `r3dDefaults`. Only the materials component of this argument is currently used by `clear3d`.

`rgl.ids` returns a dataframe containing the IDs in the currently active subscene by default, or a specified subscene, or if `subscene = 0`, in the whole `rgl` window, along with an indicator of their type.

Note that clearing the light stack leaves the scene in darkness; it should normally be followed by a call to `rgl.light` or `light3d`.

See Also

`rgl`, `rgl.bbox`, `rgl.light`, `open3d` to open a new window.

Examples

```
x <- rnorm(100)
y <- rnorm(100)
z <- rnorm(100)
p <- plot3d(x, y, z, type = 's')
rgl.ids()
lines3d(x, y, z)
rgl.ids()
if (interactive()) {
  readline("Hit enter to change spheres")
  rgl.pop(id = p["data"])
  spheres3d(x, y, z, col = "red", radius = 1/5)
  box3d()
}
```

scene3d

Saves the current scene to a variable, and displays such variables.

Description

This function saves a large part of the RGL state associated with the current window to a variable.

Usage

```
scene3d()
## S3 method for class 'rglscene'
plot3d(x, add = FALSE, ...)
## S3 method for class 'rglobject'
plot3d(x, ...)
## S3 method for class 'rglscene'
print(x, ...)
## S3 method for class 'rglobject'
print(x, ...)
```

Arguments

x	An object of class "rglscene"
add	Whether to open a new window, or add to the existing one.
...	Additional parameters, currently ignored.

Details

The components saved are: the `par3d` settings, the `material3d` settings, the `bg3d` settings, the lights and the objects in the scene.

In most cases, calling `plot3d` on that variable will duplicate the scene. (There are likely to be small differences, mostly internal, but some aspects of the scene are not currently available.) If textures are used, the name of the texture will be saved, rather than the contents of the texture file.

Other than saving the code to recreate a scene, saving the result of `scene3d` to a file will allow it to be reproduced later most accurately. In roughly decreasing order of fidelity, `writeWebGL`, `writePLY`, `writeOBJ` and `writeSTL` write the scene to a file in formats readable by other software.

Value

The `scene3d` function returns an object of class "rglscene". This is a list with some or all of the components

<code>par3d</code>	The results returned from a <code>par3d</code> call.
<code>material</code>	The results returned from a <code>material3d</code> call.
<code>bg</code>	A list containing some of the properties of the scene background.
<code>bbox</code>	A list containing some of the properties of the scene bounding box decoration.
<code>objects</code>	A list containing the RGL lights and objects in the scene.

The objects in the `objects` component are of class "rglobject". They are lists containing some or all of the components

<code>id</code>	The RGL identifier of the object in the original scene.
<code>type</code>	A character variable identifying the type of object.
<code>material</code>	Components of the material that differ from the scene material.
<code>vertices, normals, etc.</code>	Any of the attributes of the object retrievable by <code>rgl.attrib</code> .
<code>ignoreExtent</code>	A logical value indicating whether this object contributes to the bounding box. Currently this may differ from the object in the original scene.
<code>objects</code>	Sprites may contain other objects; they will be stored here as a list of "rglobject"s.

Lights in the scene are stored similarly, mixed into the `objects` list.

The `plot3d` methods invisibly return a vector of RGL object ids that were plotted. The `print` methods invisibly return the object that was printed.

Author(s)

Duncan Murdoch

See Also

[writeWebGL](#), [writePLY](#), [writeOBJ](#) and [writeSTL](#) write the scene to a file in various formats.

Examples

```
open3d()
z <- 2 * volcano      # Exaggerate the relief
x <- 10 * (1:nrow(z)) # 10 meter spacing (S to N)
y <- 10 * (1:ncol(z)) # 10 meter spacing (E to W)
persp3d(x, y, z, col = "green3", aspect = "iso")

s <- scene3d()
# Make it bigger
s$par3d$windowRect <- 1.5*s$par3d$windowRect
# and draw it again
plot3d(s)
```

select3d

Select a rectangle in an RGL scene

Description

This function allows the user to use the mouse to select a region in an RGL scene.

Usage

```
rgl.select3d(button = c("left", "middle", "right"))
select3d(...)
```

Arguments

button	Which button to use for selection.
...	Button argument to pass to <code>rgl.select3d</code>

Details

This function selects 3-dimensional regions by allowing the user to use a mouse to draw a rectangle showing the projection of the region onto the screen. It returns a function which tests points for inclusion in the selected region.

If the scene is later moved or rotated, the selected region will remain the same, no longer corresponding to a rectangle on the screen.

Value

Returns a function $f(x, y, z)$ which tests whether each of the points (x, y, z) is in the selected region, returning a logical vector. This function accepts input in a wide variety of formats as it uses [xyz.coords](#) to interpret its parameters.

Author(s)

Ming Chen / Duncan Murdoch

See Also[selectpoints3d](#), [locator](#)**Examples**

```
# Allow the user to select some points, and then redraw them
# in a different color

if (interactive()) {
  x <- rnorm(1000)
  y <- rnorm(1000)
  z <- rnorm(1000)
  open3d()
  points3d(x, y, z)
  f <- select3d()
  keep <- f(x, y, z)
  rgl.pop()
  points3d(x[keep], y[keep], z[keep], color = 'red')
  points3d(x[!keep], y[!keep], z[!keep])
}
```

`selectpoints3d`*Select points from a scene*

Description

This function uses the [select3d](#) function to allow the user to choose a point or region in the scene, then reports on all the vertices in or near that selection.

Usage

```
selectpoints3d(objects = rgl.ids()$id, value = TRUE, closest = TRUE,
               multiple = FALSE, ...)
```

Arguments

<code>objects</code>	A vector of object id values to use for the search.
<code>value</code>	If TRUE, return the coordinates of the points; otherwise, return their indices.
<code>closest</code>	If TRUE, return the points closest to the selection of no points are exactly within it.
<code>multiple</code>	If TRUE or a function, do multiple selections. See the Details below.
<code>...</code>	Other parameters to pass to select3d .

Details

The `multiple` argument may be a logical value or a function. If logical, it controls whether multiple selections will be performed. If `multiple` is `FALSE`, a single selection will be performed; it might contain multiple points. If `TRUE`, multiple selections will occur and the results will be combined into a single matrix.

If `multiple` is a function, it should take a single argument. This function will be called with the argument set to a matrix containing newly added rows to the value, i.e. it will contain coordinates of the newly selected points (if `value = TRUE`), or the indices of the points (if `value = FALSE`). It should return a logical value, `TRUE` to indicate that selection should continue, `FALSE` to indicate that it should stop.

In either case, if multiple selections are being performed, the ESC key will stop the process.

Value

If `value` is `TRUE`, a 3-column matrix giving the coordinates of the selected points. All rows in the matrix will be unique even if multiple vertices have the same coordinates.

If `value` is `FALSE`, a 2-column matrix containing columns:

<code>id</code>	The object id containing the point.
<code>index</code>	The index of the point within <code>rgl.attrib(id, "vertices")</code> . If multiple points have the same coordinates, all indices will be returned.

Author(s)

Duncan Murdoch

See Also

[select3d](#) to return a selection function.

Examples

```
xyz <- cbind(rnorm(20), rnorm(20), rnorm(20))
ids <- plot3d( xyz )

if (interactive()) {
  # Click near a point to select it and put a sphere there.
  # Press ESC to quit...

  # This version returns coordinates
  selectpoints3d(ids["data"],
    multiple = function(x) {
      spheres3d(x, color = "red", alpha = 0.3, radius = 0.2)
      TRUE
    })

  # This one returns indices
  selectpoints3d(ids["data"], value = FALSE,
    multiple = function(ids) {
```

```

        spheres3d(xyz[ids[, "index"], , drop = FALSE], color = "blue",
                  alpha = 0.3, radius = 0.2)
      TRUE
    })
  }

```

shapelist3d *Create and plot a list of shapes*

Description

These functions create and plot a list of shapes.

Usage

```
shapelist3d(shapes, x = 0, y = NULL, z = NULL, size = 1, matrix = NULL, override = TRUE,
            ..., plot = TRUE)
```

Arguments

shapes	A single shape3d object, or a list of them.
x, y, z	Translation(s) to apply
size	Scaling(s) to apply
matrix	A single matrix transformation, or a list of them.
override	Whether the material properties should override the ones in the shapes.
...	Material properties to apply.
plot	Whether to plot the result.

Details

shapelist3d is a quick way to create a complex object made up of simpler ones. Each of the arguments shapes through override may be a vector of values (a list in the case of shapes or matrix). All values will be recycled to produce a list of shapes as long as the longest of them.

The `xyz.coords` function will be used to process the x, y and z arguments, so a matrix may be used as x to specify all three. If a vector is used for x but y or z is missing, default values of 0 will be used.

The "shapelist3d" class is simply a list of "shape3d" objects.

Methods for `dot3d`, `wire3d`, `shade3d`, `translate3d`, `scale3d`, and `rotate3d` are defined for these objects.

Value

An object of class c("shapelist3d", "shape3d").

Author(s)

Duncan Murdoch

See Also[mesh3d](#)**Examples**

```
shapelist3d(icosahedron3d(), x = rnorm(10), y = rnorm(10), z = rnorm(10), col = 1:5, size = 0.3)
```

spheres3d

add sphere set shape

Description

Adds a sphere set shape node to the scene

Usage

```
spheres3d(x, y = NULL, z = NULL, radius = 1, ...)
rgl.spheres(x, y = NULL, z = NULL, radius, ...)
```

Arguments

<code>x, y, z</code>	Numeric vector of point coordinates corresponding to the center of each sphere. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
<code>radius</code>	Vector or single value defining the sphere radius/radii
<code>...</code>	Material properties. See rgl.material for details.

Details

If a non-isometric aspect ratio is chosen, these functions will still draw objects that appear to the viewer to be spheres. Use [ellipse3d](#) to draw shapes that are spherical in the data scale.

When the scale is not isometric, the radius is measured in an average scale. In this case the bounding box calculation is iterative, since rescaling the plot changes the shape of the spheres in user-coordinate, which changes the bounding box. Versions of `rgl` prior to 0.92.802 did not do this iterative adjustment.

If any coordinate or radius is NA, the sphere is not plotted.

Value

A shape ID of the spheres object is returned.

See Also

[rgl.material](#), [aspect3d](#) for setting non-isometric scales

Examples

```
open3d()
spheres3d(rnorm(10), rnorm(10), rnorm(10), radius = runif(10), color = rainbow(10))
```

spin3d *Create a function to spin a scene at a fixed rate*

Description

This creates a function to use with [play3d](#) to spin an rgl scene at a fixed rate.

Usage

```
spin3d(axis = c(0, 0, 1), rpm = 5,
       dev = rgl.cur(), subscene = currentSubscene3d(dev))
```

Arguments

axis	The desired axis of rotation
rpm	The rotation speed in rotations per minute
dev	Which rgl device to use
subscene	Which subscene to use

Value

A function with header `function(time, base = M)`, where `M` is the result of `par3d("userMatrix")` at the time the function is created. This function calculates and returns a list containing `userMatrix` updated by spinning the base matrix for `time` seconds at `rpm` revolutions per minute about the specified axis.

Author(s)

Duncan Murdoch

See Also

[play3d](#) to play the animation

Examples

```
# Spin one object
open3d()
plot3d(oh3d(col = "lightblue", alpha = 0.5))
if (!rgl.useNULL())
  play3d(spin3d(axis = c(1, 0, 0), rpm = 30), duration = 2)

# Show spinning sprites, and rotate the whole view
open3d()
spriteid <- NULL

spin1 <- spin3d(rpm = 4.5 ) # the scene spinner
spin2 <- spin3d(rpm = 9 ) # the sprite spinner

f <- function(time) {
  par3d(skipRedraw = TRUE) # stops intermediate redraws
  on.exit(par3d(skipRedraw = FALSE)) # redraw at the end

  rgl.pop(id = spriteid) # delete the old sprite
  cubeid <- shade3d(cube3d(), col = "red")
  spriteid <-<- sprites3d(0:1, 0:1, 0:1, shape = cubeid,
    userMatrix = spin2(time,
      base = spin1(time)$userMatrix)$userMatrix)
  spin1(time)
}
if (!rgl.useNULL())
  play3d(f, duration = 2)
```

sprites

add sprite set shape

Description

Adds a sprite set shape node to the scene.

Usage

```
sprites3d(x, y = NULL, z = NULL, radius = 1, shapes = NULL, userMatrix, ...)
particles3d(x, y = NULL, z = NULL, radius = 1, ...)
rgl.sprites(x, y = NULL, z = NULL, radius = 1, shapes = NULL, userMatrix, ...)
```

Arguments

x, y, z	point coordinates. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
radius	vector or single value defining the sphere radius
shapes	NULL for a simple square, or a vector of identifiers of shapes in the scene
userMatrix	if shape is not NULL, the transformation matrix for the shapes
...	material properties when shape == 0, texture mapping is supported

Details

Simple sprites (used when `shapes` is `NULL`) are 1 by 1 squares that are directed towards the view-point. Their primary use is for fast (and faked) atmospherical effects, e.g. particles and clouds using alpha blended textures. Particles are Sprites using an alpha-blended particle texture giving the illusion of clouds and gasses. The centre of each square will be at the coordinates given by `x`, `y`, `z`.

When `shapes` is not `NULL`, it should be a vector of identifiers of objects to plot in the scene (e.g. as returned by plotting functions or by `rgl.ids`). These objects will be removed from the scene and duplicated as a sprite image in a constant orientation, as specified by `userMatrix`. The origin `0, 0, 0` will be plotted at the coordinates given by `x`, `y`, `z`.

The `userMatrix` argument is ignored for `shapes = NULL`. For `shapes`, `sprites3d` defaults the matrix to `r3dDefaults$userMatrix` while `rgl.sprites` defaults it to an identity transformation.

If any coordinate is `NA`, the sprite is not plotted.

The id values of the shapes are retrieved using `rgl.attrib(id, "ids")`; the user matrix is retrieved using `rgl.attrib(id, "usermatrix")`.

Value

These functions are called for the side effect of displaying the sprites. The shape ID of the displayed object is returned.

See Also

[rgl.material](#)

Examples

```
open3d()
particles3d( rnorm(100), rnorm(100), rnorm(100), color = rainbow(100) )
# is the same as
sprites3d( rnorm(100), rnorm(100), rnorm(100), color = rainbow(100),
  lit = FALSE, alpha = .2,
  textype = "alpha", texture = system.file("textures/particle.png", package = "rgl") )
sprites3d( rnorm(10) + 6, rnorm(10), rnorm(10), shape = shade3d(tetrahedron3d(), col = "red") )
```

subdivision3d

generic subdivision surface method

Description

The Subdivision surface algorithm divide and refine (deform) a given mesh recursively to certain degree (depth). The `mesh3d` algorithm consists of two stages: divide and deform. The divide step generates for each triangle or quad four new triangles or quads, the deform step drags the points (refinement step).

Usage

```

subdivision3d( x, ...)
## S3 method for class 'mesh3d'
subdivision3d( x, depth = 1, normalize = FALSE, deform = TRUE, ... )
divide.mesh3d(mesh, vb = mesh$vb, ib = mesh$ib, it = mesh$it )
normalize.mesh3d(mesh)
deform.mesh3d(mesh, vb = mesh$vb, ib = mesh$ib, it = mesh$it )

```

Arguments

x	3d geometry mesh
mesh	3d geometry mesh
depth	recursion depth
normalize	normalize mesh3d coordinates after division if deform is TRUE
deform	deform mesh
it	indices for triangular faces
ib	indices for quad faces
vb	matrix of vertices: 4xn matrix (rows x, y, z, h) or equivalent vector, where h indicates scaling of each plotted quad
...	other arguments (unused)

Details

Generic subdivision surface method. Currently there exists an algorithm that can be applied on mesh3d objects.

See Also

[r3d mesh3d](#)

Examples

```

open3d()
shade3d( subdivision3d( cube3d(), depth = 3 ), color = "red", alpha = 0.5 )

```

subscene3d

Create, select or modify a subscene.

Description

This creates a new subscene, or selects one by id value, or adds objects to one.

Usage

```

newSubscene3d(viewport = "replace", projection = "replace", model = "replace",
              parent = currentSubscene3d(),
              copyLights = TRUE, copyShapes = FALSE, copyBBoxDeco = copyShapes,
              copyBackground = FALSE, newviewport,
              ignoreExtent)
currentSubscene3d(dev = rgl.cur())
useSubscene3d(subscene)
addToSubscene3d(ids, subscene = currentSubscene3d())
delFromSubscene3d(ids, subscene = currentSubscene3d())
gc3d(protect = NULL)

```

Arguments

viewport, projection, model	How should the new subscene be embedded? Possible values are c("inherit", "modify", "replace"). See Details below.
parent	The parent subscene (defaults to the current subscene).
copyLights, copyShapes, copyBBoxDeco, copyBackground	Whether lights, shapes, bounding box decorations and background should be copied to the new subscene.
newviewport	Optionally specify the new subscene's viewport (in pixels).
ignoreExtent	Whether to ignore the subscene's bounding box when calculating the parent bounding box. Defaults to TRUE if model is not "inherit".
dev	Which rgl device to query for the current subscene.
subscene	Which subscene to use or modify.
ids	A vector of integer object ids to add to the subscene.
protect	Object ids to protect from this garbage collection.

Details

The rgl package allows multiple windows to be open; each one corresponds to a "scene". Within each scene there are one or more "subscenes". Each subscene corresponds to a rectangular region in the window, and may have its own projection and transformation.

There is always a current subscene: most graphic operations make changes there, e.g. by adding an object to it.

The scene "owns" objects; addToSubscene3d and delFromSubscene3d put their ids into or remove them from the list being displayed within a particular subscene. The gc3d function deletes objects from the scene if they are not visible in any subscene, unless they are protected by having their id included in protect.

The viewport, projection and model parameters each have three possible settings: c("inherit", "modify", "replace"). "inherit" means that the corresponding value from the parent subscene will be used. "replace" means that the new subscene will have its own value of the value, independent of its parent. "modify" means that the child value will be applied first, and then the parent value will be applied. For viewport, this means that if the parent viewport is changed, the child will maintain its

relative position. For the two matrices, "modify" is unlikely to give satisfactory results, but it is available for possible use.

The viewport parameter controls the rectangular region in which the subscene is displayed. It is specified using newviewport (in pixels relative to the whole window), or set to match the parent viewport.

The projection parameter controls settings corresponding to the observer. These include the field of view and the zoom; they also include the position of the observer relative to the model. The par3d("projMatrix") matrix is determined by the projection.

The model parameter controls settings corresponding to the model. Mouse rotations affect the model, as does scaling. The par3d("modelMatrix") matrix is determined by these as well as by the position of the observer (since OpenGL assumes that the observer is at (0, 0, 0) after the MODELVIEW transformation). Only those parts concerning the model are inherited when model specifies inheritance, the observer setting is controlled by projection.

If copyBackground is TRUE, the background of the newly created child will overwrite anything displayed in the parent subscene, regardless of depth.

Value

If successful, each function returns the object id of the subscene, with the exception of gc3d, which returns the count of objects which have been deleted.

Author(s)

Duncan Murdoch and Fang He.

See Also

[subsceneInfo](#) for information about a subscene, [mfrow3d](#) and [layout3d](#) to set up multiple panes of subscenes.

Examples

```
# Show the Earth with a cutout by using clipplanes in subscenes

lat <- matrix(seq(90, -90, len = 50)*pi/180, 50, 50, byrow = TRUE)
long <- matrix(seq(-180, 180, len = 50)*pi/180, 50, 50)

r <- 6378.1 # radius of Earth in km
x <- r*cos(lat)*cos(long)
y <- r*cos(lat)*sin(long)
z <- r*sin(lat)

open3d()
obj <- surface3d(x, y, z, col = "white",
  texture = system.file("textures/worldsmall.png", package = "rgl"),
  specular = "black", axes = FALSE, box = FALSE, xlab = "", ylab = "", zlab = "",
  normal_x = x, normal_y = y, normal_z = z)

cols <- c(rep("chocolate4", 4), rep("burlywood1", 4), "darkgoldenrod1")
```

```

rs <- c(6350, 5639, 4928.5, 4207, 3486,
        (3486 + 2351)/2, 2351, (2351 + 1216)/2, 1216)
for (i in seq_along(rs))
  obj <- c(obj, spheres3d(0, 0, col = cols[i], radius = rs[i]))

root <- currentSubscene3d()

newSubscene3d("inherit", "inherit", "inherit", copyShapes = TRUE, parent = root)
clipplanes3d(1, 0, 0, 0)

newSubscene3d("inherit", "inherit", "inherit", copyShapes = TRUE, parent = root)
clipplanes3d(0, 1, 0, 0)

newSubscene3d("inherit", "inherit", "inherit", copyShapes = TRUE, parent = root)
clipplanes3d(0, 0, 1, 0)

# Now delete the objects from the root subscene, to reveal the clipping planes
useSubscene3d(root)
delFromSubscene3d(obj)

```

subsceneInfo

Get information on subscenes

Description

This function retrieves information about the tree of subscenes shown in the active window.

Usage

```
subsceneInfo(id = NA, embeddings, recursive = FALSE)
```

Arguments

id	Which subscene to report on; NA is the current subscene. Set to "root" for the root.
embeddings	Optional new setting for the embeddings for this subscene.
recursive	Whether to report on children recursively.

Details

In rgl, each window contains a tree of "subscenes", each containing views of a subset of the objects defined in the window.

Rendering in each subscene depends on the viewport, the projection, and the model transformation. Each of these characteristics may be inherited from the parent (`embedding[i] = "inherit"`), may modify the parent (`embedding[i] = "modify"`), or may replace the parent (`embedding[i] = "replace"`). All three must be specified if `embeddings` is used.

Value

id	The object id of the subscene
parent	The object id of the parent subscene, if any
children	If recursive, a list of the information for the children, otherwise just their object ids.
embedding	A vector of 3 components describing how this subscene is embedded in its parent.

Author(s)

Duncan Murdoch

See Also

[newSubscene3d](#)

Examples

```
example(plot3d)
subsceneInfo()
```

surface3d	<i>add height-field surface shape</i>
-----------	---------------------------------------

Description

Adds a surface to the current scene. The surface is defined by a matrix defining the height of each grid point and two vectors defining the grid.

Usage

```
surface3d(x, y, z, ..., normal_x = NULL, normal_y = NULL, normal_z = NULL)
terrain3d(x, y, z, ..., normal_x = NULL, normal_y = NULL, normal_z = NULL)
```

Arguments

x	values corresponding to rows of z, or matrix of x coordinates
y	values corresponding to the columns of z, or matrix of y coordinates
z	matrix of heights
...	Material and texture properties. See rgl.material for details.
normal_x, normal_y, normal_z	matrices of the same dimension as z giving the coordinates of normals at each grid point

Details

Adds a surface mesh to the current scene. The surface is defined by the matrix of height values in *z*, with rows corresponding to the values in *x* and columns corresponding to the values in *y*. This is the same parametrization as used in [persp](#).

If the *x* or *y* argument is a matrix, then it must be of the same dimension as *z*, and the values in the matrix will be used for the corresponding coordinates. This is used to plot shapes such as cylinders where *z* is not a function of *x* and *y*.

If the normals are not supplied, they will be calculated automatically based on neighbouring points.

`surface3d` always draws the surface with the ‘front’ upwards (i.e. towards higher *z* values). This can be used to render the top and bottom differently; see [rgl.material](#) and the example below.

For more flexibility in defining the surface, use [rgl.surface](#).

`surface3d` and `terrain3d` are synonyms.

See Also

[rgl.material](#), [rgl.surface](#). See [persp3d](#) for a higher level interface.

Examples

```
#
# volcano example taken from "persp"
#

data(volcano)

z <- 2 * volcano      # Exaggerate the relief

x <- 10 * (1:nrow(z)) # 10 meter spacing (S to N)
y <- 10 * (1:ncol(z)) # 10 meter spacing (E to W)

zlim <- range(y)
zlen <- zlim[2] - zlim[1] + 1

colorlut <- terrain.colors(zlen) # height color lookup table

col <- colorlut[ z - zlim[1] + 1 ] # assign colors to heights for each point

open3d()
surface3d(x, y, z, color = col, back = "lines")
```

Description

Adds text to the scene. The text is positioned in 3D space. Text is always oriented towards the camera.

Usage

```
rgl.texts(x, y = NULL, z = NULL, text,
          adj = 0.5, justify, family = par3d("family"), font = par3d("font"),
          cex = par3d("cex"), useFreeType = par3d("useFreeType"), ...)
text3d(x, y = NULL, z = NULL, texts, adj = 0.5, justify, ...)
texts3d(x, y = NULL, z = NULL, texts, adj = 0.5, justify, ...)
rglFonts(...)
```

Arguments

<code>x, y, z</code>	point coordinates. Any reasonable way of defining the coordinates is acceptable. See the function xyz.coords for details.
<code>text</code>	text character vector to draw
<code>texts</code>	text character vector to draw
<code>adj</code>	one value specifying the horizontal adjustment, or two, specifying horizontal and vertical adjustment respectively. .
<code>justify</code>	(deprecated, please use <code>adj</code> instead) character string specifying the horizontal adjustment; options are "left", "right", "center".
<code>family</code>	A device-independent font family name, or ""
<code>font</code>	A numeric font number from 1 to 5
<code>cex</code>	A numeric character expansion value
<code>useFreeType</code>	logical. Should FreeType be used to draw text? (See details below.)
<code>...</code>	In <code>rgl.texts</code> , material properties; see rgl.material for details. In <code>rglFonts</code> , device dependent font definitions for use with FreeType. In the other functions, additional parameters to pass to <code>rgl.texts</code> .

Details

The `adj` parameter determines the position of the text relative to the specified coordinate. Use `adj = c(0, 0)` to place the left bottom corner at (x, y, z) , `adj = c(0.5, 0.5)` to center the text there, and `adj = c(1, 1)` to put the right top corner there. The optional second coordinate for vertical adjustment defaults to 0.5. Placement is done using the "advance" of the string and the "ascent" of the font relative to the baseline, when these metrics are known.

`text3d` and `texts3d` draw text using the [r3d](#) conventions. These are synonyms; the former is singular to be consistent with the classic 2-D graphics functions, and the latter is plural to be consistent with all the other graphics primitives. Take your choice!

If any coordinate or text is NA, that text is not plotted.

Value

The text drawing functions return the object ID of the text object *i* invisibly.
 rglFonts returns the current set of font definitions.

Fonts

Fonts are specified using the family, font, cex, and useFreeType arguments. Defaults for the currently active device may be set using [par3d](#), or for future devices using [r3dDefaults](#).

The family specification is the same as for standard graphics, i.e. families `c("serif", "sans", "mono", "symbol")` are normally available, but users may add additional families. font numbers are restricted to the range 1 to 4 for standard, bold, italic and bold italic respectively; with font 5 recoded as family "symbol" font 1.

Using an unrecognized value for "family" will result in the system standard font as used in rgl up to version 0.76. That font is not resizable and font values are ignored.

If useFreeType is TRUE, then rgl will use the FreeType anti-aliased fonts for drawing. This is generally desirable, and it is the default if rgl was built to support FreeType.

FreeType fonts are specified using the rglFonts function. This function takes a vector of four filenames of TrueType font files which will be used for the four styles regular, bold, italic and bold italic. The vector is passed with a name to be used as the family name, e.g. `rglFonts(sans = c("/path/to/FreeSans.ttf"`
 In order to limit the file size, rgl ships with just 3 font files, for regular versions of the serif, sans and mono families. Additional free font files are available from the Amaya project at <http://dev.w3.org/cvsweb/Amaya/fonts/>. See the example below for how to specify a full set of fonts.

Full pathnames should normally be used to specify font files. If relative paths are used, they are interpreted differently by platform. Currently Windows fonts are looked for in the Windows fonts folder, while other platforms use the current working directory.

If FreeType fonts are not used, then bitmapped fonts will be used instead. On Windows these will be based on the fonts specified using the windowsFonts function, and are resizable. Other platforms will use the default bitmapped font which is not resizable. Currently MacOSX does not support bitmapped fonts in the Cocoa display used by R. app.

Bitmapped fonts have a limited number of characters supported; if any unsupported characters are used, an error will be thrown.

See Also

[r3d](#)

Examples

```
open3d()
famnum <- rep(1:4, 8)
family <- c("serif", "sans", "mono", "symbol")[famnum]
font <- rep(rep(1:4, each = 4), 2)
cex <- rep(1:2, each = 16)
text3d(font, cex, famnum, text = paste(family, font), adj = 0.5,
        color = "blue", family = family, font = font, cex = cex)
```

```
## Not run:
# These FreeType fonts are available from the Amaya project, and are not shipped
# with rgl. You would normally install them to the rgl/fonts directory
# and use fully qualified pathnames, e.g.
# system.file("fonts/FreeSerif.ttf", package = "rgl")

rglFonts(serif = c("FreeSerif.ttf", "FreeSerifBold.ttf", "FreeSerifItalic.ttf",
                  "FreeSerifBoldItalic.ttf"),
         sans  = c("FreeSans.ttf", "FreeSansBold.ttf", "FreeSansOblique.ttf",
                  "FreeSansBoldOblique.ttf"),
         mono  = c("FreeMono.ttf", "FreeMonoBold.ttf", "FreeMonoOblique.ttf",
                  "FreeMonoBoldOblique.ttf"),
         symbol= c("ESSTIX10.TTF", "ESSTIX12.TTF", "ESSTIX9_.TTF",
                  "ESSTIX11.TTF"))

## End(Not run)
```

triangulate

Triangulate a two-dimensional polygon.

Description

This algorithm decomposes a general polygon into simple polygons and uses the “ear-clipping” algorithm to triangulate it. Polygons with holes are supported.

Usage

```
triangulate(x, y = NULL, z = NULL, random = TRUE, plot = FALSE, partial = NA)
```

Arguments

<code>x, y, z</code>	Coordinates of a two-dimensional polygon in a format supported by xyz.coords . See Details for how <code>z</code> is handled.
<code>random</code>	Whether to use a random or deterministic triangulation.
<code>plot</code>	Whether to plot the triangulation; mainly for debugging purposes.
<code>partial</code>	If the triangulation fails, should partial results be returned?

Details

Normally `triangulate` looks only at the `x` and `y` coordinates. However, if one of those is constant, it is replaced with the `z` coordinate if present.

The algorithm works as follows. First, it breaks the polygon into pieces separated by `NA` values in `x` or `y`. Each of these pieces should be a simple, non-self-intersecting polygon, separate from the other pieces. (Though some minor exceptions to this rule may work, none are guaranteed). The nesting of these pieces is determined.

The “outer” polygon(s) are then merged with the polygons that they immediately contain, and each of these pieces is triangulated using the ear-clipping algorithm.

Finally, all the triangulated pieces are put together into one result.

Value

A three-by-n array giving the indices of the vertices of each triangle. (No vertices are added; only the original vertices are used in the triangulation.)

The array has an integer vector attribute "nextvert" with one entry per vertex, giving the index of the next vertex to proceed counter-clockwise around outer polygon boundaries, clockwise around inner boundaries.

Note

Not all inputs will succeed, even when a triangulation is possible. Generally using `random = TRUE` will find a successful triangulation if one exists, but it may occasionally take more than one try.

Author(s)

Duncan Murdoch

References

See the Wikipedia article "polygon triangulation" for a description of the ear-clipping algorithm.

See Also

[extrude3d](#) for a solid extrusion of a polygon, [polygon3d](#) for a flat display; both use `triangulate`.

Examples

```
theta <- seq(0, 2*pi, len = 25)[-25]
theta <- c(theta, NA, theta, NA, theta, NA, theta, NA, theta)
r <- c(rep(1.5, 24), NA, rep(0.5, 24), NA, rep(0.5, 24), NA, rep(0.3, 24), NA, rep(0.1, 24))
dx <- c(rep(0, 24), NA, rep(0.6, 24), NA, rep(-0.6, 24), NA, rep(-0.6, 24), NA, rep(-0.6, 24))
x <- r*cos(theta) + dx
y <- r*sin(theta)
plot(x, y, type = "n")
polygon(x, y)
triangulate(x, y, plot = TRUE)
open3d()
polygon3d(x, y, x - y, col = "red")
```

turn3d

Create a solid of rotation from a two-dimensional curve.

Description

This function "turns" the curve (as on a lathe) to form a solid of rotation along the x axis.

Usage

```
turn3d(x, y = NULL, n = 12, smooth = FALSE, ...)
```

Arguments

<code>x, y</code>	Points on the curve, in a form suitable for xy.coords . The y values must be non-negative.
<code>n</code>	How many steps in the rotation?
<code>smooth</code>	logical; whether to add normals for a smooth appearance.
<code>...</code>	Additional parameters to pass to tmesh3d .

Value

A mesh object containing triangles and/or quadrilaterals.

Author(s)

Fang He and Duncan Murdoch

See Also

[extrude3d](#)

Examples

```
x <- 1:10
y <- rnorm(10)^2
shade3d(turn3d(x, y), col = "green")
```

viewpoint	<i>Set up viewpoint</i>
-----------	-------------------------

Description

Set the viewpoint orientation.

Usage

```
view3d( theta = 0, phi = 15, ...)
rgl.viewpoint( theta = 0, phi = 15, fov = 60, zoom = 1,
               scale = par3d("scale"), interactive = TRUE, userMatrix,
               type = c("userviewpoint", "modelviewpoint") )
```

Arguments

<code>theta, phi</code>	polar coordinates
<code>...</code>	additional parameters to pass to <code>rgl.viewpoint</code>
<code>fov</code>	field-of-view angle in degrees
<code>zoom</code>	zoom factor
<code>scale</code>	real length 3 vector specifying the rescaling to apply to each axis

interactive	logical, specifying if interactive navigation is allowed
userMatrix	4x4 matrix specifying user point of view
type	which viewpoint to set?

Details

The data model can be rotated using the polar coordinates `theta` and `phi`. Alternatively, it can be set in a completely general way using the 4x4 matrix `userMatrix`. If `userMatrix` is specified, `theta` and `phi` are ignored.

The pointing device of your graphics user-interface can also be used to set the viewpoint interactively. With the pointing device the buttons are by default set as follows:

left adjust viewpoint position

middle adjust field of view angle

right or wheel adjust zoom factor

The user's view can be set with `fov` and `zoom`.

If the `fov` angle is set to 0, a parallel or orthogonal projection is used. Small non-zero values (e.g. 0.01 or less, but not 0.0) are likely to lead to rendering errors due to OpenGL limitations.

Prior to version 0.94, all of these characteristics were stored in one viewpoint object. With that release the characteristics are split into those that affect the projection (the user viewpoint) and those that affect the model (the model viewpoint). By default, this function sets both, but the `type` argument can be used to limit the effect.

See Also

[par3d](#)

Examples

```
## Not run:
# animated round trip tour for 10 seconds

rgl.open()
shade3d(oh3d(), color = "red")

start <- proc.time()[3]
while ((i <- 36*(proc.time()[3] - start)) < 360) {
  rgl.viewpoint(i, i/4);
}

## End(Not run)
```

webGLcontrols

Write HTML/Javascript code to control a WebGL display.

Description

These functions write out HTML code to control WebGL displays on the same page.

Usage

```
subsetSlider(subsets, labels = names(subsets),
             fullset = Reduce(union, subsets),
             subscenes = currentSubscene3d(), prefixes = "",
             ...)
```

```
subsetSetter(subsets, subscenes = currentSubscene3d(), prefixes = "",
             fullset = Reduce(union, subsets))
```

```
clipplaneSlider(a=NULL, b=NULL, c=NULL, d=NULL,
               plane = 1, clipplaneids, prefixes = "",
               labels = signif(values[,1],3), ...)
```

```
toggleButton(subset, subscenes = currentSubscene3d(), prefixes = "",
             label = deparse(substitute(subset)),
             id = paste0(basename(tempfile("input"))), name = id)
```

Arguments

subsets	A list of vectors of object identifiers; the slider or setter will choose among them.
labels	Labels to display corresponding to each subset. If NULL, numeric labels will be shown.
fullset	Objects in the subscene which are not in fullset will not be touched.
subscenes	The subscenes to be controlled.
prefixes	The prefixes of the WebGL scenes to be controlled.
id	The id of the input control that will be generated.
name	The name of the input control that will be generated.
...	Arguments to pass to propertySlider .
a,b,c,d	The parameter values to change. Leave as NULL to hold the parameter constant.
plane, clipplaneids	The identifier of the particular clipplane to modify.
subset	The subset that the button should toggle.
label	The button label.

Details

subsetSlider and clipplaneSlider generate an HTML5 slider control with a text label. To display no text, set the labels to blanks in the ... argument.

subsetSetter is a low-level function to produce the Javascript code used by subsetSlider. This code will not touch objects in the subscene if they are not in fullset. fullset defaults to the union of all the object ids mentioned in subsets, so by default if an id is not mentioned in one of the subsets, it will not be controlled by the slider.

toggleButton generates a button that toggles the presence of objects within a subscene. If the first entry in subset is in the subscene, all are deleted, otherwise all are added.

clipplaneSlider allows a clipping plane to be moved to a sequence of positions. Any non-NULL entries among a, b, c, d should be vectors; the slider will set those parameters of the selected clipping plane to corresponding values as the slider is moved.

Value

subsetSetter returns a length-one character vector of class "propertySetter".

The other functions use `cat` to write their output and invisibly return the id of the control that was generated.

Author(s)

Duncan Murdoch

See Also

[writeWebGL](#). See [propertySlider](#) and [propertySetter](#) for lower level, more flexible functions.

Examples

```
subsets <- list(1:3, 1:4, 1:5)
subsetSlider(subsets = subsets)
toggleButton(1:3)
clipplaneSlider(d = seq(0, 1, len=20), clipplaneid = 123)
```

writeOBJ

Write Wavefront OBJ format files; read simple ones

Description

writeOBJ writes OBJ files. This is a file format that is commonly used in 3D graphics applications. It does not represent text, but does represent points, lines, polygons (and many other types that RGL doesn't support). readOBJ reads only some parts of OBJ files.

Usage

```

writeOBJ(con,
         pointRadius = 0.005, pointShape = icosahedron3d(),
         lineRadius = pointRadius, lineSides = 20,
         pointsAsPoints = FALSE, linesAsLines = FALSE,
         withNormals = TRUE, withTextures = TRUE,
         separateObjects = TRUE,
         ids = NULL)
readOBJ(con, ...)

```

Arguments

con	A connection or filename.
pointRadius, lineRadius	The radius of points and lines relative to the overall scale of the figure, if they are converted to polyhedra.
pointShape	A mesh shape to use for points if they are converted. It is scaled by the pointRadius.
lineSides	Lines are rendered as cylinders with this many sides.
pointsAsPoints, linesAsLines	Whether to convert points and lines to “point” and “line” records in the OBJ output.
withNormals	Whether to output vertex normals for smooth shading.
separateObjects	Whether to mark each RGL object as a separate object in the file.
withTextures	Whether to output texture coordinates.
ids	The identifiers (from <code>rgl.ids</code>) of the objects to write. If NULL, try to write everything.
...	Additional arguments (typically just material) to pass to <code>tmesh3d</code> .

Details

The current writeOBJ implementation only outputs triangles, quads, planes, spheres, points, line segments, line strips and surfaces. It does not output material properties such as colors, since the OBJ format does not support the per-vertex colors that RGL uses.

The readOBJ implementation can only read faces, and ignores information about normals and textures.

The defaults for pointsAsPoints and linesAsLines have been chosen because Blender (<http://www.blender.org>) does not import points or lines, only polygons. If you are exporting to other software you may want to change them.

If present, texture coordinates are output by default, but the textures themselves are not.

Individual RGL objects are output as separate objects in the file when separateObjects = TRUE, the default.

The output file should be readable by Blender and Meshlab; the latter can write in a number of other formats, including U3D, suitable for import into a PDF document.

Value

writeObj invisibly returns the name of the connection to which the data was written.

readObj returns a mesh object constructed from the input file.

Author(s)

Duncan Murdoch

References

The file format was found at <http://www.martinreddy.net/gfx/3d/OBJ.spec> on November 11, 2012.

See Also

[scene3d](#) saves a copy of a scene to an R variable; [writeWebGL](#), [writePLY](#) and [writeSTL](#) write the scene to a file in various other formats.

Examples

```
filename <- tempfile(fileext = ".obj")
open3d()
shade3d( icosahedron3d() )
writeOBJ(filename)

# The motivation for writing readObj() was to read this shape
# file of Comet 67P/Churyumov-Gerasimenko, from the ESA:

open3d()
shade3d(readOBJ(url(
  "http://sci.esa.int/science-e/www/object/doc.cfm?fobjectid=54726"
), material = list(col = "gray"))))
```

writePLY

Write Stanford PLY format files

Description

This function writes PLY files. This is a simple file format that is commonly used in 3D printing. It does not represent text, only edges and polygons. The writePLY function does the necessary conversions.

Usage

```
writePLY(con, format = c("little_endian", "big_endian", "ascii"),
         pointRadius = 0.005, pointShape = icosahedron3d(),
         lineRadius = pointRadius, lineSides = 20,
         pointsAsEdges = FALSE, linesAsEdges = pointsAsEdges,
         withColors = TRUE, withNormals = !(pointsAsEdges || linesAsEdges),
         ids = NULL)
```

Arguments

con	A connection or filename.
format	Which output format. Defaults to little-endian binary.
pointRadius, lineRadius	The radius of points and lines relative to the overall scale of the figure, if they are converted to polyhedra.
pointShape	A mesh shape to use for points if they are converted. It is scaled by the pointRadius.
lineSides	Lines are rendered as cylinders with this many sides.
pointsAsEdges, linesAsEdges	Whether to convert points and lines to “Edge” records in the PLY output.
withColors	Whether to output vertex color information.
withNormals	Whether to output vertex normals for smooth shading.
ids	The identifiers (from <code>rgl.ids</code>) of the objects to write. If NULL, try to write everything.

Details

The current implementation only outputs triangles, quads, planes, spheres, points, line segments, line strips and surfaces.

The defaults for `pointsAsEdges` and `linesAsEdges` have been chosen because Blender (<http://www.blender.org>) does not import lines, only polygons. If you are exporting to other software you may want to change them.

Since the PLY format only allows one object per file, all RGL objects are combined into a single object when output.

The output file is readable by Blender and Meshlab; the latter can write in a number of other formats, including U3D, suitable for import into a PDF document.

Value

Invisibly returns the name of the connection to which the data was written.

Author(s)

Duncan Murdoch

References

The file format was found at <http://www.mathworks.com/matlabcentral/forums/5459/1/content/ply.htm> on November 10, 2012.

See Also

`scene3d` saves a copy of a scene to an R variable; `writeWebGL`, `writeOBJ` and `writeSTL` write the scene to a file in various other formats.

Examples

```
filename <- tempfile(fileext = ".ply")
open3d()
shade3d( icosahedron3d(col = "magenta") )
writePLY(filename)
```

writeWebGL	<i>Write scene to HTML.</i>
------------	-----------------------------

Description

Writes the current scene to a collection of files that contain WebGL code to reproduce it in a browser.

Usage

```
writeWebGL(dir = "webGL", filename = file.path(dir, "index.html"),
           template = system.file(file.path("webGL", "template.html"), package = "rgl"),
           prefix = "",
           snapshot = TRUE, commonParts = TRUE, reuse = NULL,
           font = "Arial", width, height)
```

Arguments

dir	Where to write the files.
filename	The filename to use for the main file.
template	The template web page to which to write the Javascript for the scene. See Details below.
prefix	An optional prefix to use on global identifiers in the scene; use different prefixes for different scenes displayed on the same web page. If not blank, it should be a legal identifier in Javascript and HTML.
snapshot	Whether to include a snapshot of the scene, to be displayed in browsers that don't support WebGL.
commonParts	Whether to include parts that would be common to several figures on the same page. Currently this includes a reference to and copy of the 'CanvasMatrix.js' file in the output.

reuse	When writing several figures on the same page, set this to a dataframe containing values to reuse. See the Value section below.
font	The font to use for text.
width, height	The (optional) width and height in pixels of the image to display. If omitted, the <code>par3d("windowRect")</code> dimensions will be used.

Details

This function writes out a web page containing Javascript that reconstructs the scene in WebGL.

Use the `template` argument to give the filename of a web page that is to contain the code for the new scene. It should contain a single line containing `paste0("%", prefix, "WebGL%", e.g. %WebGL%` with the default empty prefix. That line will be replaced by the Javascript and other code necessary to reproduce the current scene. The template may also contain the string `"%rglVersion%"` which will be replaced with the current **rgl** version number. If `template` is `NULL`, the output will simply be written directly to the main file.

To put more than one scene into a web page, use different values of `prefix` for each. The prefix will be used in identifiers in both Javascript and HTML, so it is safest to start with a letter and only use alphanumeric characters.

WebGL is a fairly new technology for displaying 3D scenes in browsers. Most current browsers support it to some extent, though it may not be enabled by default; see <http://get.webgl.org> for details. A major exception currently is Microsoft's Internet Explorer, though plugins are available.

Currently `writeWebGL` has a number of known limitations, some of which will be gradually eliminated as development progresses:

- The bounding box decorations are fixed; labels do not move as they do within `R`.
- User-defined mouse controls are not supported.
- No automatic movement (e.g. rotation via `spin3d`) is supported.
- Missing values are not handled properly.
- Polygons will only be rendered as filled; there is no support in WebGL for wireframe or point rendering.
- WebGL browsers generally do not support more than 65535 vertices per object. `writeWebGL` will print a warning if this limit is exceeded, but it is up to the user to break his scene into smaller objects. (And 65535 vertices may not be small enough!)

There is some experimental support for modification of the scene by other Javascript code on the same web page. Currently this is limited to the following. There will be a global variable created with name `<prefix>rgl`, where `<prefix>` will be replaced by the `prefix` argument to `writeWebGL`. Currently this variable will contain properties corresponding to some of the components returned by `par3d`, namely `FOV`, `zoom`, `userMatrix` and `listeners`. Each of these components should be indexed by a subscene number to obtain the value for that subscene; for example, use `<prefix>rgl.userMatrix[3]` to obtain the user matrix for subscene 3 as a `CanvasMatrix4` object (defined in the `'CanvasMatrix.js'` library). After modifying any of these values, user code should insert a call `<prefix>rgl.drawScene()`; to update the display.

Value

The filename is returned. If reuse is not NULL, it will have an attribute called "reuse" which contains a dataframe with columns "id" and "prefix" identifying the prefix used for objects drawn in this scene. This dataframe can be used as the reuse argument in subsequent calls to writeWebGL.

Note

If commonParts is TRUE, the output includes a binary copy of the CanvasMatrix Javascript library. This file is necessary for the Javascript code written by writeWebGL to function properly, but only one copy is needed if the output page contains multiple writeWebGL figures.

Its source (including the copyright notice and license for free use) is included in the file named by system.file("WebGL/CanvasMatrix.src.js", package = "rgl").

Author(s)

Duncan Murdoch.

References

<http://www.webgl.org>

See Also

[scene3d](#) saves a copy of a scene to an R variable; [writePLY](#), [writeOBJ](#) and [writeSTL](#) write the scene to a file in various other formats.

Examples

```
plot3d(rnorm(100), rnorm(100), rnorm(100), type = "s", col = "red")
# This writes a copy into temporary directory 'webGL', and then displays it
filename <- writeWebGL(dir = file.path(tempdir(), "webGL"),
                      width = 500, reuse = TRUE)
# Display the "reuse" attribute
attr(filename, "reuse")

# Display the scene in a browser
if (interactive())
  browseURL(paste0("file://", filename))
```

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