

Package ‘rayrender’

June 16, 2026

Type Package

Title Build and Raytrace 3D Scenes

Version 0.41.3

Date 2026-06-15

Maintainer Tyler Morgan-Wall <tylermw@gmail.com>

Description Render scenes using pathtracing. Build 3D scenes out of spheres, cubes, planes, disks, triangles, cones, curves, line segments, cylinders, ellipsoids, and 3D models in the 'Wavefront' OBJ file format or the PLY Polygon File Format. Supports several material types, textures, multicore rendering, and tone-mapping. Based on the ``Ray Tracing in One Weekend'' book series. Peter Shirley (2018) <<https://raytracing.github.io>>.

License GPL-3

Copyright file inst/COPYRIGHTS

Depends R (>= 4.1.0)

Imports Rcpp (>= 1.0.0), parallel, png, raster, decido, rayimage (>= 0.26.1), stats, progress, rayvertex (>= 0.15.0), withr, vctrs, cli, pillar

Suggests sf, spData, dplyr, Rvcg, testthat (>= 3.2.3), tibble, rayshader (>= 0.38.13), xml2, rgl

LinkingTo Rcpp, RcppThread (>= 2.4.0), progress, spacefillr (>= 0.3.0), testthat, libopenexr (>= 3.4.4), libimath (>= 3.2.2)

URL <https://www.rayrender.net>,
<https://github.com/tylermorganwall/rayrender>,
<http://www.rayrender.net/>

SystemRequirements C++20

Biarch true

Encoding UTF-8

Config/testthat/edition 3

Config/build/compilation-database true

Config/roxygen2/version 8.0.0

NeedsCompilation yes

Author Tyler Morgan-Wall [aut, cph, cre] (ORCID:
<https://orcid.org/0000-0002-3131-3814>),
 Syoyo Fujita [ctb, cph],
 Vilya Harvey [ctb, cph]

Repository CRAN

Date/Publication 2026-06-16 05:10:12 UTC

Contents

add_object	3
animate_objects	4
arrow	7
bezier_curve	9
cone	11
create_instances	13
csg_box	16
csg_capsule	17
csg_combine	18
csg_cone	20
csg_cylinder	21
csg_ellipsoid	22
csg_elongate	23
csg_group	25
csg_object	26
csg_onion	27
csg_plane	29
csg_pyramid	30
csg_rotate	31
csg_round	32
csg_rounded_cone	33
csg_scale	34
csg_sphere	35
csg_torus	36
csg_translate	37
csg_triangle	38
cube	39
cylinder	41
dielectric	42
diffuse	44
disk	47
ellipsoid	49
extruded_path	50
extruded_polygon	55
generate_camera_motion	61
generate_cornell	64
generate_ground	66

generate_studio 67

get_saved_keyframes 68

glossy 68

group_objects 71

hair 73

has_denoiser 75

lambertian 75

light 76

mesh3d_model 78

metal 80

microfacet 83

obj_model 86

path 89

pig 92

ply_model 94

raymesh_model 95

render_animation 98

render_ao 103

render_preview 107

render_scene 108

r_obj 114

screen_line 115

screen_text 118

segment 123

set_scene_material 125

sphere 126

text3d 127

triangle 130

xy_rect 131

xz_rect 133

yz_rect 134

Index **136**

add_object *Add Object*

Description

Add Object

Usage

add_object(scene, objects = NULL)

Arguments

scene Tibble of pre-existing object locations and properties.
 objects A tibble row or collection of rows representing each object.

Value

Tibble of object locations and properties.

Examples

```
#Generate the ground and add some objects
scene = generate_ground(depth=-0.5,material = diffuse(checkercolor="blue")) |>
  add_object(cube(x=0.7,
                 material=diffuse(noise=5,noise="purple",color="black",noisephase=45),
                 angle=c(0,-30,0))) |>
  add_object(sphere(x=-0.7,radius=0.5,material=metal(color="gold")))
render_scene(scene,parallel=TRUE)
```

 animate_objects

Animate Objects

Description

This function animates an object between two states. This animates objects separately from the transformations set in ‘group_objects()’ and in the object transformations themselves. This creates motion blur, controlled by the shutter open/close options in ‘render_scene()’.

Usage

```
animate_objects(
  scene,
  start_time = 0,
  end_time = 1,
  start_pivot_point = c(0, 0, 0),
  start_position = c(0, 0, 0),
  start_angle = c(0, 0, 0),
  start_order_rotation = c(1, 2, 3),
  start_scale = c(1, 1, 1),
  start_axis_rotation = NA,
  end_pivot_point = c(0, 0, 0),
  end_position = c(0, 0, 0),
  end_angle = c(0, 0, 0),
  end_order_rotation = c(1, 2, 3),
  end_scale = c(1, 1, 1),
  end_axis_rotation = NA
)
```

Arguments

scene	Tibble of pre-existing object locations.
start_time	Default '0'. Start time of movement.
end_time	Default '1'. End time of movement.
start_pivot_point	Default 'c(0,0,0)'. The point about which to pivot, scale, and move the objects.
start_position	Default 'c(0,0,0)'. Vector indicating where to offset the objects.
start_angle	Default 'c(0,0,0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
start_order_rotation	Default 'c(1,2,3)'. The order to apply the rotations, referring to "x", "y", and "z".
start_scale	Default 'c(1,1,1)'. Scaling factor for x, y, and z directions for all objects.
start_axis_rotation	Default 'NA'. Provide an axis of rotation and a single angle (via 'angle') of rotation
end_pivot_point	Default 'c(0,0,0)'. The point about which to pivot, scale, and move the group.
end_position	Default 'c(0,0,0)'. Vector indicating where to offset the objects.
end_angle	Default 'c(0,0,0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
end_order_rotation	Default 'c(1,2,3)'. The order to apply the rotations, referring to "x", "y", and "z".
end_scale	Default 'c(1,1,1)'. Scaling factor for x, y, and z directions for all objects.
end_axis_rotation	Default 'NA'. Provide an axis of rotation and a single angle (via 'angle') of rotation around that axis.

Value

Tibble of animated object.

Examples

```
#Render a pig
generate_studio() |>
  add_object(pig(y=-1.2,scale=0.5,angle=c(0,110,0)))|>
  add_object(sphere(y=5,x=5,z=-5,radius=2,material=light())) |>
  render_scene(samples=16,sample_method = "sobol_blue")
#Render a moving pig
generate_studio() |>
  add_object(
    animate_objects(
      pig(y=-1.2,scale=0.5,angle=c(0,110,0)),
      start_position = c(-0.1,0,0), end_position = c(0.1,0.2,0))
```

```

) |>
add_object(sphere(y=5,x=5,z=-5,radius=2,material=light())) |>
render_scene(samples=16,sample_method = "sobol_blue",clamp_value = 10)

#Render a shrinking pig
generate_studio() |>
add_object(
  animate_objects(
    pig(y=-1.2,scale=0.5,angle=c(0,110,0)),
    start_scale = c(1,1,1), end_scale = c(0.5,0.5,0.5))
) |>
add_object(sphere(y=5,x=5,z=-5,radius=2,material=light())) |>
render_scene(samples=16,sample_method = "sobol_blue",clamp_value = 10)

#Render a spinning pig
generate_studio() |>
add_object(
  animate_objects(
    pig(y=-1.2,scale=0.5,angle=c(0,110,0)),
    start_angle = c(0,-30,0), end_angle = c(0,30,0))
) |>
add_object(sphere(y=5,x=5,z=-5,radius=2,material=light())) |>
render_scene(samples=16,sample_method = "sobol_blue",clamp_value = 10)

#Shorten the open shutter time frame
generate_studio() |>
add_object(
  animate_objects(
    pig(y=-1.2,scale=0.5,angle=c(0,110,0)),
    start_angle = c(0,-30,0), end_angle = c(0,30,0))
) |>
add_object(sphere(y=5,x=5,z=-5,radius=2,material=light())) |>
render_scene(samples=16,sample_method = "sobol_blue",clamp_value = 10,
  shutteropen=0.4, shutterclose = 0.6)

#Change the time frame when the shutter is open
generate_studio() |>
add_object(
  animate_objects(
    pig(y=-1.2,scale=0.5,angle=c(0,110,0)),
    start_angle = c(0,-30,0), end_angle = c(0,30,0))
) |>
add_object(sphere(y=5,x=5,z=-5,radius=2,material=light())) |>
render_scene(samples=16,sample_method = "sobol_blue",clamp_value = 10,
  shutteropen=0, shutterclose = 0.1)

#Shorten the time span in which the movement occurs (which, in effect,
#increases the speed of the transition).
generate_studio() |>
add_object(
  animate_objects(start_time = 0, end_time=0.1,
    pig(y=-1.2,scale=0.5,angle=c(0,110,0)),
    start_angle = c(0,-30,0), end_angle = c(0,30,0))
) |>
add_object(sphere(y=5,x=5,z=-5,radius=2,material=light())) |>
render_scene(samples=16,sample_method = "sobol_blue",clamp_value = 10,

```

```
shutteropen=0, shutterclose = 0.1)
```

 arrow

Arrow Object

Description

Composite object (cone + segment)

Usage

```
arrow(
  start = c(0, 0, 0),
  end = c(0, 1, 0),
  radius_top = 0.2,
  radius_tail = 0.1,
  tail_proportion = 0.5,
  direction = NA,
  from_center = TRUE,
  material = diffuse(),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

<code>start</code>	Default 'c(0, 0, 0)'. Base of the arrow, specifying 'x', 'y', 'z'.
<code>end</code>	Default 'c(0, 1, 0)'. Tip of the arrow, specifying 'x', 'y', 'z'.
<code>radius_top</code>	Default '0.5'. Radius of the top of the arrow.
<code>radius_tail</code>	Default '0.2'. Radius of the tail of the arrow.
<code>tail_proportion</code>	Default '0.5'. Proportion of the arrow that is the tail.
<code>direction</code>	Default 'NA'. Alternative to 'start' and 'end', specify the direction (via a length-3 vector) of the arrow. Arrow will be centered at 'start', and the length will be determined by the magnitude of the direction vector.
<code>from_center</code>	Default 'TRUE'. If orientation specified via 'direction', setting this argument to 'FALSE' will make 'start' specify the bottom of the cone, instead of the middle.
<code>material</code>	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
<code>flipped</code>	Default 'FALSE'. Whether to flip the normals.
<code>scale</code>	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Notes: this will change the stated start/end position of the cone. Emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the cone in the scene.

Examples

```
#Draw a simple arrow from x = -1 to x = 1
generate_studio() |>
  add_object(arrow(start = c(-1,0,0), end = c(1,0,0), material=glossy(color="red"))) |>
  add_object(sphere(y=5,material=light(intensity=20))) |>
  render_scene(clamp_value=10, samples=16)
#Change the proportion of tail to top
generate_studio(depth=-2) |>
  add_object(arrow(start = c(-1,-1,0), end = c(1,-1,0), tail_proportion = 0.5,
    material=glossy(color="red"))) |>
  add_object(arrow(start = c(-1,0,0), end = c(1,0,0), tail_proportion = 0.75,
    material=glossy(color="red"))) |>
  add_object(arrow(start = c(-1,1,0), end = c(1,1,0), tail_proportion = 0.9,
    material=glossy(color="red"))) |>
  add_object(sphere(y=5,z=-5,x=2,material=light(intensity=30))) |>
  render_scene(clamp_value=10, fov=25, samples=16)
#Change the radius of the tail/top segments
generate_studio(depth=-1.5) |>
  add_object(arrow(start = c(-1,-1,0), end = c(1,-1,0), tail_proportion = 0.75,
    radius_top = 0.1, radius_tail=0.03,
    material=glossy(color="red"))) |>
  add_object(arrow(start = c(-1,0,0), end = c(1,0,0), tail_proportion = 0.75,
    radius_top = 0.2, radius_tail=0.1,
    material=glossy(color="red"))) |>
  add_object(arrow(start = c(-1,1,0), end = c(1,1,0), tail_proportion = 0.75,
    radius_top = 0.3, radius_tail=0.2,
    material=glossy(color="red"))) |>
  add_object(sphere(y=5,z=-5,x=2,material=light(intensity=30))) |>
  render_scene(clamp_value=10, samples=16)
#We can also specify arrows via a midpoint and direction:
generate_studio(depth=-1) |>
  add_object(arrow(start = c(-1,-0.5,0), direction = c(0,0,1),
    material=glossy(color="green"))) |>
  add_object(arrow(start = c(1,-0.5,0), direction = c(0,0,-1),
    material=glossy(color="red"))) |>
  add_object(arrow(start = c(0,-0.5,1), direction = c(1,0,0),
    material=glossy(color="yellow"))) |>
  add_object(arrow(start = c(0,-0.5,-1), direction = c(-1,0,0),
    material=glossy(color="purple"))) |>
  add_object(sphere(y=5,z=-5,x=2,material=light(intensity=30))) |>
  render_scene(clamp_value=10, samples=16,
    lookfrom=c(0,5,10), lookat=c(0,-0.5,0), fov=16)
#Plot a 3D vector field for a gravitational well:

r = 1.5
theta_vals = seq(0,2*pi,length.out = 16)[-16]
phi_vals = seq(0,pi,length.out = 16)[-16][-1]
arrow_list = list()
```

```

counter = 1
for(theta in theta_vals) {
  for(phi in phi_vals) {
    rval = c(r*sin(phi)*cos(theta),r*cos(phi),r*sin(phi)*sin(theta))
    arrow_list[[counter]] = arrow(rval, direction = -1/2*rval/sqrt(sum(rval*rval))^3,
                                  tail_proportion = 0.66, radius_top=0.03, radius_tail=0.01,
                                  material = diffuse(color="red"))
    counter = counter + 1
  }
}
vector_field = do.call(rbind,arrow_list)
sphere(material=diffuse(noise=1,color="blue",noisecolor="darkgreen")) |>
  add_object(vector_field) |>
  add_object(sphere(y=0,x=10,z=-5,material=light(intensity=200))) |>
  render_scene(fov=20, ambient=TRUE, samples=16,
               backgroundlow="black",backgroundhigh="white")

```

bezier_curve

Bezier Curve Object

Description

Bezier curve, defined by 4 control points.

Usage

```

bezier_curve(
  p1 = c(0, 0, 0),
  p2 = c(-1, 0.33, 0),
  p3 = c(1, 0.66, 0),
  p4 = c(0, 1, 0),
  x = 0,
  y = 0,
  z = 0,
  width = 0.1,
  width_end = NA,
  u_min = 0,
  u_max = 1,
  type = "cylinder",
  normal = c(0, 0, -1),
  normal_end = NA,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

p1	Default 'c(0,0,0)'. First control point. Can also be a list of 4 length-3 numeric vectors or 4x3 matrix/data.frame specifying the x/y/z control points.
p2	Default 'c(-1,0.33,0)'. Second control point.
p3	Default 'c(1,0.66,0)'. Third control point.
p4	Default 'c(0,1,0)'. Fourth control point.
x	Default '0'. x-coordinate offset for the curve.
y	Default '0'. y-coordinate offset for the curve.
z	Default '0'. z-coordinate offset for the curve.
width	Default '0.1'. Curve width.
width_end	Default 'NA'. Width at end of path. Same as 'width', unless specified.
u_min	Default '0'. Minimum parametric coordinate for the curve.
u_max	Default '1'. Maximum parametric coordinate for the curve.
type	Default 'cylinder'. Other options are 'flat' and 'ribbon'.
normal	Default 'c(0,0,-1)'. Orientation surface normal for the start of ribbon curves.
normal_end	Default 'NA'. Orientation surface normal for the start of ribbon curves. If not specified, same as 'normal'.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the cube in the scene.

Examples

```
#Generate the default curve:
generate_studio(depth=-0.2) |>
  add_object(bezier_curve(material=diffuse(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,radius=0.3,
    material=light(intensity=200, spotlight_focus = c(0,0.5,0))) |>
  render_scene(clamp_value = 10, lookat = c(0,0.5,0), fov=13,
    samples=16)

#Change the control points to change the direction of the curve. Here, we place spheres
#at the control point locations.
```

```

generate_studio(depth=-0.2) |>
  add_object(bezier_curve(material=diffuse(color="red"))) |>
  add_object(sphere(radius=0.075,material=glossy(color="green"))) |>
  add_object(sphere(radius=0.075,x=-1,y=0.33,material=glossy(color="green"))) |>
  add_object(sphere(radius=0.075,x=1,y=0.66,material=glossy(color="green"))) |>
  add_object(sphere(radius=0.075,y=1,material=glossy(color="green"))) |>
  add_object(sphere(y=3,z=-5,x=2,radius=0.3,
    material=light(intensity=200, spotlight_focus = c(0,0.5,0)))) |>
  render_scene(clamp_value = 10, lookat = c(0,0.5,0), fov=15,
    samples=16)
#We can make the curve flat (always facing the camera) by setting the type to `flat`
generate_studio(depth=-0.2) |>
  add_object(bezier_curve(type="flat", material=glossy(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,radius=0.3,
    material=light(intensity=200, spotlight_focus = c(0,0.5,0)))) |>
  render_scene(clamp_value = 10, lookat = c(0,0.5,0), fov=13,
    samples=16)
#We can also plot a ribbon, which is further specified by a start and end orientation with
#two surface normals.
generate_studio(depth=-0.2) |>
  add_object(bezier_curve(type="ribbon", width=0.2,
    p1 = c(0,0,0), p2 = c(0,0.33,0), p3 = c(0,0.66,0), p4 = c(0.3,1,0),
    normal_end = c(0,0,1),
    material=glossy(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,radius=0.3,
    material=light(intensity=200, spotlight_focus = c(0,0.5,0)))) |>
  render_scene(clamp_value = 10, lookat = c(0,0.5,0), fov=13,
    samples=16)
#Create a single curve and copy and rotate it around the y-axis to create a wavy fountain effect:
scene_curves = list()
for(i in 1:90) {
  scene_curves[[i]] = bezier_curve(p1 = c(0,0,0),p2 = c(0,5-sinpi(i*16/180),2),
    p3 = c(0,5-0.5 * sinpi(i*16/180),4),p4 = c(0,0,6),
    angle=c(0,i*4,0), type="cylinder",
    width = 0.1, width_end =0.1,material=glossy(color="red"))
}
all_curves = do.call(rbind, scene_curves)
generate_ground(depth=0,material=diffuse(checkercolor="grey20")) |>
  add_object(all_curves) |>
  add_object(sphere(y=7,z=0,x=0,material=light(intensity=100))) |>
  render_scene(lookfrom = c(12,20,50),samples=100,
    lookat=c(0,1,0), fov=15, clamp_value = 10)

```

 cone

Cone Object

Description

Cone Object

Usage

```

cone(
  start = c(0, 0, 0),
  end = c(0, 1, 0),
  radius = 0.5,
  direction = NA,
  from_center = TRUE,
  material = diffuse(),
  angle = c(0, 0, 0),
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

<code>start</code>	Default <code>'c(0, 0, 0)'</code> . Base of the cone, specifying <code>'x'</code> , <code>'y'</code> , <code>'z'</code> .
<code>end</code>	Default <code>'c(0, 1, 0)'</code> . Tip of the cone, specifying <code>'x'</code> , <code>'y'</code> , <code>'z'</code> .
<code>radius</code>	Default <code>'1'</code> . Radius of the bottom of the cone.
<code>direction</code>	Default <code>'NA'</code> . Alternative to <code>'start'</code> and <code>'end'</code> , specify the direction (via a length-3 vector) of the cone. Cone will be centered at <code>'start'</code> , and the length will be determined by the magnitude of the direction vector.
<code>from_center</code>	Default <code>'TRUE'</code> . If orientation specified via <code>'direction'</code> , setting this argument to <code>'FALSE'</code> will make <code>'start'</code> specify the bottom of the cone, instead of the middle.
<code>material</code>	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
<code>angle</code>	Default <code>'c(0, 0, 0)'</code> . Rotation angle. Note: This will change the <code>'start'</code> and <code>'end'</code> coordinates.
<code>flipped</code>	Default <code>'FALSE'</code> . Whether to flip the normals.
<code>scale</code>	Default <code>'c(1, 1, 1)'</code> . Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Notes: this will change the stated start/end position of the cone. Emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the cone in the scene.

Examples

```

#Generate a cone in a studio, pointing upwards:
generate_studio() |>
  add_object(cone(start=c(0,-1,0), end=c(0,1,0), radius=1,material=diffuse(color="red"))) |>
  add_object(sphere(y=5,x=5,material=light(intensity=40))) |>
  render_scene(samples=16,clamp_value=10)
#Change the radius, length, and direction
generate_studio() |>
  add_object(cone(start=c(0,0,0), end=c(0,-1,0), radius=0.5,material=diffuse(color="red"))) |>

```

```

add_object(sphere(y=5,x=5,material=light(intensity=40))) |>
render_scene(samples=16,clamp_value=10)
#Give custom start and end points (and customize the color/texture)
generate_studio() |>
add_object(cone(start=c(-1,0.5,-1), end=c(0,0,0), radius=0.5,material=diffuse(color="red"))) |>
add_object(cone(start=c(1,0.5,-1), end=c(0,0,0), radius=0.5,material=diffuse(color="green"))) |>
add_object(cone(start=c(0,1,-1), end=c(0,0,0), radius=0.5,material=diffuse(color="orange"))) |>
add_object(cone(start=c(-1,-0.5,0), end=c(1,-0.5,0), radius=0.25,
  material = diffuse(color="red",gradient_color="green"))) |>
add_object(sphere(y=5,x=5,material=light(intensity=40))) |>
render_scene(samples=16,clamp_value=10)
#Specify cone via direction and location, instead of start and end positions
#Length is derived from the magnitude of the direction.
gold_mat = microfacet(roughness=0.1,eta=c(0.216,0.42833,1.3184), kappa=c(3.239,2.4599,1.8661))
generate_studio() |>
add_object(cone(start = c(-1,0,0), direction = c(-0.5,0.5,0), material = gold_mat)) |>
add_object(cone(start = c(1,0,0), direction = c(0.5,0.5,0), material = gold_mat)) |>
add_object(cone(start = c(0,0,-1), direction = c(0,0.5,-0.5), material = gold_mat)) |>
add_object(cone(start = c(0,0,1), direction = c(0,0.5,0.5), material = gold_mat)) |>
add_object(sphere(y=5,material=light())) |>
add_object(sphere(y=3,x=-3,z=-3,material=light(color="red"))) |>
add_object(sphere(y=3,x=3,z=-3,material=light(color="green"))) |>
render_scene(lookfrom=c(0,4,-10), clamp_value=10, samples=16)
#Render the position from the base, instead of the center of the cone:
noise_mat = material = glossy(color="purple",noisecolor="blue", noise=5)
generate_studio() |>
add_object(cone(start = c(0,-1,0), from_center = FALSE, radius=1, direction = c(0,2,0),
  material = noise_mat)) |>
add_object(cone(start = c(-1.5,-1,0), from_center = FALSE, radius=0.5, direction = c(0,1,0),
  material = noise_mat)) |>
add_object(cone(start = c(1.5,-1,0), from_center = FALSE, radius=0.5, direction = c(0,1,0),
  material = noise_mat)) |>
add_object(cone(start = c(0,-1,1.5), from_center = FALSE, radius=0.5, direction = c(0,1,0),
  material = noise_mat)) |>
add_object(sphere(y=5,x=5,material=light(intensity=40))) |>
render_scene(lookfrom=c(0,4,-10), clamp_value=10,fov=25, samples=16)

```

create_instances

Create Instances of an Object

Description

This creates multiple instances of the ‘ray_scene’ passed, each with it’s own transformation applied (measured from the origin of the ray_scene). This means the scene only uses the memory of the object once and each copy only requires a 4x4 matrix in memory.

Usage

```
create_instances(
```

```

ray_scene,
x = 0,
y = 0,
z = 0,
angle_x = 0,
angle_y = 0,
angle_z = 0,
scale_x = 1,
scale_y = 1,
scale_z = 1,
material = diffuse(),
order_rotation = c(1, 2, 3)
)

```

Arguments

ray_scene	A 'ray_scene' object to be copied at the specified transformed coordinates.
x	Default '0'. A vector of x-coordinates to offset the instances. Note that this can also be a 3 column matrix or 'data.frame()' parsable by 'xyz.coords()': if so, the other axes will be ignored.
y	Default '0'. A vector of y-coordinates to offset the instances.
z	Default '0'. A vector of z-coordinates to offset the instances.
angle_x	Default '0'. A vector of angles around the x axis to rotate the instances.
angle_y	Default '0'. A vector of angles around the y axis to rotate the instances.
angle_z	Default '0'. A vector of angles around the z axis to rotate the instances.
scale_x	Default '0'. A vector of values around the scale the instances on the x-axis.
scale_y	Default '0'. A vector of values around the scale the instances on the y-axis.
scale_z	Default '0'. A vector of values around the scale the instances on the z-axis.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z" axes.

Value

Single row of a tibble describing the instance in the scene.

Examples

```

# Generate the base scene
base_scene = generate_ground(material = diffuse(checkercolor = "grey20")) |>
  add_object(sphere(z = -100, radius = 10, material = light(intensity = 70)))

# Start with a single sphere with an R in it
sphere_scene = sphere(y = 0, material = glossy(color = "#2b6eff", reflectance = 0.05)) |>
  add_object(obj_model(r_obj(simple_r = TRUE), z = -0.9, y = -0.2,

```

```

scale_obj = 0.45, angle = c(0,180,0), material = diffuse())) |>
group_objects(scale = 0.1)

# Render the scene
sphere_scene |>
  add_object(base_scene) |>
  render_scene(lookat = c(0, 1, 0), width = 800, sample_method = "sobol_blue", aperture = 0.2,
              height = 800, samples = 16, clamp_value = 20)

# Create instances at different x positions, with random rotations applied
create_instances(sphere_scene,
  x = seq(-1.5, 1.5, length.out = 10),
  angle_x = 90 * (runif(10) - 0.5),
  angle_y = 90 * (runif(10) - 0.5),
  angle_z = 90 * (runif(10) - 0.5)) |>
  add_object(base_scene) |>
  render_scene(lookat = c(0, 1, 0), width = 800, sample_method = "sobol_blue",
              height = 800, samples = 16, clamp_value = 20)

# Create instances at different x/z positions, with random scaling factors
create_instances(sphere_scene,
  x = seq(-1.5, 1.5, length.out = 10),
  y = seq(0, 1.5, length.out = 10),
  scale_x = 0.5 + runif(10),
  scale_y = 0.5 + runif(10),
  scale_z = 0.5 + runif(10)) |>
  add_object(base_scene) |>
  render_scene(lookat = c(0, 1, 0), width = 800, sample_method = "sobol_blue",
              height = 800, samples = 16, clamp_value = 20)

# Create instances of instances
create_instances(sphere_scene,
  x = seq(-1.5, 1.5, length.out = 10),
  angle_y = 90 * (runif(10) - 0.5)) |>
  create_instances(y = seq(0, 2, length.out = 10)) |>
  add_object(base_scene) |>
  render_scene(lookat = c(0, 1, 0), width = 800, sample_method = "sobol_blue",
              height = 800, samples = 16, clamp_value = 20)

# Create instances of instances of instances of instances
create_instances(sphere_scene,
  x = seq(-1.5, 1.5, length.out = 10),
  angle_y = 90 * (runif(10) - 0.5)) |>
  create_instances(y = seq(0, 1, length.out = 5)) |>
  create_instances(y = seq(0, 2, length.out = 20) * 10,
  angle_y = seq(0, 360, length.out = 20)) |>
  create_instances(x = c(-5, 0, 5),
  scale_y = c(0.5, 1, 0.75)) |>
  add_object(base_scene) |>
  render_scene(lookat = c(0, 10, 0), lookfrom = c(0, 10, -50),
              width = 800, sample_method = "sobol_blue", fov = 30,
              height = 800, samples = 16, clamp_value = 20)

```

```

# Generate a complex scene in a Cornell box and replicate it in a 3x3 grid
# Here, a single `data.frame` with all three coordinates is passed to the `x` argument.
tempfileplot = tempfile()
png(filename = tempfileplot, height = 1600, width = 1600)
plot(iris$Petal.Length, iris$Sepal.Width, col = iris$Species, pch = 18, cex = 12)
dev.off()
image_array = png::readPNG(tempfileplot)

# Note that if a instanced scene has importance sampled lights and there are many instances,
# it will be slow to render.
generate_cornell(importance_sample=FALSE) |>
  add_object(ellipsoid(x = 555 / 2, y = 100, z = 555 / 2, a = 50, b = 100, c = 50,
    material = metal(color = "lightblue"))) |>
  add_object(cube(x = 100, y = 130 / 2, z = 200, xwidth = 130,
    ywidth = 130, zwidth = 130, angle = c(0, 10, 0),
    material = diffuse(checkerperiod = "purple", checkerperiod = 30))) |>
  add_object(pig(x = 100, y = 190, z = 200, scale = 40, angle = c(0, 30, 0))) |>
  add_object(sphere(x = 420, y = 555 / 8, z = 100, radius = 555 / 8,
    material = dielectric(color = "orange"))) |>
  add_object(yz_rect(x = 5, y = 300, z = 555 / 2, zwidth = 400, ywidth = 400,
    material = diffuse(image_texture = image_array))) |>
  add_object(yz_rect(x = 555 / 2, y = 300, z = 555 - 5, zwidth = 400, ywidth = 400,
    material = diffuse(image_texture = image_array), angle = c(0, 90, 0))) |>
  add_object(yz_rect(x = 555 - 5, y = 300, z = 555 / 2, zwidth = 400, ywidth = 400,
    material = diffuse(image_texture = image_array), angle = c(0, 180, 0))) |>
  create_instances(x = expand.grid(x = seq(-1, 1, by = 1) * 570 - 555 / 2,
    y = seq(-1, 1, by = 1) * 570 - 555 / 2,
    z = 0)) |>
  render_scene(lookfrom = c(0, 0, -800) * 3, fov = 40,
    samples = 16, sample_method = "sobol_blue",
    parallel = TRUE, width = 800, height = 800)

```

csg_box

CSG Box

Description

CSG Box

Usage

```
csg_box(x = 0, y = 0, z = 0, width = c(1, 1, 1), corner_radius = 0)
```

Arguments

x	Default '0'. An x-coordinate on the box.
y	Default '0'. A y-coordinate on the box.
z	Default '0'. A z-coordinate on the box.

width Default 'c(1,1,1)'. Length-3 vector describing the x/y/z widths of the box
 corner_radius Default '0'. Radius if rounded box.

Value

List describing the box in the scene.

Examples

```
#Generate a box
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_box(), material=glossy(color="#FF69B4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=5))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(7,3,7))
#Change the width
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_box(width = c(2,1,0.5)), material=glossy(color="#FF69B4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=5))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(7,3,7))
#Subtract two boxes to make stairs
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_box(),
    csg_box(x=0.5,y=0.5,width=c(1,1,1.1)),operation="subtract"),
    material=glossy(color="#FF69B4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=5))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(7,3,7),fov=13)
```

 csg_capsule

CSG Capsule

Description

CSG Capsule

Usage

```
csg_capsule(start = c(0, 0, 0), end = c(0, 1, 0), radius = 1)
```

Arguments

start Default 'c(0, 0, 0)'. Start point of the capsule, specifying 'x', 'y', 'z'.
 end Default 'c(0, 1, 0)'. End point of the capsule, specifying 'x', 'y', 'z'.
 radius Default '1'. Capsule radius.

Value

List describing the capsule in the scene.

Examples

```

#Generate a basic capsule:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_capsule(radius=0.5),material=glossy(color="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20)
#Change the orientation by specifying a start and end
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(csg_capsule(start = c(-1,0.5,-2), end = c(1,0.5,-2),
    radius=0.5),material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(3,3,10))
#Show the effect of changing the radius
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(
    csg_combine(
      csg_capsule(start = c(-1,0.5,-2), end = c(1,0.5,-2), radius=0.5),
      csg_capsule(start = c(-0.5,1.5,-2), end = c(0.5,1.5,-2), radius=0.25)),
    material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(-3,3,10))
#Render a capsule in a Cornell box
generate_cornell() |>
  add_object(csg_object(
    csg_capsule(start = c(555/2-100,555/2,555/2), end = c(555/2+100,555/2,555/2), radius=100),
    material=glossy(color="dodgerblue4"))) |>
  render_scene(clamp_value=10, samples=16)

```

csg_combine

CSG Combine

Description

Note: Subtract operations aren't commutative: the second object is subtracted from the first.

Usage

```
csg_combine(object1, object2, operation = "union", radius = 0.5)
```

Arguments

object1	First CSG object
object2	Second CSG object
operation	Default 'union'. Can be 'union', 'subtract', 'intersection', 'blend', 'subtract-blend', or 'mix'.
radius	Default '0.5'. Blending radius.

Value

List describing the combined csg object in the scene.

Examples

```
#Combine two spheres:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(x=-0.4,z=-0.4),
    csg_sphere(x=0.4,z=0.4), operation="union"),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,fov=20,lookfrom=c(-3,5,10))
#Subtract one sphere from another:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(x=-0.4,z=-0.4),
    csg_sphere(x=0.4,z=0.4), operation="subtract"),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,fov=20,lookfrom=c(-3,5,10))
#Get the intersection of two spheres:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(x=-0.4,z=-0.4),
    csg_sphere(x=0.4,z=0.4), operation="intersection"),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,fov=20,lookfrom=c(-3,5,10))
#Get the blended union of two spheres:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(x=-0.4,z=-0.4),
    csg_sphere(x=0.4,z=0.4), operation="blend"),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,fov=20,lookfrom=c(-3,5,10))
#Get the blended subtraction of two spheres:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(x=-0.4,z=-0.4),
    csg_sphere(x=0.4,z=0.4), operation="subtractblend"),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,fov=20,lookfrom=c(-3,5,10))
#Change the blending radius:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(x=-0.4,z=-0.4),
    csg_sphere(x=0.4,z=0.4), operation="blend", radius=0.2),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
```

```

render_scene(clamp_value=10, samples=16, fov=20, lookfrom=c(-3,5,10))
#Change the subtract blending radius:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(x=-0.4,z=-0.4),
    csg_sphere(x=0.4,z=0.4), operation="subtractblend", radius=0.2),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16, fov=20, lookfrom=c(-3,5,10))
#Get the mixture of various objects:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_sphere(),
    csg_box(), operation="mix"),
    material=glossy(color="dodgerblue4"))) |>
  add_object(csg_object(csg_translate(csg_combine(
    csg_box(),
    csg_torus(), operation="mix"),z=-2.5),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_translate(csg_combine(
    csg_pyramid(),
    csg_box(), operation="mix"),z=2.5),
    material=glossy(color="green"))) |>
  add_object(sphere(y=10,x=-5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16, fov=20, lookfrom=c(-15,10,10))

```

csg_cone

CSG Cone

Description

CSG Cone

Usage

```
csg_cone(start = c(0, 0, 0), end = c(0, 1, 0), radius = 0.5)
```

Arguments

start	Default 'c(0, 0, 0)'. Start point of the cone, specifying 'x', 'y', 'z'.
end	Default 'c(0, 1, 0)'. End point of the cone, specifying 'x', 'y', 'z'.
radius	Default '1'. Radius of the bottom of the cone.

Value

List describing the box in the scene.

Examples

```

#Generate a basic cone:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_cone(),material=glossy(color="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20)
#Change the orientation by specifying a start and end
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(csg_cone(start = c(-1,0.5,-2), end = c(1,0.5,-2),
    radius=0.5),material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(3,3,10))
#Show the effect of changing the radius
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(
    csg_combine(
      csg_cone(start = c(-1,0.5,-2), end = c(1,0.5,-2), radius=0.5),
      csg_cone(start = c(-0.5,1.5,-2), end = c(0.5,1.5,-2), radius=0.2)),
    material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(-3,3,10))
#Render a glass cone in a Cornell box
generate_cornell() |>
  add_object(csg_object(
    csg_cone(start = c(555/2,0,555/2), end = c(555/2,555/2+100,555/2), radius=100),
    material=dielectric(attenuation=c(1,1,0.3)/100))) |>
  render_scene(clamp_value=10, samples=16)

```

csg_cylinder

*CSG Cylinder***Description**

CSG Cylinder

Usage

```

csg_cylinder(
  start = c(0, 0, 0),
  end = c(0, 1, 0),
  radius = 1,
  corner_radius = 0
)

```

Arguments

start	Default 'c(0, 0, 0)'. Start point of the cylinder, specifying 'x', 'y', 'z'.
end	Default 'c(0, 1, 0)'. End point of the cylinder, specifying 'x', 'y', 'z'.
radius	Default '1'. Cylinder radius.
corner_radius	Default '0'. Radius if rounded cylinder.

Value

List describing the cylinder in the scene.

Examples

```
#Generate a basic cylinder:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_cylinder(radius=0.25),material=glossy(color="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20)
#Change the orientation by specifying a start and end
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(csg_cylinder(start = c(-1,0.5,-2), end = c(1,0.5,-2),
    radius=0.5),material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(3,3,10))
#Show the effect of changing the radius
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(
    csg_combine(
      csg_cylinder(start = c(-1,0.5,-2), end = c(1,0.5,-2), radius=0.5),
      csg_cylinder(start = c(-0.5,1.5,-2), end = c(0.5,1.5,-2), radius=0.25)),
    material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(-3,3,10))
#Render a red marble cylinder in a Cornell box
generate_cornell(light=FALSE) |>
  add_object(csg_object(
    csg_cylinder(start = c(555/2,0,555/2), end = c(555/2,350,555/2), radius=100),
    material=glossy(color="darkred",noisecolor="white",noise=0.03))) |>
  add_object(sphere(y=555,x=5,z=5, radius=5,
    material=light(intensity=10000,
      spotlight_focus = c(555/2,555/2,555/2),spotlight_width = 45))) |>
  render_scene(clamp_value=4)
```

csg_ellipsoid

CSG Ellipsoid

Description

CSG Ellipsoid

Usage

```
csg_ellipsoid(x = 0, y = 0, z = 0, axes = c(0.5, 1, 0.5))
```

Arguments

x	Default '0'. x-coordinate on the ellipsoid.
y	Default '0'. y-coordinate on the ellipsoid.
z	Default '0'. z-coordinate on the ellipsoid.
axes	Default 'c(0.5,1,0.5)'. Ellipsoid principle axes.

Value

List describing the ellipsoid in the scene.

Examples

```
#Generate a basic ellipsoid:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_ellipsoid(),material=glossy(color="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20)
#Three different ellipsoids:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_group(list(
    csg_ellipsoid(x=-1.2, axes = c(0.2,0.5,0.5)),
    csg_ellipsoid(x=0, axes = c(0.5,0.2,0.5)),
    csg_ellipsoid(x=1.2, axes = c(0.5,0.5,0.2))),
    material=glossy(color="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,lookfrom=c(0,5,10))
#Generate a glass ellipsoid:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_ellipsoid(),material=dielectric(attenuation = c(1,1,0.3)))) |>
  render_scene(clamp_value=10, samples=16,fov=20)
#Generate a glass ellipsoid in a Cornell box:
generate_cornell() |>
  add_object(csg_object(csg_ellipsoid(x=555/2,y=555/2,z=555/2,axes=c(100,150,200)),
    material=dielectric(attenuation = c(1,0.3,1)/200))) |>
  render_scene(clamp_value=10, samples=16)
```

csg_elongate

CSG Elongate

Description

This operation elongates an existing CSG object in a direction.

Usage

```
csg_elongate(object, x = 0, y = 0, z = 0, elongate = c(0, 0, 0), robust = TRUE)
```

Arguments

object	CSG object.
x	Default '0'. Center of x-elongation.
y	Default '0'. Center of y-elongation.
z	Default '0'. Center of z-elongation.
elongate	Default 'c(0,0,0)' (no elongation). Elongation amount.
robust	Default 'TRUE'. 'FALSE' switches to a faster (but less robust in 2D) method.

Value

List describing the triangle in the scene.

Examples

```
#Elongate a sphere to create a capsule in 1D or a rounded rectangle in 2D:
generate_ground(material=diffuse(checkercolor="grey20",color="dodgerblue4")) |>
  add_object(csg_object(csg_sphere(z=-3,x=-3),
    material=glossy(color="purple"))) |>
  add_object(csg_object(csg_elongate(csg_sphere(z=-3,x=3),x=3,z=-3, elongate = c(0.8,0,0)),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_elongate(csg_sphere(z=2),z=2, elongate = c(0.8,0,0.8)),
    material=glossy(color="white"))) |>
  add_object(sphere(y=10,radius=3,material=light(intensity=8))) |>
  render_scene(clamp_value=10, samples=16,fov=40,lookfrom=c(0,10,10))
#Elongate a torus:
generate_ground(material=diffuse(checkercolor="grey20",color="dodgerblue4")) |>
  add_object(csg_object(csg_torus(z=-3,x=-3),
    material=glossy(color="purple"))) |>
  add_object(csg_object(csg_elongate(csg_torus(z=-3,x=3),x=3,z=-3, elongate = c(0.8,0,0)),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_elongate(csg_torus(z=2),z=2, elongate = c(0.8,0,0.8)),
    material=glossy(color="white"))) |>
  add_object(sphere(y=10,radius=3,material=light(intensity=8))) |>
  render_scene(clamp_value=10, samples=16,fov=40,lookfrom=c(0,10,10))
#Elongate a cylinder:
generate_ground(material=diffuse(checkercolor="grey20",color="dodgerblue4")) |>
  add_object(csg_object(csg_cylinder(start=c(-3,0,-3), end = c(-3,1,-3)),
    material=glossy(color="purple"))) |>
  add_object(csg_object(csg_elongate(csg_cylinder(start=c(3,0,-3), end = c(3,1,-3)), x=3, z=-3,
    elongate = c(0.8,0,0)),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_elongate(csg_cylinder(start=c(0,0,3), end = c(0,1,3)), z=3,
    elongate = c(0.8,0,0.8)),
    material=glossy(color="white"))) |>
  add_object(sphere(y=10,radius=3,material=light(intensity=8))) |>
  render_scene(clamp_value=10, samples=16,fov=40,lookfrom=c(0,10,10))
#Elongate a pyramid:
generate_ground(material=diffuse(checkercolor="grey20",color="dodgerblue4")) |>
  add_object(csg_object(csg_pyramid(z=-3,x=-3),
    material=glossy(color="purple"))) |>
```

```

add_object(csg_object(csg_elongate(csg_pyramid(z=-3,x=3),x=3,z=-3, elongate = c(0.8,0,0)),
    material=glossy(color="red"))) |>
add_object(csg_object(csg_elongate(csg_pyramid(z=2),z=2, elongate = c(0.8,0,0.8)),
    material=glossy(color="white"))) |>
add_object(sphere(y=10,radius=3,material=light(intensity=8))) |>
render_scene(clamp_value=10, samples=16,fov=40,lookfrom=c(0,10,10))
#Change the elongation point to start the elongation on the side of the pyramid:
generate_ground(material=diffuse(checkercolor="grey20",color="dodgerblue4")) |>
add_object(csg_object(csg_pyramid(z=-3,x=-3),
    material=glossy(color="purple"))) |>
add_object(csg_object(csg_elongate(csg_pyramid(z=-3,x=3),x=2.75,z=-2.75, elongate = c(0.8,0,0)),
    material=glossy(color="red"))) |>
add_object(csg_object(csg_elongate(csg_pyramid(z=2),z=2.25, elongate = c(0.8,0,0.8)),
    material=glossy(color="white"))) |>
add_object(sphere(y=10,radius=3,material=light(intensity=8))) |>
render_scene(clamp_value=10, samples=16,fov=40,
    lookfrom=c(5,5,10),lookat=c(0,0,-1.5))

```

csg_group

CSG Group

Description

CSG Group

Usage

```
csg_group(object_list)
```

Arguments

object_list List of objects created with the `csg_*` functions. This will make all further operations be applied to this object as a group.

Value

List describing the group in the scene.

Examples

```

#Group four spheres together and merge them with a box:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_group(list(csg_sphere(x=1,z=1, radius=0.5),csg_sphere(x=-1,z=1, radius=0.5),
      csg_sphere(x=1,z=-1, radius=0.5),csg_sphere(x=-1,z=-1, radius=0.5))),
    csg_box(y=0.5, width=c(2,0.2,2)), operation="blend", material=glossy(color="red"))) |>
  add_object(sphere(y=10,x=-5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(5,5,10))

```

csg_object

Constructive Solid Geometry Object

Description

This object takes an object constructed using the 'csg_*' functions. The object is drawn using ray marching/sphere tracing.

Usage

```
csg_object(
  object,
  x = 0,
  y = 0,
  z = 0,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

object	Object created with CSG interface.
x	Default '0'. x-offset of the center of the object.
y	Default '0'. y-offset of the center of the object.
z	Default '0'. z-offset of the center of the object.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Details

Note: For dielectric objects, any other objects not included in the CSG object and nested inside will be ignored.

Value

Single row of a tibble describing the sphere in the scene.

Examples

```
#We will combine these three objects:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_box(), material=glossy(color="red"))) |>
  add_object(csg_object(csg_sphere(radius=0.707), material=glossy(color="green"))) |>
  add_object(csg_object(csg_group(list(csg_cylinder(start=c(-1,0,0), end=c(1,0,0), radius=0.4),
    csg_cylinder(start=c(0,-1,0), end=c(0,1,0), radius=0.4),
    csg_cylinder(start=c(0,0,-1), end=c(0,0,1), radius=0.4))),
    material=glossy(color="blue"))) |>
  add_object(sphere(y=5,x=3,radius=1,material=light(intensity=30))) |>
  render_scene(clamp_value=10, fov=15,lookfrom=c(5,5,10),
    samples=16, sample_method="sobol_blue")
#Standard CSG sphere + box - crossed cylinder combination:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_combine(
      csg_box(),
      csg_sphere(radius=0.707),
      operation="intersection"),
    csg_group(list(csg_cylinder(start=c(-1,0,0), end=c(1,0,0), radius=0.4),
      csg_cylinder(start=c(0,-1,0), end=c(0,1,0), radius=0.4),
      csg_cylinder(start=c(0,0,-1), end=c(0,0,1), radius=0.4))),
    operation="subtract"),
    material=glossy(color="red"))) |>
  add_object(sphere(y=5,x=3,radius=1,material=light(intensity=30))) |>
  render_scene(clamp_value=10, fov=10,lookfrom=c(5,5,10),
    samples=16, sample_method="sobol_blue")
#Blend them all instead:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_combine(
      csg_box(),
      csg_sphere(radius=0.707),
      operation="blend"),
    csg_group(list(csg_cylinder(start=c(-1,0,0), end=c(1,0,0), radius=0.4),
      csg_cylinder(start=c(0,-1,0), end=c(0,1,0), radius=0.4),
      csg_cylinder(start=c(0,0,-1), end=c(0,0,1), radius=0.4))),
    operation="blend"),
    material=glossy(color="purple"))) |>
  add_object(sphere(y=5,x=3,radius=1,material=light(intensity=30))) |>
  render_scene(clamp_value=10, fov=15,lookfrom=c(5,5,10),
    samples=16, sample_method="sobol_blue")
```

Description

Note: This operation has no overt effect on the external appearance of an object—it carves regions on the interior. Thus, you will only see an effect with a transparent material or when you carve into the object.

Usage

```
csg_onion(object, thickness = 0.1)
```

Arguments

object	CSG object.
thickness	Default '0.1'. Onioning distance.

Value

List describing the triangle in the scene.

Examples

```
#Cut and onion a sphere:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_onion(csg_sphere(z=2,x=2,radius=1), thickness = 0.2),
    csg_box(y=1,width=c(10,2,10)), operation = "subtract"),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_combine(
    csg_onion(csg_sphere(radius=1), thickness = 0.4),
    csg_box(y=1,width=c(10,2,10)), operation = "subtract"),
    material=glossy(color="purple"))) |>
  add_object(csg_object(csg_combine(
    csg_onion(csg_sphere(z=-2.5,x=-2.5,radius=1), thickness = 0.6),
    csg_box(y=1,width=c(10,2,10)), operation = "subtract"),
    material=glossy(color="green"))) |>
  add_object(sphere(y=5,x=5,radius=2,material=light())) |>
  render_scene(clamp_value=10, samples=16,lookat=c(0,-0.5,0),
    lookfrom=c(3,5,10),fov=35)

#Multiple onion layers:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_onion(csg_onion(csg_onion(csg_sphere(radius=1), 0.4), 0.2),0.1),
    csg_box(y=1,width=c(10,2,10)), operation = "subtract"),
    material=glossy(color="purple"))) |>
  add_object(sphere(y=5,x=5,radius=2,material=light())) |>
  render_scene(clamp_value=10, samples=16,lookat=c(0,-0.5,0),
    lookfrom=c(3,5,10),fov=20)

#Onion with dielectric sphere to make a bubble:
generate_cornell() |>
  add_object(csg_object(
    csg_onion(csg_sphere(x=555/2,y=555/2,z=555/2, radius=150), 5),
    material=dielectric(attenuation=c(1,1,0.3)/100))) |>
```

```

render_scene(clamp_value=10, samples=16)
#Multiple onion operations to make a bubble within a bubble:
generate_cornell() |>
  add_object(csg_object(
    csg_onion(csg_onion(csg_sphere(x=555/2,y=555/2,z=555/2, radius=150), 10),5),
    material=dielectric(attenuation=c(1,1,0.3)/100))) |>
render_scene(clamp_value=10, samples=16)

```

csg_plane

CSG Plane

Description

Note: This shape isn't closed, so there may be odd lighting issues if it's oriented the wrong way.

Usage

```
csg_plane(x = 0, y = 0, z = 0, normal = c(0, 1, 0), width_x = 4, width_z = 4)
```

Arguments

x	Default '0'. An x-coordinate on the plane.
y	Default '0'. A y-coordinate on the plane.
z	Default '0'. A z-coordinate on the plane.
normal	Default 'c(0,1,0)'. Surface normal of the plane.
width_x	Default '10'.
width_z	Default '10'.

Value

List describing the plane in the scene.

Examples

```

#Generate a plane
csg_object(csg_plane(width_x=4, width_z=4), material=diffuse(checkercolor="purple")) |>
  add_object(sphere(y=5,x=5,material=light(intensity=40))) |>
  render_scene(clamp_value=10, samples=16)
#Combine the plane with a sphere
csg_object(csg_combine(
  csg_sphere(radius=0.5),
  csg_plane(width_x=4, width_z=4,y=-0.5),
  operation="blend"),material=diffuse(checkercolor="purple")) |>
  add_object(sphere(y=5,x=5,material=light(intensity=40))) |>
  render_scene(clamp_value=10, samples=16)
#Re-orient the plane using the normal and
csg_object(csg_combine(

```

```

csg_sphere(radius=0.5),
csg_plane(normal = c(1,1,0),width_x=4, width_z=4,y=-0.5),
operation="blend"),material=diffuse(checkercolor="purple")) |>
add_object(sphere(y=5,x=5,material=light(intensity=40))) |>
render_scene(clamp_value=10, samples=16)

```

csg_pyramid

CSG Pyramid

Description

Note: This primitive slows down immensely for large values of base and height. Try using `csg_scale()` with this object for large pyramids instead.

Usage

```
csg_pyramid(x = 0, y = 0, z = 0, height = 1, base = 1)
```

Arguments

x	Default '0'. x-coordinate on the pyramid.
y	Default '0'. y-coordinate on the pyramid.
z	Default '0'. z-coordinate on the pyramid.
height	Default '1'. Pyramid height.
base	Default '1'. Pyramid base width.

Value

List describing the box in the scene.

Examples

```

#Generate a simple pyramid:
generate_ground() |>
  add_object(csg_object(csg_pyramid(y=-0.99),
                        material=glossy(color="red"))) |>
  add_object(sphere(y=5,x=5,z=5,material=light(intensity=20))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(-3,1,10),
              fov=15, lookat=c(0,-0.5,0))

#Make a taller pyramid
generate_ground() |>
  add_object(csg_object(csg_pyramid(y=-0.95, height=1.5),
                        material=glossy(color="red"))) |>
  add_object(sphere(y=5,x=5,z=5,material=light(intensity=20))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(-3,1,10),
              fov=15, lookat=c(0,-0.5,0))

#Make a wider pyramid

```

```

generate_ground() |>
  add_object(csg_object(csg_pyramid(y=-0.95, base=1.5),
                        material=glossy(color="red"))) |>
  add_object(sphere(y=5,x=5,z=5,material=light(intensity=20))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(-3,1,10),
              fov=15, lookat=c(0,-0.5,0))

```

csg_rotate

*CSG Rotate***Description**

CSG Rotate

Usage

```

csg_rotate(
  object,
  pivot_point = c(0, 0, 0),
  angles = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  up = c(0, 1, 0),
  axis_x = NULL,
  axis_z = NULL
)

```

Arguments

object	CSG object.
pivot_point	Default 'c(0,0,0)'. Pivot point for the rotation.
angles	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
up	Default 'c(0,1,0). Alternative method for specifying rotation—change the new "up" vector.
axis_x	Default 'NULL', computed automatically if not passed. Given the 'up' vector as the y-axis, this is the x vector.
axis_z	Default 'NULL', computed automatically if not passed. Given the 'up' vector as the y-axis, this is the z vector.

Value

List describing the triangle in the scene.

Examples

```
#Rotate a pyramid (translating it upwards because the object is scaled from the center):
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_pyramid(z=1,y=-0.99),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_rotate(csg_pyramid(z=-1.5,y=-0.99),
    pivot_point = c(0,-0.99,-1.5),angle=c(0,45,0)),
    material=glossy(color="green"))) |>
  add_object(sphere(y=5,x=5,z=5,material=light(intensity=40))) |>
  render_scene(lookfrom=c(-3,4,10), fov=15,
    lookat=c(0,-0.5,0),clamp_value=10)

#Rotate by specifying a new up vector:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_pyramid(z=1,y=-0.99),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_rotate(csg_pyramid(z=-1.5,y=-0.49),
    pivot_point = c(0,-0.49,-1.5), up =c(1,1,0)),
    material=glossy(color="green"))) |>
  add_object(sphere(y=5,x=5,z=5,material=light(intensity=40))) |>
  render_scene(lookfrom=c(-3,4,10), fov=15,
    lookat=c(0,-0.5,0),clamp_value=10)
```

csg_round

CSG Round

Description

CSG Round

Usage

```
csg_round(object, radius = 0.1)
```

Arguments

object	CSG object.
radius	Default '0.1'. Rounding distance.

Value

List describing the triangle in the scene.

Examples

```
#Generate a rounded pyramid:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_pyramid(x=-1,y=-0.99,z=1),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_round(csg_pyramid(x=1,y=-0.89)),
    material=glossy(color="blue"))) |>
  add_object(csg_object(csg_round(csg_pyramid(x=0,z=-2,y=-0.5), radius=0.5),
    material=glossy(color="green"))) |>
  add_object(sphere(y=5,x=5,z=5,radius=1,material=light(intensity=50))) |>
  render_scene(lookfrom=c(-3,4,10), fov=22,
    lookat=c(0,-0.5,0),clamp_value=10)

#Round a blend of two objects
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_round(csg_combine(
    csg_pyramid(x=-0.5,y=-0.99,z=1.5),
    csg_pyramid(x=0.5,y=-0.99,z=2), operation="blend"), radius=0),
    material=glossy(color="red"))) |>
  add_object(csg_object(csg_round(csg_combine(
    csg_pyramid(x=-0.5,y=-0.79,z=-1.5),
    csg_pyramid(x=0.5,y=-0.79,z=-1), operation="blend"), radius=0.2),
    material=glossy(color="green"))) |>
  add_object(sphere(y=5,x=5,z=5,radius=1,material=light(intensity=50))) |>
  render_scene(lookfrom=c(-3,5,10), fov=22,
    lookat=c(0,-0.5,0),clamp_value=10)
```

csg_rounded_cone

*CSG Rounded Cone***Description**

CSG Rounded Cone

Usage

```
csg_rounded_cone(
  start = c(0, 0, 0),
  end = c(0, 1, 0),
  radius = 0.5,
  upper_radius = 0.2
)
```

Arguments

start	Default 'c(0, 0, 0)'. Start point of the cone, specifying 'x', 'y', 'z'.
end	Default 'c(0, 1, 0)'. End point of the cone, specifying 'x', 'y', 'z'.
radius	Default '0.5'. Radius of the bottom of the cone.
upper_radius	Default '0.2'. Radius from the top of the cone.

Value

List describing the box in the scene.

Examples

```
#Generate a basic rounded cone:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_rounded_cone(),material=glossy(color="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20)
#Change the orientation by specifying a start and end
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(csg_rounded_cone(start = c(-1,0.5,-2), end = c(1,0.5,-2),
  radius=0.5),material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(3,3,10))
#Show the effect of changing the radius
generate_ground(material=diffuse(color="dodgerblue4",checkercolor="grey10")) |>
  add_object(csg_object(
    csg_combine(
      csg_rounded_cone(start = c(-1,0.5,-2), end = c(1,0.5,-2), radius=0.5),
      csg_rounded_cone(start = c(-0.5,1.5,-2), end = c(0.5,1.5,-2), radius=0.2,upper_radius = 0.5)),
    material=glossy(checkercolor="red"))) |>
  render_scene(clamp_value=10, samples=16,fov=20,
    lookat=c(0,0.5,-2),lookfrom=c(-3,3,10))
#Render a glass rounded cone in a Cornell box
generate_cornell() |>
  add_object(csg_object(
    csg_rounded_cone(start = c(555/2,555/2-100,555/2), end = c(555/2,555/2+100,555/2), radius=100),
    material=dielectric(attenuation=c(1,1,0.3)/100))) |>
  render_scene(clamp_value=10, samples=16)
```

csg_scale

CSG Scale

Description

CSG Scale

Usage

```
csg_scale(object, scale = 1)
```

Arguments

object	CSG object.
scale	Default '1'.

Value

List describing the triangle in the scene.

Examples

```
#Scale a pyramid (translating it upwards because the object is scaled from the center):
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_pyramid(z=1,y=-0.99),
                        material=glossy(color="red"))) |>
  add_object(csg_object(csg_scale(csg_pyramid(z=-1,y=-0.5),2),
                        material=glossy(color="green"))) |>
  add_object(sphere(y=5,x=5,z=5,material=light(intensity=40))) |>
  render_scene(lookfrom=c(-3,4,10), fov=20,
              lookat=c(0,-0.5,-0.5),clamp_value=10)
```

csg_sphere

CSG Sphere

Description

CSG Sphere

Usage

```
csg_sphere(x = 0, y = 0, z = 0, radius = 1)
```

Arguments

x	Default '0'. x-coordinate of the center of the sphere.
y	Default '0'. y-coordinate of the center of the sphere.
z	Default '0'. z-coordinate of the center of the sphere.
radius	Default '1'. Radius of the sphere.

Value

List describing the sphere in the scene.

Examples

```
#Generate a simple sphere:
generate_ground() |>
  add_object(csg_object(csg_sphere(),
                        material=glossy(color="purple"))) |>
  render_scene(clamp_value=10, samples=16)
#Generate a bigger sphere in the cornell box.
generate_cornell() |>
  add_object(csg_object(csg_sphere(x=555/2,y=555/2,z=555/2,radius=100),
```

```

                                material=glossy(checkercolor="purple", checkerperiod=100))) |>
  render_scene(clamp_value=10, samples=16)
#Combine two spheres of different sizes
generate_cornell() |>
  add_object(csg_object(
    csg_combine(
      csg_sphere(x=555/2,y=555/2-50,z=555/2,radius=100),
      csg_sphere(x=555/2,y=555/2+50,z=555/2,radius=80)),
    material=glossy(color="purple"))) |>
  render_scene(clamp_value=10, samples=16)
#Subtract two spheres to create an indented region
generate_cornell() |>
  add_object(csg_object(
    csg_combine(
      csg_sphere(x=555/2,y=555/2-50,z=555/2,radius=100),
      csg_sphere(x=555/2+30,y=555/2+20,z=555/2-90,radius=40),
      operation="subtract"),
    material=glossy(color="grey20"))) |>
  render_scene(clamp_value=10, samples=16)
#Use csg_combine(operation="blend") to melt the two together
generate_cornell() |>
  add_object(csg_object(
    csg_combine(
      csg_sphere(x=555/2,y=555/2-50,z=555/2,radius=100),
      csg_sphere(x=555/2,y=555/2+50,z=555/2,radius=80),
      operation="blend", radius=20),
    material=glossy(color="purple"))) |>
  render_scene(clamp_value=10, samples=16)

```

csg_torus

CSG Torus

Description

CSG Torus

Usage

```
csg_torus(x = 0, y = 0, z = 0, radius = 1, minor_radius = 0.5)
```

Arguments

x	Default '0'. x-coordinate on the torus.
y	Default '0'. y-coordinate on the torus.
z	Default '0'. z-coordinate on the torus.
radius	Default '1'. Torus radius.
minor_radius	Default '0.5'. Cross section radius of the torus.

Value

List describing the torus in the scene.

Examples

```
#Generate a torus:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_torus(), material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(0,5,10),fov=30)
#Change the radius of the torus:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_torus(radius=2), material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(0,5,10),fov=30)
#Change the minor radius of the torus:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_torus(radius=2, minor_radius=0.25),
    material=glossy(color="dodgerblue4"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(0,5,10),fov=30)
#Generate a rotated torus in the Cornell Box
generate_cornell() |>
  add_object(csg_object(csg_rotate(
    csg_torus(x=555/2,y=555/2,z=555/2,radius=100, minor_radius=50),
    pivot_point = c(555/2,555/2,555/2), up =c(0,1,-1)),
    material=glossy(color="dodgerblue4"))) |>
  render_scene(clamp_value=10, samples=16)
```

csg_translate

CSG Translate

Description

CSG Translate

Usage

```
csg_translate(object, x = 0, y = 0, z = 0)
```

Arguments

object	CSG object.
x	Default '0'. x translation.
y	Default '0'. y translation.
z	Default '0'. z translation.

Value

List describing the triangle in the scene.

Examples

```
#Translate a simple object:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_torus(), material=glossy(color="dodgerblue4"))) |>
  add_object(csg_object(csg_translate(csg_torus(),x=-2,y=1,z=-2),
                           material=glossy(color="red"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(0,5,10),fov=30,
              lookat=c(-1,0.5,-1))

#Translate a blended object:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_combine(
    csg_torus(),
    csg_torus(y=1, radius=0.8), operation="blend"), material=glossy(color="dodgerblue4"))) |>
  add_object(csg_object(csg_translate(
    csg_combine(
      csg_torus(),
      csg_torus(y=1, radius=0.8), operation="blend"),
    x=-3,y=1,z=-3),
    material=glossy(color="red"))) |>
  add_object(sphere(y=5,x=5,radius=3,material=light(intensity=10))) |>
  render_scene(clamp_value=10, samples=16,lookfrom=c(0,5,10),fov=30,
              lookat=c(-1.5,0.5,-1.5))
```

csg_triangle

CSG Triangle

Description

CSG Triangle

Usage

```
csg_triangle(v1 = c(0, 1, 0), v2 = c(1, 0, 0), v3 = c(-1, 0, 0))
```

Arguments

v1	Default 'c(0,1,0)'. First vertex.
v2	Default 'c(1,0,0)'. Second vertex.
v3	Default 'c(-1,0,0)'. Third vertex.

Value

List describing the triangle in the scene.

Examples

```
#Generate a basic triangle:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_triangle(),material=diffuse(color="red"))) |>
  add_object(sphere(y=5,z=-3,material=light(intensity=30))) |>
  render_scene(clamp_value=10, samples=16,fov=20)

#Change a vertex:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_triangle(v1 = c(1,1,0)),material=diffuse(color="green"))) |>
  add_object(sphere(y=5,z=-3,material=light(intensity=30))) |>
  render_scene(clamp_value=10, samples=16,fov=20)

#Change all three vertices:
generate_ground(material=diffuse(checkercolor="grey20")) |>
  add_object(csg_object(csg_triangle(v1 = c(0.5,1,0), v2 = c(1,-0.5,0), v3 = c(-1,0.5,0)),
                        material=diffuse(color="blue"))) |>
  add_object(sphere(y=5,z=3,material=light(intensity=30))) |>
  render_scene(clamp_value=10, samples=16,fov=20,lookfrom=c(0,5,10))
```

cube

*Cube Object***Description**

Cube Object

Usage

```
cube(
  x = 0,
  y = 0,
  z = 0,
  width = 1,
  xwidth = 1,
  ywidth = 1,
  zwidth = 1,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

x	Default '0'. x-coordinate of the center of the cube
y	Default '0'. y-coordinate of the center of the cube

<code>z</code>	Default <code>'0'</code> . z-coordinate of the center of the cube
<code>width</code>	Default <code>'1'</code> . Cube width.
<code>xwidth</code>	Default <code>'1'</code> . x-width of the cube. Overrides <code>'width'</code> argument for x-axis.
<code>ywidth</code>	Default <code>'1'</code> . y-width of the cube. Overrides <code>'width'</code> argument for y-axis.
<code>zwidth</code>	Default <code>'1'</code> . z-width of the cube. Overrides <code>'width'</code> argument for z-axis.
<code>material</code>	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
<code>angle</code>	Default <code>'c(0, 0, 0)'</code> . Angle of rotation around the x, y, and z axes, applied in the order specified in <code>'order_rotation'</code> .
<code>order_rotation</code>	Default <code>'c(1, 2, 3)'</code> . The order to apply the rotations, referring to "x", "y", and "z".
<code>flipped</code>	Default <code>'FALSE'</code> . Whether to flip the normals.
<code>scale</code>	Default <code>'c(1, 1, 1)'</code> . Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the cube in the scene.

Examples

```
#Generate a cube in the cornell box.
generate_cornell() |>
  add_object(cube(x = 555/2, y = 100, z = 555/2,
                 xwidth = 200, ywidth = 200, zwidth = 200, angle = c(0, 30, 0))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
#Generate a gold cube in the cornell box
generate_cornell() |>
  add_object(cube(x = 555/2, y = 100, z = 555/2,
                 xwidth = 200, ywidth = 200, zwidth = 200, angle = c(0, 30, 0),
                 material = metal(color = "gold", fuzz = 0.2))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

#Generate a rotated dielectric box in the cornell box
generate_cornell() |>
  add_object(cube(x = 555/2, y = 200, z = 555/2,
                 xwidth = 200, ywidth = 100, zwidth = 200, angle = c(-30, 30, -30),
                 material = dielectric())) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

cylinder

*Cylinder Object***Description**

Cylinder Object

Usage

```

cylinder(
  x = 0,
  y = 0,
  z = 0,
  radius = 1,
  length = 1,
  phi_min = 0,
  phi_max = 360,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1),
  capped = TRUE
)

```

Arguments

x	Default '0'. x-coordinate of the center of the cylinder
y	Default '0'. y-coordinate of the center of the cylinder
z	Default '0'. z-coordinate of the center of the cylinder
radius	Default '1'. Radius of the cylinder.
length	Default '1'. Length of the cylinder.
phi_min	Default '0'. Minimum angle around the segment.
phi_max	Default '360'. Maximum angle around the segment.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly.
capped	Default 'TRUE'. Whether to add caps to the segment. Turned off when using the 'light()' material. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the cylinder in the scene.

Examples

#Generate a cylinder in the cornell box. Add a cap to both ends.

```
generate_cornell() |>
  add_object(cylinder(x = 555/2, y = 250, z = 555/2,
                    length = 300, radius = 100, material = metal())) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

#Rotate the cylinder

```
generate_cornell() |>
  add_object(cylinder(x = 555/2, y = 250, z = 555/2,
                    length = 300, radius = 100, angle = c(0, 0, 45),
                    material = diffuse())) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

Only render a subtended arc of the cylinder, flipping the normals.

```
generate_cornell(lightintensity=3) |>
  add_object(cylinder(x = 555/2, y = 250, z = 555/2, capped = FALSE,
                    length = 300, radius = 100, angle = c(45, 0, 0), phi_min = 0, phi_max = 180,
                    material = diffuse(), flipped = TRUE)) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

dielectric

Dielectric (glass) Material

Description

Dielectric (glass) Material

Usage

```
dielectric(
  color = "white",
  refraction = 1.5,
  attenuation = c(0, 0, 0),
  attenuation_intensity = 1,
  priority = 0,
  importance_sample = FALSE,
  bump_texture = "",
  bump_intensity = 1
)
```

Arguments

color	Default 'white'. The color of the surface. Can be either a hexadecimal code, R color string, or a numeric rgb vector listing three intensities between '0' and '1'.
refraction	Default '1.5'. The index of refraction.
attenuation	Default 'c(0,0,0)'. The Beer-Lambert color-channel specific exponential attenuation through the material. Higher numbers will result in less of that color making it through the material. If a character string is provided (either as a named R color or a hex string), this will be converted to a length-3 vector equal to one minus the RGB color vector, which should approximate the color being passed. Note: This assumes the object has a closed surface.
attenuation_intensity	Default '1'. Changes the attenuation by a multiplicative factor. Values lower than one will make the dielectric more transparent, while values greater than one will make the glass more opaque.
priority	Default '0'. When two dielectric materials overlap, the one with the lower priority value is used for intersection. NOTE: If the camera is placed inside a dielectric object, its priority value will not be taken into account when determining hits to other objects also inside the object.
importance_sample	Default 'FALSE'. If 'TRUE', the object will be sampled explicitly during the rendering process. If the object is particularly important in contributing to the light paths in the image (e.g. light sources, refracting glass ball with caustics, metal objects concentrating light), this will help with the convergence of the image.
bump_texture	Default '""'. A matrix, array, or filename (specifying a greyscale image) to be used to specify a bump map for the surface.
bump_intensity	Default '1'. Intensity of the bump map. High values may lead to unphysical results.

Value

Single row of a tibble describing the dielectric material.

Examples

```
#Generate a checkered ground
scene = generate_ground(depth=-0.5, material = diffuse(checkercolor="grey30", checkerperiod=2))
render_scene(scene, parallel=TRUE, samples=16)

#Add a glass sphere
scene |>
  add_object(sphere(x=-0.5, radius=0.5, material=dielectric())) |>
  render_scene(parallel=TRUE, samples=16)

#Add a rotated colored glass cube
scene |>
  add_object(sphere(x=-0.5, radius=0.5, material=dielectric())) |>
  add_object(cube(x=0.5, xwidth=0.5, material=dielectric(color="darkgreen"), angle=c(0, -45, 0))) |>
```

```

render_scene(parallel=TRUE,samples=16)

#Add an area light behind and at an angle and turn off the ambient lighting
scene |>
  add_object(sphere(x=-0.5,radius=0.5,material=dielectric())) |>
  add_object(cube(x=0.5,xwidth=0.5,material=dielectric(color="darkgreen"),angle=c(0,-45,0))) |>
  add_object(yz_rect(z=-3,y=1,x=0,zwidth=3,ywidth=1.5,
                    material=light(intensity=15),
                    angle=c(0,-90,45), order_rotation = c(3,2,1))) |>
  render_scene(parallel=TRUE,aperture=0, ambient_light=FALSE,samples=16)

#Color glass using Beer-Lambert attenuation, which attenuates light on a per-channel
#basis as it travels through the material. This effect is what gives some types of glass
#a green glow at the edges. We will get this effect by setting a lower attenuation value
#for the `green` (second) channel in the dielectric `attenuation` argument.
generate_ground(depth=-0.5,material=diffuse(checkercolor="grey30",checkerperiod=2)) |>
  add_object(sphere(z=5,x=-0.5,y=1,material=light(intensity=10))) |>
  add_object(cube(y=0.3,ywidth=0.1,xwidth=2,zwidth=2,
                  material=dielectric(attenuation=c(1.2,0.2,1.2)),angle=c(45,110,0))) |>
  render_scene(parallel=TRUE, samples = 16)

#If you have overlapping dielectrics, the `priority` value can help disambiguate what
#object wins. Here, I place a bubble inside a cube by setting a lower priority value and
#making the inner sphere have a index of refraction of 1. I also place spheres at the corners.
generate_ground(depth=-0.51,material=diffuse(checkercolor="grey30",checkerperiod=2)) |>
  add_object(cube(material = dielectric(priority=2, attenuation = c(10,3,10)))) |>
  add_object(sphere(radius=0.49,material = dielectric(priority=1, refraction=1))) |>
  add_object(sphere(radius=0.25,x=0.5,z=-0.5,y=0.5,
                    material = dielectric(priority=0,attenuation = c(10,3,10) ))) |>
  add_object(sphere(radius=0.25,x=-0.5,z=0.5,y=0.5,
                    material = dielectric(priority=0,attenuation = c(10,3,10)))) |>
  render_scene(parallel=TRUE, samples = 16,lookfrom=c(5,1,5))

# We can also use this as a basic Constructive Solid Geometry interface by setting
# the index of refraction equal to empty space, 1. This will subtract out those regions.
# Here I make a concave lens by subtracting two spheres from a cube.
generate_ground(depth=-0.51,material=diffuse(checkercolor="grey30",checkerperiod=2,sigma=90)) |>
  add_object(cube(material = dielectric(attenuation = c(3,3,1),priority=1))) |>
  add_object(sphere(radius=1,x=1.01,
                    material = dielectric(priority=0,refraction=1))) |>
  add_object(sphere(radius=1,x=-1.01,
                    material = dielectric(priority=0,refraction=1))) |>
  add_object(sphere(y=10,x=3,material=light(intensity=150))) |>
  render_scene(parallel=TRUE, samples = 16,lookfrom=c(5,3,5))

```

diffuse

Diffuse Material

Description

Diffuse Material

Usage

```
diffuse(
  color = "#ffffff",
  checkercolor = NA,
  checkerperiod = 3,
  noise = 0,
  noisephase = 0,
  noiseintensity = 10,
  noisecolor = "#000000",
  gradient_color = NA,
  gradient_transpose = FALSE,
  gradient_point_start = NA,
  gradient_point_end = NA,
  gradient_type = "hsv",
  image_texture = "",
  image_repeat = 1,
  alpha_texture = "",
  bump_texture = "",
  bump_intensity = 1,
  fog = FALSE,
  fogdensity = 0.01,
  sigma = NULL,
  importance_sample = FALSE
)
```

Arguments

color	Default 'white'. The color of the surface. Can be either a hexadecimal code, R color string, or a numeric rgb vector listing three intensities between '0' and '1'.
checkercolor	Default 'NA'. If not 'NA', determines the secondary color of the checkered surface. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
checkerperiod	Default '3'. The period of the checker pattern. Increasing this value makes the checker pattern bigger, and decreasing it makes it smaller
noise	Default '0'. If not '0', covers the surface in a turbulent marble pattern. This value will determine the amount of turbulence in the texture.
noisephase	Default '0'. The phase of the noise. The noise will repeat at '360'.
noiseintensity	Default '10'. Intensity of the noise.
noisecolor	Default '#000000'. The secondary color of the noise pattern. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
gradient_color	Default 'NA'. If not 'NA', creates a secondary color for a linear gradient between the this color and color specified in 'color'. Direction is determined by 'gradient_transpose'.
gradient_transpose	Default 'FALSE'. If 'TRUE', this will use the 'v' coordinate texture instead of the 'u' coordinate texture to map the gradient.

<code>gradient_point_start</code>	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'color'.
<code>gradient_point_end</code>	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'gradient_color'.
<code>gradient_type</code>	Default 'hsv'. Colorspace to calculate the gradient. Alternative 'rgb'.
<code>image_texture</code>	Default '""'. A 3-layer RGB array or filename to be used as the texture on the surface of the object.
<code>image_repeat</code>	Default '1'. Number of times to repeat the image across the surface. 'u' and 'v' repeat amount can be set independently if user passes in a length-2 vector.
<code>alpha_texture</code>	Default '""'. A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
<code>bump_texture</code>	Default '""'. A matrix, array, or filename (specifying a greyscale image) to be used to specify a bump map for the surface.
<code>bump_intensity</code>	Default '1'. Intensity of the bump map. High values may lead to unphysical results.
<code>fog</code>	Default 'FALSE'. If 'TRUE', the object will be a volumetric scatterer.
<code>fogdensity</code>	Default '0.01'. The density of the fog. Higher values will produce more opaque objects.
<code>sigma</code>	Default 'NULL'. A number between 0 and Infinity specifying the roughness of the surface using the Oren-Nayar microfacet model. Higher numbers indicate a roughed surface, where sigma is the standard deviation of the microfacet orientation angle. When 0, this reverts to the default lambertian behavior.
<code>importance_sample</code>	Default 'FALSE'. If 'TRUE', the object will be sampled explicitly during the rendering process. If the object is particularly important in contributing to the light paths in the image (e.g. light sources, refracting glass ball with caustics, metal objects concentrating light), this will help with the convergence of the image.

Value

Single row of a tibble describing the diffuse material.

Examples

```
#Generate the cornell box and add a single white sphere to the center
scene = generate_cornell() |>
  add_object(sphere(x=555/2,y=555/2,z=555/2,radius=555/8,material=diffuse()))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
```

```

#Add a checkered rectangular cube below
scene = scene |>
  add_object(cube(x=555/2,y=555/8,z=555/2,xwidth=555/2,ywidth=555/4,zwidth=555/2,
  material = diffuse(checkercolor="purple",checkerperiod=20)))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#Add a marbled sphere
scene = scene |>
  add_object(sphere(x=555/2+555/4,y=555/2,z=555/2,radius=555/8,
  material = diffuse(noise=1/20)))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#Add an orange volumetric (fog) cube
scene = scene |>
  add_object(cube(x=555/2-555/4,y=555/2,z=555/2,xwidth=555/4,ywidth=555/4,zwidth=555/4,
  material = diffuse(fog=TRUE, fogdensity=0.05,color="orange")))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#' #Add an line segment with a color gradient
scene = scene |>
  add_object(segment(start = c(555,450,450),end=c(0,450,450),radius = 50,
  material = diffuse(color="#1f7326", gradient_color = "#a60d0d")))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

```

disk

Disk Object

Description

Disk Object

Usage

```

disk(
  x = 0,
  y = 0,
  z = 0,
  radius = 1,
  inner_radius = 0,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

x	Default '0'. x-coordinate of the center of the disk
y	Default '0'. y-coordinate of the center of the disk
z	Default '0'. z-coordinate of the center of the disk
radius	Default '1'. Radius of the disk.
inner_radius	Default '0'. Inner radius of the disk.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the disk in the scene.

Examples

```
#Generate a disk in the cornell box.
generate_cornell() |>
  add_object(disk(x = 555/2, y = 50, z = 555/2, radius = 150,
                 material = diffuse(color = "orange"))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
#Rotate the disk.
generate_cornell() |>
  add_object(disk(x = 555/2, y = 555/2, z = 555/2, radius = 150, angle = c(-45, 0, 0),
                 material = diffuse(color = "orange"))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
#Pass a value for the inner radius.
generate_cornell() |>
  add_object(disk(x = 555/2, y = 555/2, z = 555/2,
                 radius = 150, inner_radius = 75, angle = c(-45, 0, 0),
                 material = diffuse(color = "orange"))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

ellipsoid

*Ellipsoid Object***Description**

Note: this is just a scaled sphere.

Usage

```
ellipsoid(
  x = 0,
  y = 0,
  z = 0,
  a = 1,
  b = 1,
  c = 1,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

x	Default '0'. x-coordinate of the center of the ellipsoid.
y	Default '0'. y-coordinate of the center of the ellipsoid.
z	Default '0'. z-coordinate of the center of the ellipsoid.
a	Default '1'. Principal x-axis of the ellipsoid.
b	Default '1'. Principal y-axis of the ellipsoid.
c	Default '1'. Principal z-axis of the ellipsoid.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the ellipsoid in the scene.

Examples

```
#Generate an ellipsoid in a Cornell box
generate_cornell() |>
  add_object(ellipsoid(x = 555/2, y = 555/2, z = 555/2,
                      a = 100, b = 50, c = 50)) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

#Change the axes to make it taller rather than wide:
generate_cornell() |>
  add_object(ellipsoid(x = 555/2, y = 555/2, z = 555/2,
                      a = 100, b = 200, c = 100, material = metal())) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

#Rotate it and make it dielectric:
generate_cornell() |>
  add_object(ellipsoid(x = 555/2, y = 555/2, z = 555/2,
                      a = 100, b = 200, c = 100, angle = c(0, 0, 45),
                      material = dielectric())) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

 extruded_path

Extruded Path Object

Description

Note: Bump mapping with non-diffuse materials does not work correctly, and smoothed normals will be flat when using a bump map.

Usage

```
extruded_path(
  points,
  x = 0,
  y = 0,
  z = 0,
  polygon = NA,
  polygon_end = NA,
  breaks = NA,
  closed = FALSE,
  closed_smooth = TRUE,
  polygon_add_points = 0,
  twists = 0,
  texture_repeats = 1,
  straight = FALSE,
```

```

precomputed_control_points = FALSE,
width = 1,
width_end = NA,
width_ease = "spline",
smooth_normals = FALSE,
u_min = 0,
u_max = 1,
linear_step = FALSE,
end_caps = c(TRUE, TRUE),
material = diffuse(),
material_caps = NA,
angle = c(0, 0, 0),
order_rotation = c(1, 2, 3),
flipped = FALSE,
scale = c(1, 1, 1)
)

```

Arguments

points	Either a list of length-3 numeric vectors or 3-column matrix/data.frame specifying the x/y/z points that the path should go through.
x	Default '0'. x-coordinate offset for the path.
y	Default '0'. y-coordinate offset for the path.
z	Default '0'. z-coordinate offset for the path.
polygon	Defaults to a circle. A polygon with no holes, specified by a data.frame() parsable by 'xy.coords()'. Vertices are taken as sequential rows. If the polygon isn't closed (the last vertex equal to the first), it will be closed automatically.
polygon_end	Defaults to 'polygon'. If specified, the number of vertices should equal the to the number of vertices of the polygon set in 'polygon'. Vertices are taken as sequential rows. If the polygon isn't closed (the last vertex equal to the first), it will be closed automatically.
breaks	Defaults to '20' times the number of control points in the bezier curve.
closed	Default 'FALSE'. If 'TRUE', the path will be closed by smoothly connecting the first and last points, also ensuring the final polygon is aligned to the first.
closed_smooth	Default 'TRUE'. If 'closed = TRUE', this will ensure C2 (second derivative) continuity between the ends. If 'closed = FALSE', the curve will only have C1 (first derivative) continuity between the ends.
polygon_add_points	Default '0'. Positive integer specifying the number of points to fill in between polygon vertices. Higher numbers can give smoother results (especially when combined with 'smooth_normals = TRUE').
twists	Default '0'. Number of twists in the polygon from one end to another.
texture_repeats	Default '1'. Number of times to repeat the texture along the length of the path.
straight	Default 'FALSE'. If 'TRUE', straight lines will be used to connect the points instead of bezier curves.

precomputed_control_points	Default 'FALSE'. If 'TRUE', 'points' argument will expect a list of control points calculated with the internal rayrender function 'rayrender::calculate_control_points()'.
width	Default '0.1'. Curve width. If 'width_ease == "spline"', 'width' is specified in a format that can be read by 'xy.coords()' (with 'y' as the width), and the 'x' coordinate is between '0' and '1', this can also specify the exact positions along the curve for the corresponding width values. If a numeric vector, specifies the different values of the width evenly along the curve. If not a single value, 'width_end' will be ignored.
width_end	Default 'NA'. Width at end of path. Same as 'width', unless specified. Ignored if multiple width values specified in 'width'.
width_ease	Default 'spline'. Ease function between width values. Other options: 'linear', 'quad', 'cubic', 'exp'.
smooth_normals	Default 'FALSE'. Whether to smooth the normals of the polygon to remove sharp angles.
u_min	Default '0'. Minimum parametric coordinate for the path. If 'closed = TRUE', values greater than one will refer to the beginning of the loop (but the path will be generated as two objects).
u_max	Default '1'. Maximum parametric coordinate for the path. If 'closed = TRUE', values greater than one will refer to the beginning of the loop (but the path will be generated as two objects).
linear_step	Default 'FALSE'. Whether the polygon intervals should be set at linear intervals, rather than intervals based on the underlying bezier curve parameterization.
end_caps	Default 'c(TRUE, TRUE)'. Specifies whether to add an end cap to the beginning and end of a path.
material	Default <code>diffuse</code> . The material, called from one of the material functions.
material_caps	Defaults to the same material set in 'material'. Note: emissive objects may not currently function correctly when scaled.
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly.

Value

Single row of a tibble describing the cube in the scene.

Examples

```
#Specify the points for the path to travel though and the ground material
points = list(c(0,0,1),c(-0.5,0,-1),c(0,1,-1),c(1,0.5,0),c(0.6,0.3,1))
ground_mat = material=diffuse(color="grey50",
```

```

                                checkercolor = "grey20",checkerperiod = 1.5)
#Default path shape is a circle
generate_studio(depth=-0.4,material=ground_mat) |>
  add_object(extruded_path(points = points, width=0.25,
                           material=diffuse(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,material=light(intensity=15))) |>
  render_scene(lookat=c(0.3,0.5,0.5),fov=12, width=800,height=800, clamp_value = 10,
               aperture=0.025, samples=16, sample_method="sobol_blue")
#Change the width evenly along the tube
generate_studio(depth=-0.4,material=ground_mat) |>
  add_object(extruded_path(points = points, width=0.25,
                           width_end = 0.5,
                           material=diffuse(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,material=light(intensity=15))) |>
  render_scene(lookat=c(0.3,0.5,0.5),fov=12, width=800,height=800, clamp_value = 10,
               aperture=0.025, samples=16, sample_method="sobol_blue")
#Change the width along the full length of the tube
generate_studio(depth=-0.4,material=ground_mat) |>
  add_object(extruded_path(points = points,
                           width=0.25*sinpi(0:72*20/180),
                           material=diffuse(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,material=light(intensity=15))) |>
  render_scene(lookat=c(0.3,0.5,0.5),fov=12, width=800,height=800, clamp_value = 10,
               aperture=0.025, samples=16, sample_method="sobol_blue")
#Specify the exact parametric x positions for the width values:
custom_width = data.frame(x=c(0,0.2,0.5,0.8,1), y=c(0.25,0.5,0,0.5,0.25))
generate_studio(depth=-0.4,material=ground_mat) |>
  add_object(extruded_path(points = points,
                           width=custom_width,
                           material=diffuse(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,material=light(intensity=15))) |>
  render_scene(lookat=c(0.3,0.5,0.5),fov=12, width=800,height=800, clamp_value = 10,
               aperture=0.025, samples=16, sample_method="sobol_blue")
#Generate a star polygon
angles = seq(360,0,length.out=21)
xx = c(rep(c(1,0.75,0.5,0.75),5),1) * sinpi(angles/180)/4
yy = c(rep(c(1,0.75,0.5,0.75),5),1) * cospi(angles/180)/4
star_polygon = data.frame(x=xx,y=yy)

#Extrude a path using a star polygon
generate_studio(depth=-0.4,material=ground_mat) |>
  add_object(extruded_path(points = points, width=0.5,
                           polygon = star_polygon,
                           material=diffuse(color="red"))) |>
  add_object(sphere(y=3,z=-5,x=2,material=light(intensity=15))) |>
  render_scene(lookat=c(0.3,0.5,1),fov=12, width=800,height=800, clamp_value = 10,
               aperture=0.025, samples=16, sample_method="sobol_blue")
#Specify a circle polygon
angles = seq(360,0,length.out=21)
xx = sinpi(angles/180)/4
yy = cospi(angles/180)/4
circ_polygon = data.frame(x=xx,y=yy)

```



```

add_object(sphere(y=20,x=0,z=-21,material=light(intensity = 1000))) |>
render_scene(lookat=c(0,0.5,0), fov=10, samples=16, sample_method = "sobol_blue",
             width = 800, height=800)
#Create a green glass tube with the dielectric priority interface
#and fill it with a purple neon tube light
generate_ground(depth=-0.4,material=diffuse(color="grey50",
                                             checkercolor = "grey20",checkerperiod = 1.5)) |>
add_object(extruded_path(points = points, width=0.7, linear_step = TRUE,
                         polygon = star_polygon, twists = 2, closed = TRUE,
                         polygon_end = star_polygon, breaks=500,
                         material=dielectric(priority = 1, refraction = 1.2,
                                             attenuation=c(1,0.3,1),
                                             attenuation_intensity=20))) |>
add_object(extruded_path(points = points, width=0.4, linear_step = TRUE,
                         polygon = star_polygon,twists = 2, closed = TRUE,
                         polygon_end = star_polygon, breaks=500,
                         material=dielectric(priority = 0,refraction = 1))) |>
add_object(extruded_path(points = points, width=0.05, closed = TRUE,
                         material=light(color="purple", intensity = 5,
                                         importance_sample = FALSE))) |>
add_object(sphere(y=10,z=-5,x=0,radius=5,material=light(color = "white",intensity = 5))) |>
render_scene(lookat=c(0,0.5,1),fov=10,
             width=800,height=800, clamp_value = 10,
             aperture=0.025, samples=16, sample_method="sobol_blue")

```

extruded_polygon

Extruded Polygon Object

Description

Extruded Polygon Object

Usage

```

extruded_polygon(
  polygon = NULL,
  x = 0,
  y = 0,
  z = 0,
  plane = "xz",
  top = 1,
  bottom = 0,
  holes = NULL,
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  material = diffuse(),
  center = FALSE,
  flip_horizontal = FALSE,

```

```

flip_vertical = FALSE,
data_column_top = NULL,
data_column_bottom = NULL,
scale_data = 1,
scale = c(1, 1, 1)
)

```

Arguments

polygon	'sf' object, "SpatialPolygon" 'sp' object, or xy coordinates of polygon represented in a way that can be processed by 'xy.coords()'. If xy-coordinate based polygons are open, they will be closed by adding an edge from the last point to the first. If the 'sf' object contains MULTIPOLYGONZ data, it will be flattened.
x	Default '0'. x-coordinate to offset the extruded model.
y	Default '0'. y-coordinate to offset the extruded model.
z	Default '0'. z-coordinate to offset the extruded model.
plane	Default 'xz'. The plane the polygon is drawn in. All possible orientations are 'xz', 'zx', 'xy', 'yx', 'yz', and 'zy'.
top	Default '1'. Extruded top distance. If this equals 'bottom', the polygon will not be extruded and just the one side will be rendered.
bottom	Default '0'. Extruded bottom distance. If this equals 'top', the polygon will not be extruded and just the one side will be rendered.
holes	Default '0'. If passing in a polygon directly, this specifies which index represents the holes in the polygon. See the 'earcut' function in the 'decido' package for more information.
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
material	Default diffuse . The material, called from one of the material functions diffuse , metal , or dielectric .
center	Default 'FALSE'. Whether to center the polygon at the origin.
flip_horizontal	Default 'FALSE'. Flip polygon horizontally in the plane defined by 'plane'.
flip_vertical	Default 'FALSE'. Flip polygon vertically in the plane defined by 'plane'.
data_column_top	Default 'NULL'. A string indicating the column in the 'sf' object to use to specify the top of the extruded polygon.
data_column_bottom	Default 'NULL'. A string indicating the column in the 'sf' object to use to specify the bottom of the extruded polygon.
scale_data	Default '1'. If specifying 'data_column_top' or 'data_column_bottom', how much to scale that value when rendering.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Multiple row tibble describing the extruded polygon in the scene.

Examples

```

angles = seq(0, 360, by = 36)
xx = rev(c(rep(c(1, 0.5), 5), 1) * sinpi(angles / 180))
yy = rev(c(rep(c(1, 0.5), 5), 1) * cospi(angles / 180))
star_polygon = data.frame(x = xx, y = yy)

generate_ground(
  depth = 0,
  material = diffuse(color = "grey50", checkercolor = "grey20")
) |>
add_object(extruded_polygon(
  star_polygon,
  top = 0.5,
  bottom = 0,
  material = diffuse(color = "red", sigma = 90)
)) |>
add_object(sphere(
  y = 4,
  x = -3,
  z = -3,
  material = light(intensity = 30)
)) |>
render_scene(
  parallel = TRUE,
  lookfrom = c(0, 2, 3),
  samples = 16,
  lookat = c(0, 0.5, 0),
  fov = 60
)

#Now, let's add a hole to the center of the polygon. We'll make the polygon
#hollow by shrinking it, combining it with the normal size polygon,
#and specify with the `holes` argument that everything after `nrow(star_polygon)`
#in the following should be used to draw a hole:

hollow_star = rbind(star_polygon, 0.8 * star_polygon)

generate_ground(
  depth = -0.01,
  material = diffuse(color = "grey50", checkercolor = "grey20")
) |>
add_object(extruded_polygon(
  hollow_star,
  top = 0.25,
  bottom = 0,
  holes = nrow(star_polygon) + 1,
  material = diffuse(color = "red", sigma = 90)
)) |>

```

```

add_object(sphere(
  y = 4,
  x = -3,
  z = -3,
  material = light(intensity = 30)
)) |>
render_scene(
  parallel = TRUE,
  lookfrom = c(0, 2, 4),
  samples = 16,
  lookat = c(0, 0, 0),
  fov = 30
)

# Render one in the y-x plane as well by changing the `plane` argument,
# as well as offset it slightly.
generate_ground(
  depth = -0.01,
  material = diffuse(color = "grey50", checkercolor = "grey20")
) |>
add_object(extruded_polygon(
  hollow_star,
  top = 0.25,
  bottom = 0,
  holes = nrow(star_polygon),
  material = diffuse(color = "red", sigma = 90)
)) |>
add_object(extruded_polygon(
  hollow_star,
  top = 0.25,
  bottom = 0,
  y = 1.2,
  z = -1.2,
  holes = nrow(star_polygon) + 1,
  plane = "yx",
  material = diffuse(color = "green", sigma = 90)
)) |>
add_object(sphere(y = 4, x = -3, material = light(intensity = 30))) |>
render_scene(
  parallel = TRUE,
  lookfrom = c(0, 2, 4),
  samples = 16,
  lookat = c(0, 0.9, 0),
  fov = 40
)

# Now add the zy plane:
generate_ground(
  depth = -0.01,
  material = diffuse(color = "grey50", checkercolor = "grey20")
) |>
add_object(extruded_polygon(
  hollow_star,

```

```

top = 0.25,
bottom = 0,
holes = nrow(star_polygon) + 1,
material = diffuse(color = "red", sigma = 90)
)) |>
add_object(extruded_polygon(
hollow_star,
top = 0.25,
bottom = 0,
y = 1.2,
z = -1.2,
holes = nrow(star_polygon) + 1,
plane = "yx",
material = diffuse(color = "green", sigma = 90)
)) |>
add_object(extruded_polygon(
hollow_star,
top = 0.25,
bottom = 0,
y = 1.2,
x = 1.2,
holes = nrow(star_polygon) + 1,
plane = "zy",
material = diffuse(color = "blue", sigma = 90)
)) |>
  add_object(sphere(y = 4, x = 3, material = light(intensity = 30))) |>
    render_scene(
      parallel = TRUE,
      lookfrom = c(4, 2, 4),
      samples = 16,
      lookat = c(0, 0.9, 0),
      fov = 40
    )

#We can also directly pass in sf polygons:
if (length(find.package("spData", quiet = TRUE)) > 0) {
us_states = spData::us_states
texas = us_states[us_states$NAME == "Texas", ]
#Fix no sfc class in us_states geometry data
class(texas$geometry) = c("list", "sfc")
}

#This uses the raw coordinates, unless `center = TRUE`, which centers the bounding box
#of the polygon at the origin.
generate_ground(
depth = -0.01,
material = diffuse(color = "grey50", checkercolor = "grey20")
) |>
add_object(extruded_polygon(
texas,
center = TRUE,
material = diffuse(color = "#ff2222", sigma = 90)
)) |>

```

```

add_object(sphere(
  y = 30,
  x = -30,
  radius = 10,
  material = light(color = "lightblue", intensity = 40)
)) |>
render_scene(
  parallel = TRUE,
  lookfrom = c(0, 10, -10),
  samples = 16,
  fov = 60
)

#Here we use the raw coordinates, but offset the polygon manually.
generate_ground(
  depth = -0.01,
  material = diffuse(color = "grey50", checkercolor = "grey20")
) |>
add_object(extruded_polygon(
  us_states,
  x = 96,
  z = -40,
  top = 2,
  material = diffuse(color = "#ff2222", sigma = 90)
)) |>
add_object(sphere(
  y = 30,
  x = -100,
  radius = 10,
  material = light(color = "dodgerblue", intensity = 200)
)) |>
add_object(sphere(
  y = 30,
  x = 100,
  radius = 10,
  material = light(color = "orange", intensity = 200)
)) |>
render_scene(
  parallel = TRUE,
  lookfrom = c(0, 120, -120),
  samples = 160,
  fov = 20
)

```

#We can also set the map the height of each polygon to a column in the sf object, #scaling it down by the maximum population state.

```

generate_ground(
  depth = 0,
  material = diffuse(color = "grey50", checkercolor = "grey20", sigma = 90)
) |>
add_object(extruded_polygon(
  us_states,

```

```

x = 96,
z = -45,
data_column_top = "total_pop_15",
scale_data = 1 / max(us_states$total_pop_15) * 5,
material = diffuse(color = "#ff2222", sigma = 90)
)) |>
add_object(sphere(
y = 30,
x = -100,
z = 60,
radius = 10,
material = light(color = "dodgerblue", intensity = 250)
)) |>
add_object(sphere(
y = 30,
x = 100,
z = -60,
radius = 10,
material = light(color = "orange", intensity = 200)
)) |>
render_scene(
parallel = TRUE,
lookfrom = c(60, 50, -40),
lookat = c(0, -5, 0),
samples = 160,
fov = 30
)

```

```
generate_camera_motion
```

Generate Camera Movement

Description

Takes a series of key frame camera positions and smoothly interpolates between them. Generates a data.frame that can be passed to 'render_animation()'.

Usage

```

generate_camera_motion(
  positions,
  lookats = NULL,
  apertures = 0,
  fovs = 40,
  focal_distances = NULL,
  ortho_dims = NULL,
  camera_ups = NULL,
  type = "cubic",

```

```

frames = 30,
closed = FALSE,
aperture_linear = TRUE,
fov_linear = TRUE,
focal_linear = TRUE,
ortho_linear = TRUE,
constant_step = TRUE,
curvature_adjust = "none",
curvature_scale = 30,
offset_lookat = 0,
damp_motion = FALSE,
damp_magnitude = 0.1,
progress = TRUE
)

```

Arguments

positions	A list or 3-column XYZ matrix of camera positions. These will serve as key frames for the camera position. Alternatively, this can also be the a dataframe of the keyframe output from an interactive rayrender session ('ray_keyframes').
lookats	Default 'NULL', which sets the camera lookat to the origin 'c(0,0,0)' for the animation. A list or 3-column XYZ matrix of 'lookat' points. Must be the same number of points as 'positions'.
apertures	Default '0'. A numeric vector of aperture values.
fovs	Default '40'. A numeric vector of field of view values.
focal_distances	Default 'NULL', automatically the distance between positions and lookats. Numeric vector of focal distances.
ortho_dims	Default 'NULL', which results in 'c(1,1)' orthographic dimensions. A list or 2-column matrix of orthographic dimensions.
camera_ups	Default 'NULL', which gives at up vector of 'c(0,1,0)'. Camera up orientation.
type	Default 'cubic'. Type of transition between keyframes. Other options are 'linear', 'quad', 'bezier', 'exp', and 'manual'. 'manual' just returns the values passed in, properly formatted to be passed to 'render_animation()'.
frames	Default '30'. Total number of frames.
closed	Default 'FALSE'. Whether to close the camera curve so the first position matches the last. Set this to 'TRUE' for perfect loops.
aperture_linear	Default 'TRUE'. This linearly interpolates focal distances, rather than using a smooth Bezier curve or easing function.
fov_linear	Default 'TRUE'. This linearly interpolates focal distances, rather than using a smooth Bezier curve or easing function.
focal_linear	Default 'TRUE'. This linearly interpolates focal distances, rather than using a smooth Bezier curve or easing function.
ortho_linear	Default 'TRUE'. This linearly interpolates orthographic dimensions, rather than using a smooth Bezier curve or easing function.

constant_step	Default 'TRUE'. This will make the camera travel at a constant speed.
curvature_adjust	Default 'none'. Other options are 'position', 'lookat', and 'both'. Whether to slow down the camera at areas of high curvature to prevent fast swings. Only used for curve 'type = bezier'. This does not preserve key frame positions. Note: This feature will likely result in the 'lookat' and 'position' diverging if they do not have similar curvatures at each point. This feature is best used when passing the same set of points to 'positions' and 'lookats' and providing an 'offset_lookat' value, which ensures the curvature will be the same.
curvature_scale	Default '30'. Constant dividing factor for curvature. Higher values will subdivide the path more, potentially finding a smoother path, but increasing the calculation time. Only used for curve 'type = bezier'. Increasing this value after a certain point will not increase the quality of the path, but it is scene-dependent.
offset_lookat	Default '0'. Amount to offset the lookat position, either along the path (if 'constant_step = TRUE') or towards the derivative of the Bezier curve.
damp_motion	Default 'FALSE'. Whether to damp the motion of the camera, so that quick movements are damped and don't result in shakey motion. This function tracks the current position, and linearly interpolates between that point and the next point using value 'damp_magnitude'. The equation for the position is 'cam_current = cam_current * damp_magnitude + cam_next_point * (1 - damp_magnitude)'.
damp_magnitude	Default '0.1'. Amount to damp the motion, a numeric value greater than '0' (no damping) and less than '1'.
progress	Default 'TRUE'. Whether to display a progress bar.

Value

Data frame of camera positions, orientations, apertures, focal distances, and field of views

Examples

```
#Create and animate flying through a scene on a simulated roller coaster
set.seed(3)
elliplist = list()
ellip_colors = rainbow(8)
for(i in 1:1200) {
  elliplist[[i]] = ellipsoid(x=10*runif(1)-5,y=10*runif(1)-5,z=10*runif(1)-5,
    angle = 360*runif(3), a=0.1,b=0.05,c=0.1,
    material=glossy(color=sample(ellip_colors,1)))
}
ellip_scene = do.call(rbind, elliplist)

camera_pos = list(c(0,1,15),c(5,-5,5),c(-5,5,-5),c(0,1,-15))

#Plot the camera path and render from above using the path object:
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(path(camera_pos, material=diffuse(color="red"))) |>
```

```

render_scene(lookfrom=c(0,20,0), width=800,height=800,samples=16,
             camera_up = c(0,0,1),
             fov=80)
#Side view
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(path(camera_pos, material=diffuse(color="red"))) |>
  render_scene(lookfrom=c(20,0,0),width=800,height=800,samples=16,
             fov=80)
#View from the start
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(path(camera_pos, material=diffuse(color="red"))) |>
  render_scene(lookfrom=c(0,1.5,16),width=800,height=800,samples=16,
             fov=80)
#Generate Camera movement, setting the lookat position to be same as camera position, but offset
#slightly in front. We'll render 12 frames, but you'd likely want more in a real animation.

camera_motion = generate_camera_motion(positions = camera_pos, lookats = camera_pos,
                                     offset_lookat = 1, fovs=80, frames=12,
                                     type="bezier")

#This returns a data frame of individual camera positions, interpolated by cubic bezier curves.
camera_motion

#Pass NA filename to plot to the device. We'll keep the path and offset it slightly to see
#where we're going. This results in a "roller coaster" effect.
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(obj_model(r_obj(simple_r = TRUE),x=10,y=-10,scale_obj=3, angle=c(0,315,0),
                      material=dielectric(attenuation=c(1,1,0.3)))) |>
  add_object(pig(x=-7,y=10,z=-5,scale=1,angle=c(0,-45,80),emotion="angry")) |>
  add_object(pig(x=0,y=-0.25,z=-15,scale=1,angle=c(0,225,-22), order_rotation = c(3,2,1),
             emotion="angry", spider=TRUE)) |>
  add_object(path(camera_pos, y=-0.2,material=diffuse(color="red"))) |>
  render_animation(filename = NA, camera_motion = camera_motion, samples=16,
                 sample_method="sobol_blue",
                 clamp_value=10, width=400, height=400)

```

generate_cornell

Generate Cornell Box

Description

Generate Cornell Box

Usage

```
generate_cornell(
  light = TRUE,
  lightintensity = 5,
  lightcolor = "white",
  lightwidth = 332,
  lightdepth = 343,
  light_position = c(555/2, 554, 555/2),
  sigma = 0,
  leftcolor = "#1f7326",
  rightcolor = "#a60d0d",
  roomcolor = "#bababa",
  importance_sample = TRUE
)
```

Arguments

<code>light</code>	Default 'TRUE'. Whether to include a light on the ceiling of the box.
<code>lightintensity</code>	Default '5'. The intensity of the light.
<code>lightcolor</code>	Default 'white'. The color the of the light.
<code>lightwidth</code>	Default '332'. Width (z) of the light.
<code>lightdepth</code>	Default '343'. Depth (x) of the light.
<code>light_position</code>	Default 'c(555/2,554,555/2)'. Position of the light.
<code>sigma</code>	Default '0'. Oren-Nayar microfacet angle.
<code>leftcolor</code>	Default '#1f7326' (green).
<code>rightcolor</code>	Default '#a60d0d' (red).
<code>roomcolor</code>	Default '#bababa' (light grey).
<code>importance_sample</code>	Default 'TRUE'. Importance sample the light in the room.

Value

Tibble containing the scene description of the Cornell box.

Examples

```
#Generate and render the default Cornell box.
render_scene(generate_cornell(),
             samples=16,aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
#Make a much smaller light in the center of the room.
render_scene(generate_cornell(lightwidth=200,lightdepth=200),
             samples=16,aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
#Place a sphere in the middle of the box.
scene = generate_cornell(lightwidth=200,lightdepth=200) |>
  add_object(sphere(x=555/2,y=555/2,z=555/2,radius=555/4))
render_scene(scene, samples=16,aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
```

```
#Reduce "fireflies" by setting a clamp_value in render_scene()
render_scene(scene, samples=16,aperture=0, fov=40, ambient_light=FALSE,
             parallel=TRUE,clamp_value=3)
# Change the color scheme of the cornell box
generate_cornell(leftcolor="purple", rightcolor="yellow") |>
  render_scene(samples=16,aperture=0, fov=40, ambient_light=FALSE,
              parallel=TRUE,clamp_value=3)
```

generate_ground

Generate Ground

Description

Generates a large sphere that can be used as the ground for a scene.

Usage

```
generate_ground(
  depth = -1,
  spheresize = 1000,
  material = diffuse(color = "#ccff00")
)
```

Arguments

depth	Default '-1'. Depth of the surface.
spheresize	Default '1000'. Radius of the sphere representing the surface.
material	Default <code>diffuse</code> with <code>'color= "#ccff00"'</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
color	Default '#ccff00'. The color of the sphere. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.

Value

Single row of a tibble describing the ground.

Examples

```
#Generate the ground and add some objects
scene = generate_ground(depth=-0.5,
                       material = diffuse(noise=1,noisecolor="blue",noisephase=10)) |>
  add_object(cube(x=0.7,material=diffuse(color="red"),angle=c(0,-15,0))) |>
  add_object(sphere(x=-0.7,radius=0.5,material=dielectric(color="white")))
render_scene(scene, parallel=TRUE,lookfrom=c(0,2,10))

# Make the sphere representing the ground larger and make it a checkered surface.
scene = generate_ground(depth=-0.5, spheresize=10000,
```

```

      material = diffuse(checkercolor="grey50")) |>
add_object(cube(x=0.7,material=diffuse(color="red"),angle=c(0,-15,0))) |>
add_object(sphere(x=-0.7,radius=0.5,material=dielectric(color="white")))
render_scene(scene, parallel=TRUE,lookfrom=c(0,1,10))

```

generate_studio

Generate Studio

Description

Generates a curved studio backdrop.

Usage

```

generate_studio(
  depth = -1,
  distance = -10,
  width = 100,
  height = 100,
  curvature = 8,
  material = diffuse()
)

```

Arguments

depth	Default '-1'. Depth of the ground in the scene.
distance	Default '-10'. Distance to the backdrop in the scene from the origin, on the z-axis.
width	Default '100'. Width of the backdrop.
height	Default '100'. height of the backdrop.
curvature	Default '2'. Radius of the curvature connecting the bottom plane to the vertical backdrop.
material	Default <code>diffuse</code> with <code>'color= "#ccff00"'</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .

Value

Tibble representing the scene.

Examples

```

#Generate the ground and add some objects
scene = generate_studio(depth=-1, material = diffuse(color="white")) |>
  add_object(obj_model(r_obj(),y=-0.5,x=0.5, scale=1.2,
    material=glossy(color="darkred"),angle=c(0,20,0))) |>
  add_object(sphere(x=-0.5,radius=0.5,material=dielectric())) |>

```

```

    add_object(sphere(y=3,x=-2,z=-20,material=light(intensity=600)))
render_scene(scene, parallel = TRUE, lookfrom = c(0,2,-10), lookat=c(0,-0.25,0),
             fov = 14, clamp_value = 10, samples = 16)

#Zooming out to show the full default scene
render_scene(scene, parallel=TRUE,lookfrom=c(0,200,-400),clamp_value=10,samples=16)

```

`get_saved_keyframes` *Get Saved Keyframes*

Description

Get a dataframe of the saved keyframes (using the interactive renderer) to pass to ‘generate_camera_motion()’

Usage

```
get_saved_keyframes()
```

Value

Data frame of keyframes

Examples

```

#This will return an empty data frame if no keyframes have been set.
get_saved_keyframes()

```

`glossy` *Glossy Material*

Description

Glossy Material

Usage

```

glossy(
  color = "white",
  gloss = 1,
  reflectance = 0.05,
  microfacet = "tbr",
  checkercolor = NA,
  checkerperiod = 3,
  noise = 0,
  noisephase = 0,

```

```

noiseintensity = 10,
noisecolor = "#000000",
gradient_color = NA,
gradient_transpose = FALSE,
gradient_point_start = NA_real_,
gradient_point_end = NA_real_,
gradient_type = "hsv",
image_texture = "",
image_repeat = 1,
alpha_texture = "",
bump_texture = "",
bump_intensity = 1,
roughness_texture = "",
roughness_range = c(1e-04, 0.2),
roughness_flip = FALSE,
importance_sample = FALSE
)

```

Arguments

color	Default 'white'. The color of the surface. Can be either a hexadecimal code, R color string, or a numeric rgb vector listing three intensities between '0' and '1'.
gloss	Default '0.8'. Gloss of the surface, between '1' (completely glossy) and '0' (rough glossy). Can be either a single number, or two numbers indicating an anisotropic distribution of normals (as in 'microfacet()').
reflectance	Default '0.03'. The reflectivity of the surface. '1' is a full mirror, '0' is diffuse with a glossy highlight.
microfacet	Default 'tbr'. Type of microfacet distribution. Alternative option 'beckmann'.
checkercolor	Default 'NA'. If not 'NA', determines the secondary color of the checkered surface. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
checkerperiod	Default '3'. The period of the checker pattern. Increasing this value makes the checker pattern bigger, and decreasing it makes it smaller
noise	Default '0'. If not '0', covers the surface in a turbulent marble pattern. This value will determine the amount of turbulence in the texture.
noisephase	Default '0'. The phase of the noise. The noise will repeat at '360'.
noiseintensity	Default '10'. Intensity of the noise.
noisecolor	Default '#000000'. The secondary color of the noise pattern. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
gradient_color	Default 'NA'. If not 'NA', creates a secondary color for a linear gradient between the this color and color specified in 'color'. Direction is determined by 'gradient_transpose'.
gradient_transpose	Default 'FALSE'. If 'TRUE', this will use the 'v' coordinate texture instead of the 'u' coordinate texture to map the gradient.

<code>gradient_point_start</code>	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'color'.
<code>gradient_point_end</code>	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'gradient_color'.
<code>gradient_type</code>	Default 'hsv'. Colorspace to calculate the gradient. Alternative 'rgb'.
<code>image_texture</code>	Default '""'. A 3-layer RGB array or filename to be used as the texture on the surface of the object.
<code>image_repeat</code>	Default '1'. Number of times to repeat the image across the surface. 'u' and 'v' repeat amount can be set independently if user passes in a length-2 vector.
<code>alpha_texture</code>	Default '""'. A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
<code>bump_texture</code>	Default '""'. A matrix, array, or filename (specifying a greyscale image) to be used to specify a bump map for the surface.
<code>bump_intensity</code>	Default '1'. Intensity of the bump map. High values may lead to unphysical results.
<code>roughness_texture</code>	Default '""'. A matrix, array, or filename (specifying a greyscale image) to be used to specify a roughness map for the surface.
<code>roughness_range</code>	Default 'c(0.0001, 0.2)'. This is a length-2 vector that specifies the range of roughness values that the 'roughness_texture' can take.
<code>roughness_flip</code>	Default 'FALSE'. Setting this to 'TRUE' flips the roughness values specified in the 'roughness_texture' so high values are now low values and vice versa.
<code>importance_sample</code>	Default 'FALSE'. If 'TRUE', the object will be sampled explicitly during the rendering process. If the object is particularly important in contributing to the light paths in the image (e.g. light sources, refracting glass ball with caustics, metal objects concentrating light), this will help with the convergence of the image.

Value

Single row of a tibble describing the glossy material.

Examples

```
#Generate a glossy sphere
generate_ground(material=diffuse(sigma=90)) |>
  add_object(sphere(y=0.2,material=glossy(color="#2b6eff"))) |>
  add_object(sphere(y=2.8,material=light())) |>
  render_scene(parallel=TRUE,clamp_value=10,samples=16,sample_method="sobol_blue")
```

```

#Change the color of the underlying diffuse layer
generate_ground(material=diffuse(sigma=90)) |>
  add_object(sphere(y=0.2,x=-2.1,material=glossy(color="#fc3d03"))) |>
  add_object(sphere(y=0.2,material=glossy(color="#2b6eff"))) |>
  add_object(sphere(y=0.2,x=2.1,material=glossy(color="#2fed4f"))) |>
  add_object(sphere(y=8,z=-5,radius=3,material=light(intensity=20))) |>
  render_scene(parallel=TRUE,clamp_value=10,samples=16,fov=40,sample_method="sobol_blue")
#Change the amount of gloss
generate_ground(material=diffuse(sigma=90)) |>
  add_object(sphere(y=0.2,x=-2.1,material=glossy(gloss=1,color="#fc3d03"))) |>
  add_object(sphere(y=0.2,material=glossy(gloss=0.5,color="#2b6eff"))) |>
  add_object(sphere(y=0.2,x=2.1,material=glossy(gloss=0,color="#2fed4f"))) |>
  add_object(sphere(y=8,z=-5,radius=3,material=light(intensity=20))) |>
  render_scene(parallel=TRUE,clamp_value=10,samples=16,fov=40,sample_method="sobol_blue")
#Add gloss to a pattern
generate_ground(material=diffuse(sigma=90)) |>
  add_object(sphere(y=0.2,x=-2.1,material=glossy(noise=2,noisecolor="black"))) |>
  add_object(sphere(y=0.2,material=glossy(color="#ff365a",checkercolor="#2b6eff"))) |>
  add_object(sphere(y=0.2,x=2.1,material=glossy(color="blue",gradient_color="#2fed4f"))) |>
  add_object(sphere(y=8,z=-5,radius=3,material=light(intensity=20))) |>
  render_scene(parallel=TRUE,clamp_value=10,samples=16,fov=40,sample_method="sobol_blue")
#Add an R and a fill light (this may look familiar)
generate_ground(material=diffuse()) |>
  add_object(sphere(y=0.2,material=glossy(color="#2b6eff",reflectance=0.05))) |>
  add_object(obj_model(r_obj(simple_r = TRUE),
                      z=-1,y=-0.05,scale=0.45,angle=c(0,180,0),material=diffuse())) |>
  add_object(sphere(y=6,z=-1,radius=4,material=light(intensity=3))) |>
  add_object(sphere(z=-15,material=light(intensity=50))) |>
  render_scene(parallel=TRUE,clamp_value=10,samples=16,sample_method="sobol_blue")

```

group_objects

Group Objects

Description

Group and transform objects together.

Usage

```

group_objects(
  scene,
  pivot_point = c(0, 0, 0),
  translate = c(0, 0, 0),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  scale = c(1, 1, 1),
  axis_rotation = NA
)

```

Arguments

scene	Tibble of pre-existing object locations and properties to group together.
pivot_point	Default 'c(0,0,0)'. The point about which to pivot, scale, and move the group.
translate	Default 'c(0,0,0)'. Vector indicating where to offset the group.
angle	Default 'c(0,0,0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1,2,3)'. The order to apply the rotations, referring to "x", "y", and "z".
scale	Default 'c(1,1,1)'. Scaling factor for x, y, and z directions for all objects in group.
axis_rotation	Default 'NA'. Provide an axis of rotation and a single angle (via 'angle') of rotation around that axis.

Value

Tibble of grouped object locations and properties.

Examples

```
#Generate the ground and add some objects
scene = generate_cornell() |>
  add_object(cube(x=555/2,y=555/8,z=555/2,width=555/4)) |>
  add_object(cube(x=555/2,y=555/4+555/16,z=555/2,width=555/8))
render_scene(scene,lookfrom=c(278,278,-800),lookat = c(278,278,0), aperture=0,
  samples=16, fov=50, parallel=TRUE, clamp_value=5)

#Group the entire room and rotate around its center, but keep the cubes in the same place.
scene2 = group_objects(generate_cornell(),
  pivot_point=c(555/2,555/2,555/2),
  angle=c(0,30,0)) |>
  add_object(cube(x=555/2,y=555/8,z=555/2,width=555/4)) |>
  add_object(cube(x=555/2,y=555/4+555/16,z=555/2,width=555/8))

render_scene(scene2,lookfrom=c(278,278,-800),lookat = c(278,278,0), aperture=0,
  samples=16, fov=50, parallel=TRUE, clamp_value=5)
#Now group the cubes instead of the Cornell box, and rotate/translate them together
twocubes = cube(x=555/2,y=555/8,z=555/2,width=555/4) |>
  add_object(cube(x=555/2, y=555/4 + 555/16, z=555/2, width=555/8))
scene3 = generate_cornell() |>
  add_object(group_objects(twocubes, translate = c(0,50,0),angle = c(0,45,0),
  pivot_point = c(555/2,0,555/2)))

render_scene(scene3,lookfrom=c(278,278,-800),lookat = c(278,278,0), aperture=0,
  samples=16, fov=50, parallel=TRUE, clamp_value=5)
#Flatten and stretch the cubes together on two axes
scene4 = generate_cornell() |>
  add_object(group_objects(twocubes, translate = c(0,-40,0),
  angle = c(0,45,0), scale = c(2,0.5,1),
  pivot_point = c(555/2,0,555/2)))
```

```

render_scene(scene4,lookfrom=c(278,278,-800),lookat = c(278,278,0), aperture=0,
             samples=16, fov=50, parallel=TRUE, clamp_value=5)
#Add another layer of grouping, including the Cornell box
scene4 |>
  group_objects(pivot_point = c(555/2,555/2,555/2),scale=c(1.5,0.5,0.3), angle=c(-20,0,20)) |>
  render_scene(lookfrom=c(278,278,-800),lookat = c(278,278,0), aperture=0,
             samples=509, fov=50, parallel=TRUE, clamp_value=5)

```

hair

Hair Material

Description

Hair Material

Usage

```

hair(
  pigment = 1.3,
  red_pigment = 0,
  color = NA,
  sigma_a = NA,
  eta = 1.55,
  beta_m = 0.3,
  beta_n = 0.3,
  alpha = 2
)

```

Arguments

<code>pigment</code>	Default '1.3'. Concentration of the eumelanin pigment in the hair. Blonde hair has concentrations around 0.3, brown around 1.3, and black around 8.
<code>red_pigment</code>	Default '0'. Concentration of the pheomelanin pigment in the hair. Pheomelanin makes red hair red.
<code>color</code>	Default 'NA'. Approximate color. Overrides 'pigment'/'redness' arguments.
<code>sigma_a</code>	Default 'NA'. Attenuation. Overrides 'color' and 'pigment'/'redness' arguments.
<code>eta</code>	Default '1.55'. Index of refraction of the hair medium.
<code>beta_m</code>	Default '0.3'. Longitudinal roughness of the hair. Should be between 0 and 1. This roughness controls the size and shape of the hair highlight.
<code>beta_n</code>	Default '0.3'. Azimuthal roughness of the hair. Should be between 0 and 1.
<code>alpha</code>	Default '2'. Angle of scales on the hair surface, in degrees.

Value

Single row of a tibble describing the hair material.

Examples

```
#Create a hairball
#Generate random points on a sphere
lengthval = 0.5
theta = acos(2*runif(10000)-1.0);
phi = 2*pi*(runif(10000))
bezier_list = list()

#Grow the hairs
for(i in 1:length(phi)) {
  pointval = c(sin(theta[i]) * sin(phi[i]),
               cos(theta[i]),
               sin(theta[i]) * cos(phi[i]))
  bezier_list[[i]] = bezier_curve(width=0.01, width_end=0.008,
                                  p1 = pointval,
                                  p2 = (1+(lengthval*0.33))*pointval,
                                  p3 = (1+(lengthval*0.66))*pointval,
                                  p4 = (1+(lengthval)) * pointval,
                                  material=hair(pigment = 0.3, red_pigment = 1.3,
                                                beta_m = 0.3, beta_n= 0.3),
                                  type="flat")
}
hairball = dplyr::bind_rows(bezier_list)

generate_ground(depth=-2,material=diffuse(color="grey20")) |>
  add_object(sphere()) |>
  add_object(hairball) |>
  add_object(sphere(y=20,z=20,radius=5,material=light(color="white",intensity = 100))) |>
  render_scene(samples=16, lookfrom=c(0,3,10),clamp_value = 10,
               fov=20, width=800, height=800)

#Specify the color directly and increase hair roughness
for(i in 1:length(phi)) {
  pointval = c(sin(theta[i]) * sin(phi[i]),
               cos(theta[i]),
               sin(theta[i]) * cos(phi[i]))
  bezier_list[[i]] = bezier_curve(width=0.01, width_end=0.008,
                                  p1 = pointval,
                                  p2 = (1+(lengthval*0.33))*pointval,
                                  p3 = (1+(lengthval*0.66))*pointval,
                                  p4 = (1+(lengthval)) * pointval,
                                  material=hair(color="purple",
                                                beta_m = 0.5, beta_n= 0.5),
                                  type="flat")
}
hairball = dplyr::bind_rows(bezier_list)
generate_ground(depth=-2,material=diffuse(color="grey20")) |>
  add_object(sphere()) |>
```

```

add_object(hairball) |>
add_object(sphere(y=20,z=20,radius=5,material=light(color="white",intensity = 100))) |>
render_scene(samples=16, lookfrom=c(0,3,10),clamp_value = 10,
             fov=20, width=800, height=800)

```

has_denoiser	<i>Check for Denoiser Support</i>
--------------	-----------------------------------

Description

Returns TRUE if rayrender was compiled with Open Image Denoise (OIDN) support.

Usage

```
has_denoiser()
```

Value

Logical value.

Examples

```
has_denoiser()
```

lambertian	<i>Lambertian Material (deprecated)</i>
------------	---

Description

Lambertian Material (deprecated)

Usage

```
lambertian(...)
```

Arguments

... Arguments to pass to diffuse() function.

Value

Single row of a tibble describing the diffuse material.

Examples

```
#Deprecated lambertian material. Will display a warning.
scene = generate_cornell() |>
  add_object(sphere(x=555/2,y=555/2,z=555/2,radius=555/8,material=lambertian()))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
```

light*Light Material*

Description

Light Material

Usage

```
light(
  color = "#ffffff",
  intensity = 10,
  importance_sample = TRUE,
  spotlight_focus = NA,
  spotlight_width = 30,
  spotlight_start_falloff = 15,
  invisible = FALSE,
  image_texture = "",
  image_repeat = 1,
  gradient_color = NA,
  gradient_transpose = FALSE,
  gradient_point_start = NA,
  gradient_point_end = NA,
  gradient_type = "hsv"
)
```

Arguments

color	Default 'white'. The color of the light Can be either a hexadecimal code, R color string, or a numeric rgb vector listing three intensities between '0' and '1'.
intensity	Default '10'. If a positive value, this will turn this object into a light emitting the value specified in 'color' (ignoring other properties). Higher values will produce a brighter light.
importance_sample	Default 'TRUE'. Keeping this on for lights improves the convergence of the rendering algorithm, in most cases. If the object is particularly important in contributing to the light paths in the image (e.g. light sources, refracting glass ball with caustics, metal objects concentrating light), this will help with the convergence of the image.

spotlight_focus	Default 'NA', no spotlight. Otherwise, a length-3 numeric vector specifying the x/y/z coordinates that the spotlight should be focused on. Only works for spheres and rectangles.
spotlight_width	Default '30'. Angular width of the spotlight.
spotlight_start_falloff	Default '15'. Angle at which the light starts fading in intensity.
invisible	Default 'FALSE'. If 'TRUE', the light itself will be invisible.
image_texture	Default '""'. A 3-layer RGB array or filename to be used as the texture on the surface of the object.
image_repeat	Default '1'. Number of times to repeat the image across the surface. 'u' and 'v' repeat amount can be set independently if user passes in a length-2 vector.
gradient_color	Default 'NA'. If not 'NA', creates a secondary color for a linear gradient between the this color and color specified in 'color'. Direction is determined by 'gradient_transpose'.
gradient_transpose	Default 'FALSE'. If 'TRUE', this will use the 'v' coordinate texture instead of the 'u' coordinate texture to map the gradient.
gradient_point_start	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'color'.
gradient_point_end	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'gradient_color'.
gradient_type	Default 'hsv'. Colorspace to calculate the gradient. Alternative 'rgb'.

Value

Single row of a tibble describing the light material.

Examples

```
#Generate the cornell box without a light and add a single white sphere to the center
scene = generate_cornell(light=FALSE) |>
  add_object(sphere(x=555/2,y=555/2,z=555/2,radius=555/8,material=light()))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#Remove the light for direct camera rays, but keep the lighting
scene = generate_cornell(light=FALSE) |>
  add_object(sphere(x=555/2,y=555/2,z=555/2,radius=555/8,
    material=light(intensity=15,invisible=TRUE)))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
```

```

aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#All gather around the orb
scene = generate_ground(material = diffuse(checkercolor="grey50")) |>
  add_object(sphere(radius=0.25,material=light(intensity=90,color="#f11")) |>
  add_object(obj_model(r_obj(), scale=2.5,z=-3,x=-1.25,y=0, angle=c(0,235,0))) |>
  add_object(pig(scale=0.3, x=1.5,z=-2,y=-1.5,angle=c(0,-135,0)))
render_scene(scene, samples=16, parallel=TRUE, clamp_value=10, lookfrom=c(0,0,10))

```

mesh3d_model	<i>'mesh3d' model</i>
--------------	-----------------------

Description

Load an 'mesh3d' (or 'shapelist3d') object, as specified in the 'rgl' package.

Usage

```

mesh3d_model(
  mesh,
  x = 0,
  y = 0,
  z = 0,
  swap_yz = FALSE,
  reverse = FALSE,
  subdivision_levels = 1,
  verbose = FALSE,
  displacement_texture = "",
  displacement_intensity = 1,
  displacement_vector = FALSE,
  recalculate_normals = FALSE,
  override_material = FALSE,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

mesh	A 'mesh3d' or 'shapelist3d' object. Pulls the vertex, index, texture coordinates, normals, and material information. If the material references an image texture, the 'mesh\$material\$texture' argument should be set to the image filename. The 'mesh3d' format only supports one image texture per mesh. All quads will be triangulated.
x	Default '0'. x-coordinate to offset the model.

y	Default '0'. y-coordinate to offset the model.
z	Default '0'. z-coordinate to offset the model.
swap_yz	Default 'FALSE'. Swap the Y and Z coordinates.
reverse	Default 'FALSE'. Reverse the orientation of the indices, flipping their normals.
subdivision_levels	Default '1'. Number of Loop subdivisions to be applied to the mesh.
verbose	Default 'FALSE'. If 'TRUE', prints information about the mesh to the console.
displacement_texture	Default '""'. File path to the displacement texture. This texture is used to displace the vertices of the mesh based on the texture's pixel values.
displacement_intensity	Default '1'. Intensity of the displacement effect. Higher values result in greater displacement.
displacement_vector	Default 'FALSE'. Whether to use vector displacement. If 'TRUE', the displacement texture is interpreted as providing a 3D displacement vector. Otherwise, the texture is interpreted as providing a scalar displacement.
recalculate_normals	Default 'FALSE'. Whether to recalculate vertex normals based on the connecting face orientations. This can be used to compute normals for meshes lacking them or to calculate new normals after a displacement map has been applied to the mesh.
override_material	Default 'FALSE'. If 'TRUE', overrides the material specified in the 'mesh3d' object with the one specified in 'material'.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the mesh3d model in the scene.

Examples

```
#Load a mesh3d object (from the Rvcg) and render it:
library(Rvcg)
data(humface)
```

```

generate_studio() |>
  add_object(mesh3d_model(humface,y=-0.3,x=0,z=0,
                        material=glossy(color="dodgerblue4"), scale = 1/70,
                        angle = c(0,180,0))) |>
  add_object(sphere(y=5,x=5,z=-5,material=light(intensity=50))) |>
  render_scene(samples=16,width=800,height=800,
              lookat = c(0,0.5,1), aperture=0.0)

```

metal

Metallic Material

Description

Metallic Material

Usage

```

metal(
  color = "#ffffff",
  eta = 0,
  kappa = 0,
  fuzz = 0,
  checkercolor = NA,
  checkerperiod = 3,
  noise = 0,
  noisephase = 0,
  noiseintensity = 10,
  noisecolor = "#000000",
  gradient_color = NA,
  gradient_transpose = FALSE,
  gradient_point_start = NA,
  gradient_point_end = NA,
  gradient_type = "hsv",
  image_texture = "",
  image_repeat = 1,
  alpha_texture = "",
  bump_texture = "",
  bump_intensity = 1,
  importance_sample = FALSE
)

```

Arguments

color Default 'white'. The color of the sphere. Can be either a hexadecimal code, R color string, or a numeric rgb vector listing three intensities between '0' and '1'.

eta	Default '0'. Wavelength dependent refractivity of the material (red, green, and blue channels). If single number, will be repeated across all three channels.
kappa	Default '0'. Wavelength dependent absorption of the material (red, green, and blue channels). If single number, will be repeated across all three channels.
fuzz	Default '0'. Deprecated—Use the microfacet material instead, as it is designed for rough metals. The roughness of the metallic surface. Maximum '1'.
checkercolor	Default 'NA'. If not 'NA', determines the secondary color of the checkered surface. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
checkerperiod	Default '3'. The period of the checker pattern. Increasing this value makes the checker pattern bigger, and decreasing it makes it smaller
noise	Default '0'. If not '0', covers the surface in a turbulent marble pattern. This value will determine the amount of turbulence in the texture.
noisephase	Default '0'. The phase of the noise. The noise will repeat at '360'.
noiseintensity	Default '10'. Intensity of the noise.
noisecolor	Default '#000000'. The secondary color of the noise pattern. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
gradient_color	Default 'NA'. If not 'NA', creates a secondary color for a linear gradient between the this color and color specified in 'color'. Direction is determined by 'gradient_transpose'.
gradient_transpose	Default 'FALSE'. If 'TRUE', this will use the 'v' coordinate texture instead of the 'u' coordinate texture to map the gradient.
gradient_point_start	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'color'.
gradient_point_end	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'gradient_color'.
gradient_type	Default 'hsv'. Colorspace to calculate the gradient. Alternative 'rgb'.
image_texture	Default '""'. A 3-layer RGB array or filename to be used as the texture on the surface of the object.
image_repeat	Default '1'. Number of times to repeat the image across the surface. 'u' and 'v' repeat amount can be set independently if user passes in a length-2 vector.
alpha_texture	Default '""'. A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
bump_texture	Default '""'. A matrix, array, or filename (specifying a greyscale image) to be used to specify a bump map for the surface.

`bump_intensity` Default '1'. Intensity of the bump map. High values may lead to unphysical results.

`importance_sample`

Default 'FALSE'. If 'TRUE', the object will be sampled explicitly during the rendering process. If the object is particularly important in contributing to the light paths in the image (e.g. light sources, refracting glass ball with caustics, metal objects concentrating light), this will help with the convergence of the image.

Value

Single row of a tibble describing the metallic material.

Examples

```
# Generate the cornell box with a single chrome sphere in the center. For other metals,
# See the website refractiveindex.info for eta and k data, use wavelengths 5
# 80nm (R), 530nm (G), and 430nm (B).
scene = generate_cornell() |>
  add_object(sphere(x=555/2,y=555/2,z=555/2,radius=555/8,
  material=metal(eta=c(3.2176,3.1029,2.1839), k = c(3.3018,3.33,3.0339))))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
#Add an aluminum rotated shiny metal block
scene = scene |>
  add_object(cube(x=380,y=150/2,z=200,xwidth=150,ywidth=150,zwidth=150,
  material = metal(eta = c(1.07,0.8946,0.523), k = c(6.7144,6.188,4.95)),angle=c(0,45,0)))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
#Add a copper metal cube
scene = scene |>
  add_object(cube(x=150,y=150/2,z=300,xwidth=150,ywidth=150,zwidth=150,
  material = metal(eta = c(0.497,0.8231,1.338),
  k = c(2.898,2.476,2.298)),
  angle=c(0,-30,0)))
render_scene(scene, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#Finally, let's add a lead pipe
scene2 = scene |>
  add_object(cylinder(x=450,y=200,z=400,length=400,radius=30,
  material = metal(eta = c(1.44,1.78,1.9),
  k = c(3.18,3.36,3.43)),
  angle=c(0,-30,0)))
render_scene(scene2, lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)
```

 microfacet

Microfacet Material

Description

Microfacet Material

Usage

```
microfacet(
  color = "white",
  roughness = 1e-04,
  transmission = FALSE,
  eta = 0,
  kappa = 0,
  microfacet = "tbr",
  checkercolor = NA,
  checkerperiod = 3,
  noise = 0,
  noisephase = 0,
  noiseintensity = 10,
  noisecolor = "#000000",
  gradient_color = NA,
  gradient_transpose = FALSE,
  gradient_point_start = NA_real_,
  gradient_point_end = NA_real_,
  gradient_type = "hsv",
  image_texture = "",
  image_repeat = 1,
  alpha_texture = "",
  bump_texture = "",
  bump_intensity = 1,
  roughness_texture = "",
  roughness_range = c(1e-04, 0.2),
  roughness_flip = FALSE,
  importance_sample = FALSE
)
```

Arguments

color	Default 'white'. The color of the surface. Can be either a hexadecimal code, R color string, or a numeric rgb vector listing three intensities between '0' and '1'.
roughness	Default '0.0001'. Roughness of the surface, between '0' (smooth) and '1' (diffuse). Can be either a single number, or two numbers indicating an anisotropic distribution of normals. '0' is a smooth surface, while '1' is extremely rough. This can be used to create a wide-variety of materials (e.g. '0-0.01' is specular metal, '0.02'-'0.1' is brushed metal, '0.1'-'0.3' is a rough metallic surface ,

	'0.3'-'0.5' is diffuse, and above that is a rough satin-like material). Two numbers will specify the x and y roughness separately (e.g. 'roughness = c(0.01, 0.001)' gives an etched metal effect). If '0', this defaults to the 'metal()' material for faster evaluation.
transmission	Default 'FALSE'. If 'TRUE', this material will be a rough dielectric instead of a rough metallic surface.
eta	Default '0'. Wavelength dependent refractivity of the material (red, green, and blue channels). If single number, will be repeated across all three channels. If 'transmission = TRUE', this is a single value representing the index of refraction of the material.
kappa	Default '0'. Wavelength dependent absorption of the material (red, green, and blue channels). If single number, will be repeated across all three channels. If 'transmission = TRUE', this length-3 vector specifies the attenuation of the dielectric (analogous to the dielectric 'attenuation' argument).
microfacet	Default 'tbr'. Type of microfacet distribution. Alternative option 'beckmann'.
checkercolor	Default 'NA'. If not 'NA', determines the secondary color of the checkered surface. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
checkerperiod	Default '3'. The period of the checker pattern. Increasing this value makes the checker pattern bigger, and decreasing it makes it smaller
noise	Default '0'. If not '0', covers the surface in a turbulent marble pattern. This value will determine the amount of turbulence in the texture.
noisephase	Default '0'. The phase of the noise. The noise will repeat at '360'.
noiseintensity	Default '10'. Intensity of the noise.
noisecolor	Default '#000000'. The secondary color of the noise pattern. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
gradient_color	Default 'NA'. If not 'NA', creates a secondary color for a linear gradient between the this color and color specified in 'color'. Direction is determined by 'gradient_transpose'.
gradient_transpose	Default 'FALSE'. If 'TRUE', this will use the 'v' coordinate texture instead of the 'u' coordinate texture to map the gradient.
gradient_point_start	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'color'.
gradient_point_end	Default 'NA'. If not 'NA', this changes the behavior from mapping texture coordinates to mapping to world space coordinates. This should be a length-3 vector specifying the x,y, and z points where the gradient begins with value 'gradient_color'.
gradient_type	Default 'hsv'. Colorspace to calculate the gradient. Alternative 'rgb'.

image_texture	Default <code>""</code> . A 3-layer RGB array or filename to be used as the texture on the surface of the object.
image_repeat	Default <code>'1'</code> . Number of times to repeat the image across the surface. <code>'u'</code> and <code>'v'</code> repeat amount can be set independently if user passes in a length-2 vector.
alpha_texture	Default <code>""</code> . A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
bump_texture	Default <code>""</code> . A matrix, array, or filename (specifying a greyscale image) to be used to specify a bump map for the surface.
bump_intensity	Default <code>'1'</code> . Intensity of the bump map. High values may lead to unphysical results.
roughness_texture	Default <code>""</code> . A matrix, array, or filename (specifying a greyscale image) to be used to specify a roughness map for the surface.
roughness_range	Default <code>c(0.0001, 0.2)</code> . This is a length-2 vector that specifies the range of roughness values that the <code>'roughness_texture'</code> can take.
roughness_flip	Default <code>'FALSE'</code> . Setting this to <code>'TRUE'</code> flips the roughness values specified in the <code>'roughness_texture'</code> so high values are now low values and vice versa.
importance_sample	Default <code>'FALSE'</code> . If <code>'TRUE'</code> , the object will be sampled explicitly during the rendering process. If the object is particularly important in contributing to the light paths in the image (e.g. light sources, refracting glass ball with caustics, metal objects concentrating light), this will help with the convergence of the image.

Value

Single row of a tibble describing the microfacet material.

Examples

```
# Generate a golden egg, using eta and kappa taken from physical measurements
# See the website refractiveindex.info for eta and k data, use
# wavelengths 580nm (R), 530nm (G), and 430nm (B).
generate_cornell() |>
  add_object(ellipsoid(x=555/2, y=555/2, z=150, a=100, b=150, c=100,
    material=microfacet(roughness=0.1,
      eta=c(0.216, 0.42833, 1.3184), kappa=c(3.239, 2.4599, 1.8661)))) |>
  render_scene(lookfrom=c(278, 278, -800), lookat = c(278, 278, 0), samples=16,
    aperture=0, fov=40, parallel=TRUE, clamp_value=10)
#Make the roughness anisotropic (either horizontal or vertical), adding an extra light in front
#to show off the different microfacet orientations
generate_cornell() |>
  add_object(sphere(x=555/2, z=50, y=75, radius=20, material=light())) |>
  add_object(ellipsoid(x=555-150, y=555/2, z=150, a=100, b=150, c=100,
    material=microfacet(roughness=c(0.3, 0.1),
      eta=c(0.216, 0.42833, 1.3184), kappa=c(3.239, 2.4599, 1.8661)))) |>
  add_object(ellipsoid(x=150, y=555/2, z=150, a=100, b=150, c=100,
```

```

        material=microfacet(roughness=c(0.1,0.3),
            eta=c(0.216,0.42833,1.3184), kappa=c(3.239,2.4599,1.8661)))) |>
render_scene(lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
    aperture=0, fov=40, parallel=TRUE,clamp_value=10)
#Render a rough silver R with a smaller golden egg in front
generate_cornell() |>
  add_object(obj_model(r_obj(simple_r = TRUE),
    x=555/2,z=350,y=0, scale_obj = 200, angle=c(0,200,0),
    material=microfacet(roughness=0.2,
      eta=c(1.1583,0.9302,0.5996), kappa=c(6.9650,6.396,5.332)))) |>
add_object(ellipsoid(x=200,z=200,y=80, a=50,b=80,c=50,
  material=microfacet(roughness=0.1,
    eta=c(0.216,0.42833,1.3184), kappa=c(3.239,2.4599,1.8661)))) |>
render_scene(lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, parallel=TRUE,clamp_value=10)
#Increase the roughness
generate_cornell() |>
  add_object(obj_model(r_obj(simple_r = TRUE),
    x=555/2,z=350,y=0, scale_obj = 200, angle=c(0,200,0),
    material=microfacet(roughness=0.5,
      eta=c(1.1583,0.9302,0.5996), kappa=c(6.9650,6.396,5.332)))) |>
add_object(ellipsoid(x=200,z=200,y=80, a=50,b=80,c=50,
  material=microfacet(roughness=0.3,
    eta=c(0.216,0.42833,1.3184), kappa=c(3.239,2.4599,1.8661)))) |>
render_scene(lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=16,
  aperture=0, fov=40, parallel=TRUE,clamp_value=10)
#Use transmission for a rough dielectric
generate_cornell() |>
  add_object(obj_model(r_obj(simple_r = TRUE),
    x=555/2,z=350,y=0, scale_obj = 200, angle=c(0,200,0),
    material=microfacet(roughness=0.3, transmission=T, eta=1.6))) |>
add_object(ellipsoid(x=200,z=200,y=80, a=50,b=80,c=50,
  material=microfacet(roughness=0.3, transmission=T, eta=1.6))) |>
render_scene(lookfrom=c(278,278,-800),lookat = c(278,278,0), samples=64,
  aperture=0, fov=40, parallel=TRUE,clamp_value=10, min_variance=1e-6)

```

obj_model

'obj' File Object

Description

Load an obj file via a filepath. Currently only supports the diffuse texture with the 'texture' argument. Note: light importance sampling currently not supported for this shape.

Usage

```

obj_model(
  filename,
  x = 0,

```

```

y = 0,
z = 0,
scale_obj = 1,
load_material = TRUE,
load_textures = TRUE,
load_normals = TRUE,
vertex_colors = FALSE,
calculate_consistent_normals = TRUE,
subdivision_levels = 1,
displacement_texture = "",
displacement_intensity = 1,
displacement_vector = FALSE,
recalculate_normals = FALSE,
importance_sample_lights = TRUE,
material = diffuse(),
angle = c(0, 0, 0),
order_rotation = c(1, 2, 3),
flipped = FALSE,
scale = c(1, 1, 1)
)

```

Arguments

filename	Filename and path to the 'obj' file. Can also be a 'txt' file, if it's in the correct 'obj' internally.
x	Default '0'. x-coordinate to offset the model.
y	Default '0'. y-coordinate to offset the model.
z	Default '0'. z-coordinate to offset the model.
scale_obj	Default '1'. Amount to scale the model. Use this to scale the object up or down on all axes, as it is more robust to numerical precision errors than the generic scale option.
load_material	Default 'TRUE'. Whether to load the obj file material (MTL file). If material for faces aren't specified, the default material will be used (specified by the user in 'material').
load_textures	Default 'TRUE'. If 'load_material = TRUE', whether to load textures in the MTL file (versus just using the colors specified for each material).
load_normals	Default 'TRUE'. Whether to load the vertex normals if they exist in the OBJ file.
vertex_colors	Default 'FALSE'. Set to 'TRUE' if the OBJ file has vertex colors to apply them to the model.
calculate_consistent_normals	Default 'TRUE'. Whether to calculate consistent vertex normals to prevent energy loss at edges.
subdivision_levels	Default '1'. Number of Loop subdivisions to be applied to the mesh.

displacement_texture	Default <code>""</code> . File path to the displacement texture. This texture is used to displace the vertices of the mesh based on the texture's pixel values.
displacement_intensity	Default <code>'1'</code> . Intensity of the displacement effect. Higher values result in greater displacement.
displacement_vector	Default <code>'FALSE'</code> . Whether to use vector displacement. If <code>'TRUE'</code> , the displacement texture is interpreted as providing a 3D displacement vector. Otherwise, the texture is interpreted as providing a scalar displacement.
recalculate_normals	Default <code>'FALSE'</code> . Whether to recalculate vertex normals based on the connecting face orientations. This can be used to compute normals for meshes lacking them or to calculate new normals after a displacement map has been applied to the mesh.
importance_sample_lights	Default <code>'TRUE'</code> . Whether to importance sample lights specified in the OBJ material (objects with a non-zero <code>Ke</code> MTL material).
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default <code>'c(0, 0, 0)'</code> . Angle of rotation around the x, y, and z axes, applied in the order specified in <code>'order_rotation'</code> .
order_rotation	Default <code>'c(1, 2, 3)'</code> . The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default <code>'FALSE'</code> . Whether to flip the normals.
scale	Default <code>'c(1, 1, 1)'</code> . Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the obj model in the scene.

Examples

```
#Load the included example R object file, by calling the r_obj() function. This
#returns the local file path to the `r.txt` obj file. The file extension is "txt"
#due to package constraints, but the file contents are identical and it does not
#affect the function.
```

```
#Load the basic 3D R logo with the included materials
generate_ground(material = diffuse(checkercolor = "grey50")) |>
  add_object(obj_model(y = 0.2, filename = rayrender::r_obj(),
                      scale_obj=3)) |>
  add_object(sphere(z = -20, x = 20, y = 20, radius = 10,
                  material = light(intensity = 10))) |>
  render_scene(parallel = TRUE, samples = 16, aperture = 0.05,
              sample_method="sobol_blue",
```

```

fov = 20, lookfrom = c(0, 2, -10))

# Smooth a mesh by setting the number of subdivision levels
generate_ground(material = diffuse(checkercolor = "grey50")) |>
  add_object(obj_model(y = 0.2, filename = rayrender::r_obj(),
    scale_obj=3, subdivision_levels = 3)) |>
  add_object(sphere(z = -20, x = 20, y = 20, radius = 10,
    material = light(intensity = 10))) |>
render_scene(parallel = TRUE, samples = 16, aperture = 0.05,
  sample_method="sobol_blue",
  fov = 20, lookfrom = c(0, 2, -10))

#Override the materials for each object
generate_ground(material = diffuse(checkercolor = "grey50")) |>
  add_object(obj_model(y = 1.4, filename = rayrender::r_obj(), load_material = FALSE,
    scale_obj = 1.8, angle=c(10,0,0),
    material = microfacet(color = "gold", roughness = 0.2))) |>
  add_object(obj_model(x = 0.9, y = 0, filename = rayrender::r_obj(), load_material = FALSE,
    scale_obj = 1.8, angle=c(0,20,0),
    material = diffuse(color = "dodgerblue"))) |>
  add_object(obj_model(x = -0.9, y = 0, filename = rayrender::r_obj(), load_material = FALSE,
    scale_obj = 1.8, angle=c(0,-40,0),
    material = dielectric(attenuation = c(1,0.3,1), priority = 1,
      attenuation_intensity = 20))) |>
  add_object(sphere(z = -20, x = 20, y = 20, radius = 10,
    material = light(intensity = 10))) |>
render_scene(parallel = TRUE, samples = 16, aperture = 0.05,
  sample_method="sobol_blue", lookat=c(0,0.5,0),
  fov = 22, lookfrom = c(0, 2, -10))

```

path

Path Object

Description

Either a closed or open path made up of bezier curves that go through the specified points (with continuous first and second derivatives), or straight line segments.

Usage

```

path(
  points,
  x = 0,
  y = 0,
  z = 0,
  closed = FALSE,
  closed_smooth = TRUE,
  straight = FALSE,

```

```

precomputed_control_points = FALSE,
width = 0.1,
width_end = NA,
u_min = 0,
u_max = 1,
type = "cylinder",
normal = c(0, 0, -1),
normal_end = NA,
material = diffuse(),
angle = c(0, 0, 0),
order_rotation = c(1, 2, 3),
flipped = FALSE,
scale = c(1, 1, 1)
)

```

Arguments

points	Either a list of length-3 numeric vectors or 3-column matrix/data.frame specifying the x/y/z points that the path should go through.
x	Default '0'. x-coordinate offset for the path.
y	Default '0'. y-coordinate offset for the path.
z	Default '0'. z-coordinate offset for the path.
closed	Default 'FALSE'. If 'TRUE', the path will be closed by smoothly connecting the first and last points.
closed_smooth	Default 'TRUE'. If 'closed = TRUE', this will ensure C2 (second derivative) continuity between the ends. If 'closed = FALSE', the curve will only have C1 (first derivative) continuity between the ends.
straight	Default 'FALSE'. If 'TRUE', straight lines will be used to connect the points instead of bezier curves.
precomputed_control_points	Default 'FALSE'. If 'TRUE', 'points' argument will expect a list of control points calculated with the internal rayrender function 'rayrender:::calculate_control_points()'.
width	Default '0.1'. Curve width.
width_end	Default 'NA'. Width at end of path. Same as 'width', unless specified.
u_min	Default '0'. Minimum parametric coordinate for the path.
u_max	Default '1'. Maximum parametric coordinate for the path.
type	Default 'cylinder'. Other options are 'flat' and 'ribbon'.
normal	Default 'c(0,0,-1)'. Orientation surface normal for the start of ribbon curves.
normal_end	Default 'NA'. Orientation surface normal for the start of ribbon curves. If not specified, same as 'normal'.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.

order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the cube in the scene.

Examples

```
#Generate a wavy line, showing the line goes through the specified points:
wave = list(c(-2,1,0),c(-1,-1,0),c(0,1,0),c(1,-1,0),c(2,1,0))
point_mat = glossy(color="green")
generate_studio(depth=-1.5) |>
  add_object(path(points = wave,material=glossy(color="red"))) |>
  add_object(sphere(x=-2,y=1,radius=0.1,material=point_mat)) |>
  add_object(sphere(x=-1,y=-1,radius=0.1,material=point_mat)) |>
  add_object(sphere(x=0,y=1,radius=0.1,material=point_mat)) |>
  add_object(sphere(x=1,y=-1,radius=0.1,material=point_mat)) |>
  add_object(sphere(x=2,y=1,radius=0.1,material=point_mat)) |>
  add_object(sphere(z=-5,x=5,y=5,radius=2,material=light(intensity=15))) |>
  render_scene(samples=16, clamp_value=10, fov=30)
#Here we use straight lines by setting `straight = TRUE`:
generate_studio(depth=-1.5) |>
  add_object(path(points = wave,straight = TRUE, material=glossy(color="red"))) |>
  add_object(sphere(z=-5,x=5,y=5,radius=2,material=light(intensity=15))) |>
  render_scene(samples=16, clamp_value=10, fov=30)
#We can also pass a matrix of values, specifying the x/y/z coordinates. Here,
#we'll create a random curve:
set.seed(21)
random_mat = matrix(runif(3*9)*2-1, ncol=3)
generate_studio(depth=-1.5) |>
  add_object(path(points=random_mat, material=glossy(color="red"))) |>
  add_object(sphere(y=5,radius=1,material=light(intensity=30))) |>
  render_scene(samples=16, clamp_value=10)
#We can ensure the curve is closed by setting `closed = TRUE`
generate_studio(depth=-1.5) |>
  add_object(path(points=random_mat, closed = TRUE, material=glossy(color="red"))) |>
  add_object(sphere(y=5,radius=1,material=light(intensity=30))) |>
  render_scene(samples=16, clamp_value=10)
#Finally, let's render a pretzel to show how you can render just a subset of the curve:
pretzel = list(c(-0.8,-0.5,0.1),c(0,-0.2,-0.1),c(0,0.3,0.1),c(-0.5,0.5,0.1), c(-0.6,-0.5,-0.1),
  c(0,-0.8,-0.1),
  c(0.6,-0.5,-0.1),c(0.5,0.5,-0.1), c(0,0.3,-0.1),c(-0,-0.2,0.1), c(0.8,-0.5,0.1))

#Render the full pretzel:
generate_studio(depth = -1.1) |>
  add_object(path(pretzel, width=0.17, material = glossy(color="#db5b00"))) |>
  add_object(sphere(y=5,x=2,z=-4,material=light(intensity=20,spotlight_focus = c(0,0,0))) |>
```

```

render_scene(samples=16, clamp_value=10)
#Here, we'll render only the first third of the pretzel by setting `u_max = 0.33`
generate_studio(depth = -1.1) |>
  add_object(path(pretzel, width=0.17, u_max=0.33, material = glossy(color="#db5b00"))) |>
  add_object(sphere(y=5,x=2,z=-4,material=light(intensity=20,spotlight_focus = c(0,0,0))) |>
  render_scene(samples=16, clamp_value=10)
#Here's the last third, by setting `u_min = 0.66`
generate_studio(depth = -1.1) |>
  add_object(path(pretzel, width=0.17, u_min=0.66, material = glossy(color="#db5b00"))) |>
  add_object(sphere(y=5,x=2,z=-4,material=light(intensity=20,spotlight_focus = c(0,0,0))) |>
  render_scene(samples=16, clamp_value=10)
#Here's the full pretzel, decomposed into thirds using the u_min and u_max coordinates
generate_studio(depth = -1.1) |>
  add_object(path(pretzel, width=0.17, u_max=0.33, x = -0.8, y =0.6,
                 material = glossy(color="#db5b00"))) |>
  add_object(path(pretzel, width=0.17, u_min=0.66, x = 0.8, y =0.6,
                 material = glossy(color="#db5b00"))) |>
  add_object(path(pretzel, width=0.17, u_min=0.33, u_max=0.66, x=0,
                 material = glossy(color="#db5b00"))) |>
  add_object(sphere(y=5,x=2,z=-4,material=light(intensity=20,spotlight_focus = c(0,0,0))) |>
  render_scene(samples=16, clamp_value=10, lookfrom=c(0,3,-10))

```

pig

Pig Object

Description

Pig Object

Usage

```

pig(
  x = 0,
  y = 0,
  z = 0,
  emotion = "neutral",
  spider = FALSE,
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  scale = c(1, 1, 1),
  diffuse_sigma = 0
)

```

Arguments

x	Default '0'. x-coordinate of the center of the pig.
y	Default '0'. y-coordinate of the center of the pig.

z	Default '0'. z-coordinate of the center of the pig.
emotion	Default 'neutral'. Other options include 'skeptical', 'worried', and 'angry'.
spider	Default 'FALSE'. Spiderpig.
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly.
diffuse_sigma	Default '0'. Controls the Oren-Nayar sigma parameter for the pig's diffuse material.

Value

Single row of a tibble describing the pig in the scene.

Examples

```
#Generate a pig in the cornell box.

generate_cornell() |>
  add_object(pig(x=555/2,z=555/2,y=120,
  scale=c(80,80,80), angle = c(0,135,0))) |>
  render_scene(parallel=TRUE, samples=16,clamp_value=10)
# Show the pig staring into a mirror, worried
generate_cornell() |>
  add_object(pig(x=555/2-70,z=555/2+50,y=120,scale=c(80,80,80),
  angle = c(0,-40,0), emotion = "worried")) |>
  add_object(cube(x=450,z=450,y=250, ywidth=500, xwidth=200,
  angle = c(0,45,0), material = metal())) |>
  render_scene(parallel=TRUE, samples=16,clamp_value=10)
# Render many small pigs facing random directions, with an evil pig overlord
set.seed(1)
lots_of_pigs = list()
for(i in 1:10) {
  lots_of_pigs[[i]] = pig(x=50 + 450 * runif(1), z = 50 + 450 * runif(1), y=50,
  scale = c(30,30,30), angle = c(0,360*runif(1),0), emotion = "worried")
}

many_pigs_scene = do.call(rbind, lots_of_pigs) |>
  add_object(generate_cornell(lightintensity=30, lightwidth=100)) |>
  add_object(pig(z=500,x=555/2,y=350, emotion = "angry",
  scale=c(100,100,100),angle=c(-30,90,0), order_rotation=c(3,2,1)))

render_scene(many_pigs_scene,parallel=TRUE,clamp_value=10, samples=16)
#Render spiderpig
generate_studio() |>
  add_object(pig(y=-1,angle=c(0,80,0), scale=1/2,spider=TRUE)) |>
  add_object(sphere(y=5,z=-5,x=5,material=light(intensity=100))) |>
  render_scene(samples=16,lookfrom=c(0,2,-10),clamp_value=10)
```

ply_model *'ply' File Object*

Description

Load an PLY file via a filepath. Note: light importance sampling currently not supported for this shape.

Usage

```
ply_model(
  filename,
  x = 0,
  y = 0,
  z = 0,
  scale_ply = 1,
  subdivision_levels = 1,
  recalculate_normals = FALSE,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

filename	Filename and path to the 'ply' file. Can also be a 'txt' file, if it's in the correct 'ply' internally.
x	Default '0'. x-coordinate to offset the model.
y	Default '0'. y-coordinate to offset the model.
z	Default '0'. z-coordinate to offset the model.
scale_ply	Default '1'. Amount to scale the model. Use this to scale the object up or down on all axes, as it is more robust to numerical precision errors than the generic scale option.
subdivision_levels	Default '1'. Number of Loop subdivisions to be applied to the mesh.
recalculate_normals	Default 'FALSE'. Whether to recalculate vertex normals based on the connecting face orientations. This can be used to compute normals for meshes lacking them or to calculate new normals after a displacement map has been applied to the mesh.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .

angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the obj model in the scene.

Examples

```
#See the documentation for `obj_model()`--no example PLY models are included with this package,
#but the process of loading a model is the same (without support for vertex colors).
```

raymesh_model	<i>'raymesh' model</i>
---------------	------------------------

Description

Load an 'raymesh' object, as specified in the 'rayvertex' package.

Usage

```
raymesh_model(
  mesh,
  x = 0,
  y = 0,
  z = 0,
  flip_transmittance = TRUE,
  verbose = FALSE,
  importance_sample_lights = FALSE,
  calculate_consistent_normals = TRUE,
  subdivision_levels = 1,
  displacement_texture = "",
  displacement_intensity = 1,
  displacement_vector = FALSE,
  recalculate_normals = FALSE,
  override_material = NULL,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
```

```

    scale = c(1, 1, 1),
    validate_mesh = TRUE
)

```

Arguments

mesh	A 'raymesh' object. Pulls the vertex, index, texture coordinates, normals, and material information.
x	Default '0'. x-coordinate to offset the model.
y	Default '0'. y-coordinate to offset the model.
z	Default '0'. z-coordinate to offset the model.
flip_transmittance	Default 'TRUE'. Flips '(1-t)' the transmittance values to match the way the colors would be interpreted in a rasterizer (where it specifies the transmitted color). Turn off to specify the attenuation values directly.
verbose	Default 'FALSE'. If 'TRUE', prints information about the mesh to the console.
importance_sample_lights	Default 'TRUE'. Whether to importance sample lights specified in the OBJ material (objects with a non-zero Ke MTL material).
calculate_consistent_normals	Default 'TRUE'. Whether to calculate consistent vertex normals to prevent energy loss at edges.
subdivision_levels	Default '1'. Number of Loop subdivisions to be applied to the mesh.
displacement_texture	Default '""'. File path to the displacement texture. This texture is used to displace the vertices of the mesh based on the texture's pixel values.
displacement_intensity	Default '1'. Intensity of the displacement effect. Higher values result in greater displacement.
displacement_vector	Default 'FALSE'. Whether to use vector displacement. If 'TRUE', the displacement texture is interpreted as providing a 3D displacement vector. Otherwise, the texture is interpreted as providing a scalar displacement.
recalculate_normals	Default 'FALSE'. Whether to recalculate vertex normals based on the connecting face orientations. This can be used to compute normals for meshes lacking them or to calculate new normals after a displacement map has been applied to the mesh.
override_material	Default 'NULL', which overrides the material specified in the 'raymesh' object only when the user passes a value to 'material'. If 'TRUE', overrides the material specified in the 'raymesh' object with the one specified in 'material'.
material	Default <code>diffuse</code> , but ignored unless 'override_material = TRUE'. The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .

angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.
validate_mesh	Default 'TRUE'. Validates the 'raymesh' object using 'rayvertex::validate_mesh()' before parsing to ensure correct parsing. Set to 'FALSE' to speed up scene construction if 'raymesh_model()' is taking a long time (Note: this does not affect rendering time).

Value

Single row of a tibble describing the raymesh model in the scene.

Examples

```
#Render a simple raymesh object
library(rayvertex)
raymesh_model(sphere_mesh(position = c(-1, 0, 0),
  material = material_list(transmittance = "red"))) |>
  add_object(generate_ground(material = diffuse(checkercolor="grey20"))) |>
  render_scene(fov = 30, samples=16, sample_method="sobol_blue")

# We create a complex rayvertex mesh, using the `rayvertex::add_shape` function which
# creates a new `raymesh` object out of individual `raymesh` objects
rm_scene = sphere_mesh(position = c(-1, 0, 0),
  material = material_list(transmittance = "red")) |>
  add_shape(sphere_mesh(position = c(1, 0, 0),
    material = material_list(transmittance = "green", ior = 1.5)))

# Pass the single raymesh object to `raymesh_model()`
# `raymesh_model()`
raymesh_model(rm_scene) |>
  add_object(generate_ground(material = diffuse(checkercolor="grey20"))) |>
  render_scene(fov = 30, samples=16, sample_method="sobol_blue")

# Set `flip_transmittance = FALSE` argument to specify attenuation coefficients directly
# (as specified in the `dielectric()` material). We change the material's numerical attenuation
# constants using `rayvertex::change_material`
rm_scene_new= change_material(rm_scene, transmittance = c(1,2,0.3), id = 1) |>
  change_material(transmittance = c(3,1,2), id = 2)
raymesh_model(rm_scene_new, flip_transmittance = FALSE) |>
  add_object(generate_ground(material = diffuse(checkercolor="grey20"))) |>
  render_scene(fov = 30, samples=16, sample_method="sobol_blue")

# Override the material specified in the `raymesh` object and render the scene
raymesh_model(rm_scene,
```

```

        material = dielectric(attenuation = "dodgerblue2", attenuation_intensity = 4),
        override_material = TRUE) |>
    add_object(generate_ground(material = diffuse(checkercolor="grey20"))) |>
    render_scene(fov = 30, samples=16, sample_method="sobol_blue")

# Adjusting the scale, position, and rotation parameters of the `raymesh` model
raymesh_model(rm_scene,
              x = 0, y = 0.5, z = -1, angle = c(0, 0, 20)) |>
    add_object(generate_ground(material = diffuse(checkercolor="grey20"))) |>
    render_scene(fov = 30,lookat=c(0,0.5,0), samples=16, sample_method="sobol_blue")

```

render_animation	<i>Render Animation</i>
------------------	-------------------------

Description

Takes the scene description and renders an image, either to the device or to a filename.

Usage

```

render_animation(
  scene,
  camera_motion,
  start_frame = 1,
  end_frame = NA,
  width = 400,
  height = 400,
  preview = interactive(),
  denoise = TRUE,
  camera_description_file = NA,
  camera_scale = 1,
  iso = 100,
  film_size = 22,
  samples = 100,
  min_variance = 0,
  min_adaptive_size = 8,
  sample_method = "sobol",
  ambient_occlusion = FALSE,
  keep_colors = FALSE,
  sample_dist = 10,
  max_depth = 50,
  roulette_active_depth = 10,
  ambient_light = FALSE,
  clamp_value = Inf,
  filename = NA,
  backgroundhigh = "#80b4ff",
  backgroundlow = "#ffffff",

```

```

shutteropen = 0,
shutterclose = 1,
focal_distance = NULL,
ortho_dimensions = c(1, 1),
tonemap = "raw",
bloom = TRUE,
parallel = TRUE,
bvh_type = "sah",
environment_light = NULL,
rotate_env = 0,
intensity_env = 1,
debug_channel = "none",
plot_scene = TRUE,
progress = interactive(),
verbose = FALSE,
transparent_background = FALSE,
preview_light_direction = c(0, -1, 0),
preview_exponent = 6,
integrator_type = "rtiow"
)

```

Arguments

scene	Tibble of object locations and properties.
camera_motion	Data frame of camera motion vectors, calculated with <code>'generate_camera_motion()'</code> .
start_frame	Default '1'. Frame to start the animation.
end_frame	Default 'NA'. By default, this is set to <code>'nrow(camera_motion)'</code> , the full number of frames.
width	Default '400'. Width of the render, in pixels.
height	Default '400'. Height of the render, in pixels.
preview	Default <code>'interactive()'</code> . Whether to display a realtime progressive preview of the render. Press ESC to cancel the render.
denoise	Default <code>'TRUE'</code> . Whether to de-noise the final image and preview images. Note, this requires the free Intel Open Image Denoise (OIDN) library be installed on your system. Pre-compiled binaries can be installed from ppenimagedenoise.org , as well as https://github.com/Alexandru-Mihaila/oidn . Linking during rayrender installation is done by defining the environment variable <code>OIDN_PATH</code> (set it in the <code>.Renviron</code> file by calling <code>'usethis::edit_r_environ()'</code>) to the top-level directory for OIDN (the directory containing the "lib", "bin", and "include" directories) and re-installing this package from source.
camera_description_file	Default <code>'NA'</code> . Filename of a camera description file for rendering with a realistic camera. Several camera files are built-in: <code>"50mm"</code> , <code>"wide"</code> , <code>"fisheye"</code> , and <code>"telephoto"</code> .
camera_scale	Default '1'. Amount to scale the camera up or down in size. Use this rather than scaling a scene.

iso	Default '100'. Camera exposure.
film_size	Default '22', in 'mm' (scene units in 'm'. Size of the film if using a realistic camera, otherwise ignored.
samples	Default '100'. The maximum number of samples for each pixel. If this is a length-2 vector and the 'sample_method' is 'stratified', this will control the number of strata in each dimension. The total number of samples in this case will be the product of the two numbers.
min_variance	Default '0'. Minimum acceptable variance for a block of pixels for the adaptive sampler. Smaller numbers give higher quality images, at the expense of longer rendering times. If this is set to zero, the adaptive sampler will be turned off and the renderer will use the maximum number of samples everywhere.
min_adaptive_size	Default '8'. Width of the minimum block size in the adaptive sampler.
sample_method	Default 'sobol'. The type of sampling method used to generate random numbers. The other options are 'random' (worst quality but simple), 'stratified' (only implemented for completion), and 'sobol_blue' (best option for sample counts below 256).
ambient_occlusion	Default 'FALSE'. If 'TRUE', the animation will be rendered with the ambient occlusion renderer. This uses the background color specified in 'background_high'
keep_colors	Default 'FALSE'. Whether to keep the diffuse material colors.
sample_dist	Default '10'. Sample distance if 'debug_channel = "ao"'.
max_depth	Default '50'. Maximum number of bounces a ray can make in a scene.
roulette_active_depth	Default '10'. Number of ray bounces until a ray can stop bouncing via Russian roulette.
ambient_light	Default 'FALSE', unless there are no emitting objects in the scene. If 'TRUE', the background will be a gradient varying from 'backgroundhigh' directly up (+y) to 'backgroundlow' directly down (-y).
clamp_value	Default 'Inf'. If a bright light or a reflective material is in the scene, occasionally there will be bright spots that will not go away even with a large number of samples. These can be removed (at the cost of slightly darkening the image) by setting this to a small number greater than 1.
filename	Default 'NA'. If present, the renderer will write to the filename instead of the current device.
backgroundhigh	Default '#ffffff'. The "high" color in the background gradient. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
backgroundlow	Default '#ffffff'. The "low" color in the background gradient. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
shutteropen	Default '0'. Time at which the shutter is open. Only affects moving objects.
shutterclose	Default '1'. Time at which the shutter is open. Only affects moving objects.

focal_distance	Default 'NULL', automatically set to the 'lookfrom-lookat' distance unless otherwise specified.
ortho_dimensions	Default 'c(1,1)'. Width and height of the orthographic camera. Will only be used if 'fov = 0'.
tonemap	Default 'raw', no tonemapping. See 'rayimage::render_tonemap()' for options.
bloom	Default 'TRUE'. Set to 'FALSE' to get the raw, pathtraced image. Otherwise, this performs a convolution of the HDR image of the scene with a sharp, long-tailed exponential kernel, which does not visibly affect dimly pixels, but does result in emitters light slightly bleeding into adjacent pixels. This provides an antialiasing effect for lights, even when tonemapping the image. Pass in a matrix to specify the convolution kernel manually, or a positive number to control the intensity of the bloom (higher number = more bloom).
parallel	Default 'FALSE'. If 'TRUE', it will use all available cores to render the image (or the number specified in 'options("cores")' if that option is not 'NULL').
bvh_type	Default "sah", "surface area heuristic". Method of building the bounding volume hierarchy structure used when rendering. Other option is "equal", which splits tree into groups of equal size.
environment_light	Default 'NULL'. An image to be used for the background for rays that escape the scene. Supports both HDR ('.hdr') and low-dynamic range ('.png', '.jpg') images.
rotate_env	Default '0'. The number of degrees to rotate the environment map around the scene.
intensity_env	Default '1'. The amount to increase the intensity of the environment lighting. Useful if using a LDR (JPEG or PNG) image as an environment map.
debug_channel	Default 'none'. If 'depth', function will return a depth map of rays into the scene instead of an image. If 'normals', function will return an image of scene normals, mapped from 0 to 1. If 'uv', function will return an image of the uv coords. If 'variance', function will return an image showing the number of samples needed to take for each block to converge. If 'dpdu' or 'dpdv', function will return an image showing the differential 'u' and 'v' coordinates. If 'color', function will return the raw albedo values (with white for 'metal' and 'dielectric' materials). If 'preview', an image rendered with 'render_preview()' will be returned. Can set to 'ao' to render an animation with the ambient occlusion renderer.
plot_scene	Default 'TRUE'. Whether to plot the rendered scene.
progress	Default 'TRUE' if interactive session, 'FALSE' otherwise.
verbose	Default 'FALSE'. Prints information and timing information about scene construction and raytracing progress.
transparent_background	Default 'FALSE'. If 'TRUE', any initial camera rays that escape the scene will be marked as transparent in the final image. If for a pixel some rays escape and others hit a surface, those pixels will be partially transparent.

`preview_light_direction`
 Default 'c(0,-1,0)'. Vector specifying the orientation for the global light using for phong shading.

`preview_exponent`
 Default '6'. Phong exponent.

`integrator_type`
 Default "rtiow" (the algorithm specified in the book "Raytracing in One Weekend", a basic form of path guiding). Other options include "nee" (Next Event Estimation, with direct light sampling) and "basic" (basic pathtracing, for high sample reference renders and debugging only).

Value

Raytraced plot to current device, or an image saved to a file.

Examples

```
#Create and animate flying through a scene on a simulated roller coaster
set.seed(3)
elliplist = list()
ellip_colors = rainbow(8)
for(i in 1:1200) {
  elliplist[[i]] = ellipsoid(x=10*runif(1)-5,y=10*runif(1)-5,z=10*runif(1)-5,
    angle = 360*runif(3), a=0.1,b=0.05,c=0.1,
    material=glossy(color=sample(ellip_colors,1)))
}
ellip_scene = do.call(rbind, elliplist)

camera_pos = list(c(0,1,15),c(5,-5,5),c(-5,5,-5),c(0,1,-15))

#Plot the camera path and render from above using the path object:
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(path(camera_pos, material=diffuse(color="red"))) |>
  render_scene(lookfrom=c(0,20,0), width=800,height=800,samples=32,
    camera_up = c(0,0,1),
    fov=80)

#Side view
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(path(camera_pos, material=diffuse(color="red"))) |>
  render_scene(lookfrom=c(20,0,0),width=800,height=800,samples=32,
    fov=80)

#View from the start
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(path(camera_pos, material=diffuse(color="red"))) |>
  render_scene(lookfrom=c(0,1.5,16),width=800,height=800,samples=32,
    fov=80)
```

```

#Generate Camera movement, setting the lookat position to be same as camera position, but offset
#slightly in front. We'll render 12 frames, but you'd likely want more in a real animation.

camera_motion = generate_camera_motion(positions = camera_pos, lookats = camera_pos,
                                       offset_lookat = 1, fovs=80, frames=12,
                                       type="bezier")

#This returns a data frame of individual camera positions, interpolated by cubic bezier curves.
camera_motion

#Pass NA filename to plot to the device. We'll keep the path and offset it slightly to see
#where we're going. This results in a "roller coaster" effect.
generate_ground(material=diffuse(checkercolor="grey20"),depth=-10) |>
  add_object(ellip_scene) |>
  add_object(sphere(y=50,radius=10,material=light(intensity=30))) |>
  add_object(obj_model(r_obj(),x=10,y=-5,z=10,scale=7, angle=c(45,135,0),
                    material=dielectric(attenuation=c(1,1,0.3)))) |>
  add_object(pig(x=-7,y=10,z=-5,scale=1,angle=c(0,-45,80),emotion="angry")) |>
  add_object(pig(x=0,y=-0.25,z=-15,scale=1,angle=c(0,225,-22), order_rotation = c(3,2,1),
                    emotion="angry", spider=TRUE)) |>
  add_object(path(camera_pos, y=-0.2,material=diffuse(color="red"))) |>
  render_animation(filename = NA, camera_motion = camera_motion, samples=16,
                  sample_method="sobol_blue",
                  clamp_value=10, width=400, height=400)

```

render_ao

Render Ambient Occlusion

Description

Takes the scene description and renders an image using ambient occlusion, either to the device or to a filename.

Usage

```

render_ao(
  scene,
  width = 400,
  height = 400,
  fov = 20,
  sample_dist = 10,
  keep_colors = FALSE,
  samples = 100,
  camera_description_file = NA,
  camera_scale = 1,
  iso = 100,
  film_size = 22,
  min_variance = 0,

```

```

min_adaptive_size = 8,
sample_method = "sobol",
background_color = "white",
lookfrom = c(0, 1, 10),
lookat = c(0, 0, 0),
camera_up = c(0, 1, 0),
aperture = 0.1,
clamp_value = Inf,
filename = NA,
shutteropen = 0,
shutterclose = 1,
focal_distance = NULL,
ortho_dimensions = c(1, 1),
parallel = TRUE,
bvh_type = "sah",
progress = interactive(),
verbose = FALSE
)

```

Arguments

scene	Tibble of object locations and properties.
width	Default '400'. Width of the render, in pixels.
height	Default '400'. Height of the render, in pixels.
fov	Default '20'. Field of view, in degrees. If this is '0', the camera will use an orthographic projection. The size of the plane used to create the orthographic projection is given in argument 'ortho_dimensions'. From '0' to '180', this uses a perspective projections. If this value is '360', a 360 degree environment image will be rendered.
sample_dist	Default '10'. Ambient occlusion sampling distance.
keep_colors	Default 'FALSE'. Whether to keep the diffuse material colors.
samples	Default '100'. The maximum number of samples for each pixel. If this is a length-2 vector and the 'sample_method' is 'stratified', this will control the number of strata in each dimension. The total number of samples in this case will be the product of the two numbers.
camera_description_file	Default 'NA'. Filename of a camera description file for rendering with a realistic camera. Several camera files are built-in: "50mm", "wide", "fisheye", and "telephoto".
camera_scale	Default '1'. Amount to scale the camera up or down in size. Use this rather than scaling a scene.
iso	Default '100'. Camera exposure.
film_size	Default '22', in 'mm' (scene units in 'm'. Size of the film if using a realistic camera, otherwise ignored.

min_variance	Default '0.00005'. Minimum acceptable variance for a block of pixels for the adaptive sampler. Smaller numbers give higher quality images, at the expense of longer rendering times. If this is set to zero, the adaptive sampler will be turned off and the renderer will use the maximum number of samples everywhere.
min_adaptive_size	Default '8'. Width of the minimum block size in the adaptive sampler.
sample_method	Default 'sobol'. The type of sampling method used to generate random numbers. The other options are 'random' (worst quality but fastest), 'stratified' (only implemented for completion), 'sobol_blue' (best option for sample counts below 256), and 'sobol' (slowest but best quality, better than 'sobol_blue' for sample counts greater than 256).
background_color	Default '"white"'. Background color.
lookfrom	Default 'c(0,1,10)'. Location of the camera.
lookat	Default 'c(0,0,0)'. Location where the camera is pointed.
camera_up	Default 'c(0,1,0)'. Vector indicating the "up" position of the camera.
aperture	Default '0.1'. Aperture of the camera. Smaller numbers will increase depth of field, causing less blurring in areas not in focus.
clamp_value	Default 'Inf'. If a bright light or a reflective material is in the scene, occasionally there will be bright spots that will not go away even with a large number of samples. These can be removed (at the cost of slightly darkening the image) by setting this to a small number greater than 1.
filename	Default 'NA'. If present, the renderer will write to the filename instead of the current device.
shutteropen	Default '0'. Time at which the shutter is open. Only affects moving objects.
shutterclose	Default '1'. Time at which the shutter is open. Only affects moving objects.
focal_distance	Default 'NULL', automatically set to the 'lookfrom-lookat' distance unless otherwise specified.
ortho_dimensions	Default 'c(1,1)'. Width and height of the orthographic camera. Will only be used if 'fov = 0'.
parallel	Default 'FALSE'. If 'TRUE', it will use all available cores to render the image (or the number specified in 'options("cores")' if that option is not 'NULL').
bvh_type	Default '"sah"', "surface area heuristic". Method of building the bounding volume hierarchy structure used when rendering. Other option is "equal", which splits tree into groups of equal size.
progress	Default 'TRUE' if interactive session, 'FALSE' otherwise.
verbose	Default 'FALSE'. Prints information and timing information about scene construction and raytracing progress.

Value

Raytraced plot to current device, or an image saved to a file. Invisibly returns the array (containing either debug data or the RGB)

Examples

```

#Generate and render a regular scene and an ambient occlusion version of that scene
angles = seq(0,360,by=36)
xx = rev(c(rep(c(1,0.5),5),1) * sinpi(angles/180))
yy = rev(c(rep(c(1,0.5),5),1) * cospi(angles/180))
star_polygon = data.frame(x=xx,y=yy)
hollow_star = rbind(star_polygon,0.8*star_polygon)

generate_ground(material = diffuse(color="grey20", checkercolor = "grey50",sigma=90)) |>
  add_object(sphere(material=metal())) |>
  add_object(obj_model(r_obj(),y=-0.25,x=-1.8,scale=2,
    angle=c(0,-45,0),material = diffuse(sigma=90))) |>
  add_object(pig(x=1.8,y=-1.2,scale=0.5,angle=c(0,90,0),diffuse_sigma = 90)) |>
  add_object(extruded_polygon(hollow_star,top=-0.5,bottom=-1, z=-2,
    hole = nrow(star_polygon),
    material=diffuse(color="red",sigma=90))) |>
  render_scene(parallel = TRUE,width=800,height=800,
    fov=70,clamp_value=10,samples=16, aperture=0.1,
    lookfrom=c(-0.9,1.2,-4.5),lookat=c(0,-1,0))

#Render the scene with ambient occlusion
generate_ground(material = diffuse(color="grey20", checkercolor = "grey50",sigma=90)) |>
  add_object(sphere(material=metal())) |>
  add_object(obj_model(r_obj(),y=-0.25,x=-1.8,scale=2,
    angle=c(0,-45,0),material = diffuse(sigma=90))) |>
  add_object(pig(x=1.8,y=-1.2,scale=0.5,angle=c(0,90,0),diffuse_sigma = 90)) |>
  add_object(extruded_polygon(hollow_star,top=-0.5,bottom=-1, z=-2,
    hole = nrow(star_polygon),
    material=diffuse(color="red",sigma=90))) |>
  render_ao(parallel = TRUE,width=800,height=800, sample_dist=10,
    fov=70,samples=16, aperture=0.1,
    lookfrom=c(-0.9,1.2,-4.5),lookat=c(0,-1,0))

#Decrease the ray occlusion search distance
generate_ground(material = diffuse(color="grey20", checkercolor = "grey50",sigma=90)) |>
  add_object(sphere(material=metal())) |>
  add_object(obj_model(r_obj(),y=-0.25,x=-1.8,scale=2,
    angle=c(0,-45,0),material = diffuse(sigma=90))) |>
  add_object(pig(x=1.8,y=-1.2,scale=0.5,angle=c(0,90,0),diffuse_sigma = 90)) |>
  add_object(extruded_polygon(hollow_star,top=-0.5,bottom=-1, z=-2,
    hole = nrow(star_polygon),
    material=diffuse(color="red",sigma=90))) |>
  render_ao(parallel = TRUE,width=800,height=800, sample_dist=1,
    fov=70,samples=16, aperture=0.1,
    lookfrom=c(-0.9,1.2,-4.5),lookat=c(0,-1,0))

#Turn on colors
generate_ground(material = diffuse(color="grey20", checkercolor = "grey50",sigma=90)) |>
  add_object(sphere(material=metal())) |>
  add_object(obj_model(r_obj(), y=-0.25,x=-1.8,scale=2,
    angle=c(0,-45,0),material = diffuse(sigma=90))) |>
  add_object(pig(x=1.8,y=-1.2,scale=0.5,angle=c(0,90,0),diffuse_sigma = 90)) |>
  add_object(extruded_polygon(hollow_star,top=-0.5,bottom=-1, z=-2,
    hole = nrow(star_polygon),

```

```

                                material=diffuse(color="red",sigma=90))) |>
render_ao(parallel = TRUE,width=800,height=800, sample_dist=1,
          fov=70,samples=16, aperture=0.1, keep_colors = TRUE,
          lookfrom=c(-0.9,1.2,-4.5),lookat=c(0,-1,0))

```

render_preview	<i>Render Preview</i>
----------------	-----------------------

Description

Takes the scene description and renders an image, either to the device or to a filename.

Usage

```
render_preview(..., light_direction = c(0, -1, 0), exponent = 6)
```

Arguments

...	All arguments that would be passed to 'render_scene()'.
light_direction	Default 'c(0,-1,0)'. Vector specifying the orientation for the global light using for phong shading.
exponent	Default '6'. Phong exponent.

Value

Raytraced plot to current device, or an image saved to a file.

Examples

```

generate_ground(material=diffuse(color="darkgreen")) |>
  add_object(sphere(material=diffuse(checkercolor="red"))) |>
  render_preview()
#Change the light direction
generate_ground(material=diffuse(color="darkgreen")) |>
  add_object(sphere(material=diffuse(checkercolor="red"))) |>
  render_preview(light_direction = c(-1,-1,0))
#Change the Phong exponent
generate_ground(material=diffuse(color="darkgreen")) |>
  add_object(sphere(material=diffuse(checkercolor="red"))) |>
  render_preview(light_direction = c(-1,-1,0), exponent=100)

```

render_scene	<i>Render Scene</i>
--------------	---------------------

Description

Takes the scene description and renders an image, either to the device or to a filename. The user can also interactively fly around the 3D scene if they have X11 support on their system or are on Windows.

Usage

```
render_scene(  
  scene,  
  width = 400,  
  height = 400,  
  fov = 20,  
  samples = 100,  
  camera_description_file = NA,  
  preview = interactive(),  
  interactive = TRUE,  
  deferred_render = FALSE,  
  denoise = TRUE,  
  camera_scale = 1,  
  iso = 100,  
  auto_exposure = FALSE,  
  film_size = 22,  
  min_variance = 0,  
  min_adaptive_size = 8,  
  sample_method = "sobol_blue",  
  max_depth = NA,  
  roulette_active_depth = 100,  
  ambient_light = NULL,  
  lookfrom = c(0, 1, -10),  
  lookat = c(0, 0, 0),  
  camera_up = c(0, 1, 0),  
  aperture = 0.1,  
  clamp_value = Inf,  
  filename = NA,  
  backgroundhigh = "#80b4ff",  
  backgroundlow = "#ffffff",  
  shutteropen = 0,  
  shutterclose = 1,  
  focal_distance = NULL,  
  ortho_dimensions = c(1, 1),  
  tonemap = "raw",  
  bloom = TRUE,  
  parallel = TRUE,
```

```

    bvh_type = "sah",
    environment_light = NULL,
    rotate_env = 0,
    intensity_env = 1,
    transparent_background = FALSE,
    debug_channel = "none",
    plot_scene = TRUE,
    progress = interactive(),
    verbose = FALSE,
    print_debug_info = FALSE,
    new_page = TRUE,
    integrator_type = "rtiow",
    screen_text = NULL,
    screen_line = NULL
)

```

Arguments

scene	Tibble of object locations and properties.
width	Default '400'. Width of the render, in pixels.
height	Default '400'. Height of the render, in pixels.
fov	Default '20'. Field of view, in degrees. If this is '0', the camera will use an orthographic projection. The size of the plane used to create the orthographic projection is given in argument 'ortho_dimensions'. From '0' to '180', this uses a perspective projections. If this value is '360', a 360 degree environment image will be rendered.
samples	Default '100'. The maximum number of samples for each pixel. If this is a length-2 vector and the 'sample_method' is 'stratified', this will control the number of strata in each dimension. The total number of samples in this case will be the product of the two numbers.
camera_description_file	Default 'NA'. Filename of a camera description file for rendering with a realistic camera. Several camera files are built-in: "50mm", "wide", "fisheye", and "telephoto".
preview	Default 'interactive()'. Whether to display a real-time progressive preview of the render. Press ESC to cancel the render. If 'deferred_render = TRUE', the preview stays interactive until the final render is explicitly started.
interactive	Default 'interactive()'. Whether the scene preview should be interactive. Camera movement orbits around the lookat point (unless the mode is switched to free flying), with the following control mapping: W = Forward, S = Backward, A = Left, D = Right, Q = Up, Z = Down, E = 2x Step Distance (max 128), C = 0.5x Step Distance, Up Key = Zoom In (decrease FOV), Down Key = Zoom Out (increase FOV), Left Key = Decrease Aperture, Right Key = Increase Aperture, 1 = Decrease Focal Distance, 2 = Increase Focal Distance, 3/4 = Rotate Environment Light, Right bracket/left bracket = Increase/Decrease Preview Exposure, R = Reset Camera, Return = Toggle between deferred and final render if 'deferred_render = TRUE', TAB: Toggle Orbit Mode, Left Mouse Click: Change

Look Direction, Right Mouse Click: Change Look At K: Save Keyframe (at the conclusion of the render, this will create the 'ray_keyframes' data.frame in the global environment, which can be passed to 'generate_camera_motion()' to tween between those saved positions. L: Reset Camera to Last Keyframe (if set) F: Toggle Fast Travel Mode

Initial step size is 1/20th of the distance from 'lookat' to 'lookfrom'.

Note: Clicking on the environment image will only redirect the view direction, not change the orbit point. Some options aren't available all cameras. When using a realistic camera, the aperture and field of view cannot be changed from their initial settings. Additionally, clicking to direct the camera at the background environment image while using a realistic camera will not always point to the exact position selected.

deferred_render	Default 'FALSE'. If 'TRUE' and interactive preview is enabled, rayrender will keep updating the progressive preview until Return is pressed. Pressing Return toggles the full render in the same window; pressing Return again returns to deferred mode.
denoise	Default 'TRUE'. Whether to de-noise the final image and preview images. Note, this requires the free Intel Open Image Denoise (OIDN) library be installed on your system. Pre-compiled binaries can be installed from ppenimagedenoise.org , as well as https://github.com/Alexandru/oidn . Linking during rayrender installation is done by defining the environment variable OIDN_PATH (set it in the .Renviro file by calling 'usethis::edit_r_enviro()' to the top-level directory for OIDN (the directory containing the "lib", "bin", and "include" directories) and re-installing this package from source.
camera_scale	Default '1'. Amount to scale the camera up or down in size. Use this rather than scaling a scene.
iso	Default '100'. Camera exposure.
auto_exposure	Default 'FALSE'. If 'TRUE', automatically adjust the exposure with 'rayimage::render_exposure(auto = TRUE)'. If 'preview = TRUE', the preview window exposure is calibrated from the 90% luminance quantile of the first rendered frame.
film_size	Default '22', in 'mm' (scene units in 'm'. Size of the film if using a realistic camera, otherwise ignored.
min_variance	Default '0'. Minimum acceptable variance for a block of pixels for the adaptive sampler. Smaller numbers give higher quality images, at the expense of longer rendering times. If this is set to zero, the adaptive sampler will be turned off and the renderer will use the maximum number of samples everywhere.
min_adaptive_size	Default '8'. Width of the minimum block size in the adaptive sampler.
sample_method	Default 'sobol'. The type of sampling method used to generate random numbers. The other options are 'random' (worst quality but fastest), 'stratified' (only implemented for completion), 'sobol_blue' (best option for sample counts below 256), and 'sobol' (slowest but best quality, better than 'sobol_blue' for sample counts greater than 256). If 'samples > 256' and 'sobol_blue' is selected, the method will automatically switch to 'sample_method = "sobol"':

max_depth	Default 'NA', automatically sets to 50. Maximum number of bounces a ray can make in a scene. Alternatively, if a debugging option is chosen, this sets the bounce to query the debugging parameter (only for some options).
roulette_active_depth	Default '100'. Number of ray bounces until a ray can stop bouncing via Russian roulette.
ambient_light	Default 'FALSE', unless there are no emitting objects in the scene. If 'TRUE', the background will be a gradient varying from 'backgroundhigh' directly up (+y) to 'backgroundlow' directly down (-y).
lookfrom	Default 'c(0,1,10)'. Location of the camera.
lookat	Default 'c(0,0,0)'. Location where the camera is pointed.
camera_up	Default 'c(0,1,0)'. Vector indicating the "up" position of the camera.
aperture	Default '0.1'. Aperture of the camera. Smaller numbers will increase depth of field, causing less blurring in areas not in focus.
clamp_value	Default 'Inf'. If a bright light or a reflective material is in the scene, occasionally there will be bright spots that will not go away even with a large number of samples. These can be removed (at the cost of slightly darkening the image) by setting this to a small number greater than 1.
filename	Default 'NULL'. If present, the renderer will write to the filename instead of the current device. Can write to JPEG/JPG, PNG, and high dynamic range EXR images.
backgroundhigh	Default '#80b4ff'. The "high" color in the background gradient. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
backgroundlow	Default '#ffffff'. The "low" color in the background gradient. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between '0' and '1'.
shutteropen	Default '0'. Time at which the shutter is open. Only affects moving objects.
shutterclose	Default '1'. Time at which the shutter is open. Only affects moving objects.
focal_distance	Default 'NULL', automatically set to the 'lookfrom-lookat' distance unless otherwise specified.
ortho_dimensions	Default 'c(1,1)'. Width and height of the orthographic camera. Will only be used if 'fov = 0'.
tonemap	Default 'raw', no tonemapping. Choose the tone mapping function, 'reinhard' scales values by their individual color channels 'color/(1+color)' and then performs the gamma adjustment. 'uncharted' uses the mapping developed for Uncharted 2 by John Hable. 'hbd' uses an optimized formula by Jim Hejl and Richard Burgess-Dawson.
bloom	Default 'TRUE'. Set to 'FALSE' to get the raw, pathtraced image. Otherwise, this performs a convolution of the HDR image of the scene with a sharp, long-tailed exponential kernel, which does not visibly affect dimly pixels, but does result in emitters light slightly bleeding into adjacent pixels. This provides an antialiasing effect for lights, even when tonemapping the image. Pass in a matrix

	to specify the convolution kernel manually, or a positive number to control the intensity of the bloom (higher number = more bloom).
parallel	Default 'TRUE'. If 'FALSE', it will use all available cores to render the image (or the number specified in 'options("cores")' or 'options("Ncpus")' if that option is not 'NULL').
bvh_type	Default "sah", "surface area heuristic". Method of building the bounding volume hierarchy structure used when rendering. Other option is "equal", which splits tree into groups of equal size.
environment_light	Default 'NULL'. An image to be used for the background for rays that escape the scene. Supports both HDR ('.hdr') and low-dynamic range ('.png', '.jpg') images.
rotate_env	Default '0'. The number of degrees to rotate the environment map around the scene.
intensity_env	Default '1'. The amount to increase the intensity of the environment lighting. Useful if using a LDR (JPEG or PNG) image as an environment map.
transparent_background	Default 'FALSE'. If 'TRUE', any initial camera rays that escape the scene will be marked as transparent in the final image. If for a pixel some rays escape and others hit a surface, those pixels will be partially transparent.
debug_channel	Default 'none'. If 'depth', function will return a depth map of rays into the scene instead of an image. If 'normals', function will return an image of scene normals, mapped from 0 to 1. If 'uv', function will return an image of the uv coords. If 'variance', function will return an image showing the number of samples needed to take for each block to converge. If 'dpdu' or 'dpdv', function will return an image showing the differential 'u' and 'v' coordinates. If 'color', function will return the raw albedo values (with white for 'metal' and 'dielectric' materials).
plot_scene	Default 'TRUE'. Whether to plot the rendered scene.
progress	Default 'interactive()' if interactive session, 'FALSE' otherwise.
verbose	Default 'FALSE'. Prints information and timing information about scene construction and raytracing progress.
print_debug_info	Default 'FALSE'. This will print out additional information on the compilation environment with each render.
new_page	Default 'TRUE'. Whether to call 'grid::grid.newpage()' when plotting the image (if no filename specified). Set to 'FALSE' for faster plotting (does not affect render time).
integrator_type	Default "rtiow" (the algorithm specified in the book "Raytracing in One Weekend", a basic form of path guiding). Other options include "nee" (Next Event Estimation, with direct light sampling) and "basic" (basic pathtracing, for high sample reference renders and debugging only).
screen_text	Default 'NULL'. Optional screen-space text overlay created with 'screen_text()', or a list of 'screen_text()' outputs to draw in order.

`screen_line` Default 'NULL'. Optional screen-space line overlay created with `'screen_line()'`, or a list of `'screen_line()'` outputs to draw in order. Labels are anchored to 3D world-space points, projected through the current camera, and drawn after rendering so text size and justification are independent of scene scale and view distance.

Value

A pathtraced image to the current device, or an image saved to a file. Invisibly returns the array (containing either debug data or the RGB).

Examples

```
# Generate a large checkered sphere as the ground
scene = generate_ground(depth = -0.5,
  material = diffuse(color = "white", checkercolor = "darkgreen"))
render_scene(scene, parallel = TRUE, samples = 16, sample_method = "sobol")
# Add a sphere to the center
scene = scene |>
  add_object(sphere(x = 0, y = 0, z = 0, radius = 0.5, material = diffuse(color = c(1, 0, 1))))
render_scene(scene, fov = 20, parallel = TRUE, samples = 16)
# Add a marbled cube
scene = scene |>
  add_object(cube(x = 1.1, y = 0, z = 0, material = diffuse(noise = 3)))
render_scene(scene, fov = 20, parallel = TRUE, samples = 16)
# Add a metallic gold sphere, using stratified sampling for a higher quality render
# We also add a light, which turns off the default ambient lighting
scene = scene |>
  add_object(sphere(x = -1.1, y = 0, z = 0, radius = 0.5,
    material = metal(color = "gold", fuzz = 0.1))) |>
  add_object(sphere(y=10,z=-13,radius=2,material=light(intensity=40)))
render_scene(scene, fov = 20, parallel = TRUE, samples = 16)
# Lower the number of samples to render more quickly (here, we also use only one core).
render_scene(scene, samples = 4, parallel = FALSE)
# Add a floating R plot using the iris dataset as a png onto a floating 2D rectangle
tempfileplot = tempfile()
png(filename = tempfileplot, height = 400, width = 800)
plot(iris$Petal.Length, iris$Sepal.Width, col = iris$Species, pch = 18, cex = 4)
dev.off()
image_array = aperm(png::readPNG(tempfileplot), c(2, 1, 3))
scene = scene |>
  add_object(xy_rect(x = 0, y = 1.1, z = 0, xwidth = 2, angle = c(0, 0, 0),
    flipped = TRUE,
    material = diffuse(image_texture = image_array)))
render_scene(scene, fov = 20, parallel = TRUE, samples = 16)
# Move the camera
render_scene(scene, lookfrom = c(7, 1.5, 10), lookat = c(0, 0.5, 0), fov = 15, parallel = TRUE)
# Change the background gradient to a firey sky
render_scene(scene, lookfrom = c(7, 1.5, 10), lookat = c(0, 0.5, 0), fov = 15,
  backgroundhigh = "orange", backgroundlow = "red", parallel = TRUE,
  ambient = TRUE,
  samples = 16)
```

```

# Increase the aperture to blur objects that are further from the focal plane.
render_scene(scene, lookfrom = c(7, 1.5, 10), lookat = c(0, 0.5, 0), fov = 15,
             aperture = 1, parallel = TRUE, samples = 16)
# We can also capture a 360 environment image by setting `fov = 360` (can be used for VR).
# The left edge of the image is directly where the camera is pointing--we point the image
# backwards so the full cornell box is in the "center" of the environment map.
generate_cornell() |>
  add_object(ellipsoid(x = 555 / 2, y = 100, z = 555 / 2, a = 50, b = 100, c = 50,
                    material = metal(color = "lightblue"))) |>
  add_object(cube(x = 100, y = 130 / 2, z = 200, xwidth = 130, ywidth = 130, zwidth = 130,
                material = diffuse(checkerperiod = "purple",
                                checkerperiod = 30), angle = c(0, 10, 0))) |>
  add_object(pig(x = 100, y = 190, z = 200, scale = 40, angle = c(0, 30, 0))) |>
  add_object(sphere(x = 420, y = 555 / 8, z = 100, radius = 555 / 8,
                  material = dielectric(color = "orange"))) |>
  add_object(xz_rect(x = 555 / 2, z = 555 / 2, y = 1, xwidth = 555, zwidth = 555,
                   material = glossy(checkerperiod = "white",
                                    checkerperiod = 10, color = "dodgerblue"))) |>
  render_scene(lookfrom = c(278, 278, -10), lookat = c(278, 278, -300), clamp_value = 100,
             fov = 360, samples = 16, width = 800, height = 800)
# Spin the camera around the scene, decreasing the number of samples to render faster. To make
# an animation, specify the a filename in `render_scene` for each frame and use the `av` package
# or ffmpeg to combine them all into a movie.
t = 1:9
xpos = 10 * sin(t * 18 * pi / 180 + pi / 2)
zpos = 10 * cos(t * 18 * pi / 180 + pi / 2)
image_output = list()
for (i in 1:9) {
  image_output[[i]] = render_scene(scene, samples = 16, plot_scene = FALSE,
                                lookfrom = c(xpos[i], 1.5, zpos[i]), lookat = c(0, 0.5, 0), parallel = TRUE)
}
rayimage::plot_image_grid(image_output, dim = c(3,3) )

```

r_obj

R 3D Model

Description

3D obj model of R logo (created from the R SVG logo with the ‘raybevel’ package), to be used with ‘obj_model()’

Usage

```
r_obj(simple_r = FALSE)
```

Arguments

simple_r Default ‘FALSE’. If ‘TRUE’, this will return a 3D R (instead of the R logo).

Value

File location of the 3d_r_logo.obj file (saved with a .txt extension)

Examples

```
#Load and render the included example R object file.
generate_ground(material = diffuse(noise = TRUE, noisecolor = "grey20")) |>
  add_object(sphere(x = 2, y = 3, z = -2, radius = 1,
                  material = light(intensity = 10))) |>
  add_object(obj_model(r_obj(), scale=2.5, angle = c(0,0,0), material = diffuse(color="red"))) |>
  render_scene(parallel=TRUE, lookfrom = c(0, 1, -10), clamp_value = 5, samples = 200)
```

screen_line

Screen-space Lines

Description

Creates line annotations for 'render_scene()' that are anchored to 3D world-space endpoints but drawn in 2D screen space after rendering.

Usage

```
screen_line(
  x = 0,
  y = 0,
  z = 0,
  xend = 0,
  yend = 0,
  zend = 0,
  start = NULL,
  end = NULL,
  offset = c(0, 0),
  end_offset = offset,
  width = 2,
  color = "black",
  alpha = 1,
  lineend = "round",
  clip = TRUE,
  occlusion = FALSE,
  occlusion_mode = "anchor",
  occlusion_tolerance = 0.001
)
```

Arguments

x, y, z	Default '0'. World-space coordinates of the line start point.
xend, yend, zend	Default '0'. World-space coordinates of the line end point.
start, end	Default 'NULL'. Optional 3-column matrix/data frame of world-space start and end points. If supplied, overrides 'x', 'y', 'z' and 'xend', 'yend', 'zend'.
offset	Default 'c(0,0)'. Pixel offset for the start point, as 'c(x,y)', with positive y moving down the image.
end_offset	Default 'offset'. Pixel offset for the end point.
width	Default '2'. Line width in pixels.
color	Default '"black"'. Line color.
alpha	Default '1'. Line alpha.
lineend	Default '"round"'. Line end style. Options are '"round"', '"butt"', and '"square"'.
clip	Default 'TRUE'. If 'TRUE', lines whose endpoints are both behind the camera are skipped.
occlusion	Default 'FALSE'. If 'TRUE', use scene geometry to hide the line.
occlusion_mode	Default '"anchor"'. If '"anchor"', occlusion skips the entire line when its mid-point is blocked. If '"line"' or '"partial"', each line pixel is hidden only when the scene depth at that pixel is closer than the interpolated screen-space line depth.
occlusion_tolerance	Default '0.001'. Endpoint tolerance for occlusion.

Value

A data frame describing screen-space line annotations.

Examples

```
# Build the scene first, then add independent screen-space line layers.
scene = generate_cornell(lightwidth = 250, lightdepth = 250) |>
  add_object(sphere(
    x = 180, y = 90, z = 260, radius = 90,
    material = diffuse(color = "#f2c14e")
  )) |>
  add_object(cube(
    x = 385, y = 90, z = 330, xwidth = 120, ywidth = 180, zwidth = 120,
    angle = c(0, 25, 0), material = diffuse(color = "#243846")
  ))

# A round-ended measurement across the sphere uses matrix start/end points.
sphere_measure = screen_line(
  start = matrix(c(90, 6, 260), ncol = 3),
  end = matrix(c(270, 6, 260), ncol = 3),
  offset = c(0, 0),
  end_offset = c(0, 0),
  width = 5,
  color = "#f2c14e",
```

```
alpha = 1,
lineend = "round",
clip = TRUE,
occlusion = FALSE,
occlusion_mode = "anchor",
occlusion_tolerance = 0.001
)

# A vertical guide on the rotated box exercises line-level occlusion.
box_measure = screen_line(
  start = matrix(c(385, 0, 330), ncol = 3),
  end = matrix(c(385, 180, 330), ncol = 3),
  offset = c(-12, 0),
  end_offset = c(-12, 0),
  width = 7,
  color = "#4d9de0",
  alpha = 0.8,
  lineend = "butt",
  clip = TRUE,
  occlusion = TRUE,
  occlusion_mode = "line",
  occlusion_tolerance = 0.004
)

# A back-wall rule uses square caps, no clipping, and the "partial" alias.
wall_rule = screen_line(
  start = matrix(c(85, 18, 545), ncol = 3),
  end = matrix(c(505, 18, 545), ncol = 3),
  offset = c(0, -8),
  end_offset = c(0, -8),
  width = 4,
  color = "white",
  alpha = 0.6,
  lineend = "square",
  clip = FALSE,
  occlusion = TRUE,
  occlusion_mode = "partial",
  occlusion_tolerance = 0.01
)

# Scalar coordinates work too, which is handy for one-off callout lines.
callout_line = screen_line(
  x = 180, y = 190, z = 260,
  xend = 245, yend = 255, zend = 230,
  offset = c(0, -4),
  end_offset = c(30, -24),
  width = 3,
  color = "black",
  alpha = 0.9,
  lineend = "round",
  clip = TRUE,
  occlusion = TRUE,
  occlusion_mode = "anchor",
```

```

    occlusion_tolerance = 0.002
  )

  # Build a 3D spiral from many short screen-space line segments.
  spiral_theta = seq(0, 5 * pi, length.out = 120)
  spiral_radius = seq(6, 65, length.out = length(spiral_theta))
  spiral_points = cbind(
    445 + spiral_radius * cos(spiral_theta),
    390 + spiral_radius * sin(spiral_theta),
    seq(245, 390, length.out = length(spiral_theta))
  )
  spiral_count = nrow(spiral_points) - 1
  spiral_lines = screen_line(
    start = spiral_points[-nrow(spiral_points), ],
    end = spiral_points[-1, ],
    width = seq(1, 4, length.out = spiral_count),
    color = grDevices::hcl(seq(250, 360, length.out = spiral_count), 80, 65),
    alpha = seq(0.35, 0.95, length.out = spiral_count),
    lineend = "round",
    clip = TRUE
  )

  line_layers = list(
    sphere_measure,
    box_measure,
    wall_rule,
    callout_line,
    spiral_lines
  )

  render_scene(
    scene,
    samples = 32,
    clamp_value = 5,
    aperture = 0,
    ambient_light = FALSE,
    screen_line = line_layers
  )

```

screen_text

Screen-space Text

Description

Creates text annotations for ‘render_scene()’ that are anchored to 3D world-space points but drawn in 2D screen space after rendering.

Usage

```

screen_text(
  label,
  x = 0,
  y = 0,
  z = 0,
  point = NULL,
  offset = c(0, 0),
  hjust = 0,
  vjust = 0.5,
  size = 16,
  color = "black",
  font = "sans",
  lineheight = 1,
  background_color = "white",
  background_alpha = 0,
  just = "left",
  clip = TRUE,
  halo_color = NA,
  halo_expand = 0,
  halo_alpha = 1,
  halo_offset = c(0, 0),
  halo_blur = 0,
  halo_edge_softness = 0.1,
  halo_gap_fill = 2,
  halo_gap_fill_alpha_threshold = 0.25,
  occlusion = FALSE,
  occlusion_mode = "anchor",
  occlusion_tolerance = 0.001
)

```

Arguments

label	Character vector of labels.
x	Default '0'. World-space x-coordinate of the anchor point.
y	Default '0'. World-space y-coordinate of the anchor point.
z	Default '0'. World-space z-coordinate of the anchor point.
point	Default 'NULL'. Optional 3-column matrix/data frame of world-space anchor points. If supplied, overrides 'x', 'y', and 'z'.
offset	Default 'c(0,0)'. Pixel offset from the projected anchor point, as 'c(x,y)', with positive y moving down the image.
hjust	Default '0'. Horizontal text adjustment, where '0' places the left edge at the anchor, '0.5' centers the label, and '1' right-aligns it.
vjust	Default '0.5'. Vertical text adjustment, where '0' places the top edge at the anchor, '0.5' centers the label, and '1' bottom-aligns it.
size	Default '16'. Text size in pixels.

color	Default "black". Text color.
font	Default "sans". Font family.
lineheight	Default '1'. Line height passed to 'rayimage::render_text_image()'.
background_color	Default "white". Background color passed to 'rayimage::render_text_image()'.
background_alpha	Default '0'. Background alpha passed to 'rayimage::render_text_image()'.
just	Default "left". Text justification passed to 'rayimage::render_text_image()'.
clip	Default 'TRUE'. If 'TRUE', labels whose anchor point projects outside the image are skipped.
halo_color	Default 'NA', no halo. If a color is specified, the text label will be surrounded by a halo of this color.
halo_expand	Default '0'. Number of pixels to expand the halo.
halo_alpha	Default '1'. Transparency of the halo.
halo_offset	Default 'c(0,0)'. Pixel offset to apply to the halo, as 'c(x,y)', with positive y moving down the image.
halo_blur	Default '0'. Amount of blur to apply to the halo.
halo_edge_softness	Default '0.1'. Width of the softened halo edge transition, in pixels.
halo_gap_fill	Default '2'. Maximum alpha gap width, in pixels, to bridge in the halo outline.
halo_gap_fill_alpha_threshold	Default '0.25'. Alpha threshold used to protect enclosed interior halo gaps from 'halo_gap_fill'.
occlusion	Default 'FALSE'. If 'TRUE', trace a ray from the camera to the anchor point and skip the label when another scene object blocks it.
occlusion_mode	Default "anchor". If "anchor", occlusion skips the entire label when the anchor point is blocked. If "label" or "partial", the label and halo are treated as a screen-space banner at the anchor depth and each text pixel is hidden only when the scene depth at that pixel is closer.
occlusion_tolerance	Default '0.001'. Endpoint tolerance for the occlusion ray. Values below '1' are treated as a fraction of the camera-to-anchor distance, which helps avoid self-occlusion when the anchor lies on a surface. Values of '1' or greater are treated as scene-unit distances.

Value

A data frame describing screen-space text annotations.

Examples

```
# Start with a Cornell box that has one bright object and one dark object.
scene = generate_cornell(lightwidth = 250, lightdepth = 250) |>
  add_object(sphere(
```

```

    x = 180, y = 90, z = 260, radius = 90,
    material = diffuse(color = "#f2c14e")
)) |>
add_object(cube(
  x = 385, y = 90, z = 330, xwidth = 120, ywidth = 180, zwidth = 120,
  angle = c(0, 25, 0), material = diffuse(color = "#243846")
))

# Labels can be built in separate calls and passed as a list to render_scene().
sphere_label = screen_text(
  label = "matte sphere\nanchor test",
  x = 180, y = 190, z = 260,
  offset = c(18, -28),
  hjust = 0.5,
  vjust = 1,
  size = 18,
  color = "black",
  lineheight = 0.95,
  background_alpha = 0,
  just = "left",
  halo_color = "#f2c14e",
  halo_expand = 4,
  halo_alpha = 0.8,
  halo_offset = c(1, 1),
  halo_blur = 0.5,
  halo_edge_softness = 0.5,
  halo_gap_fill = 1,
  halo_gap_fill_alpha_threshold = 0.2,
  occlusion = TRUE,
  occlusion_mode = "anchor",
  occlusion_tolerance = 0.002
)

# Dark text over a dark object remains legible with a subtle white halo.
box_label = screen_text(
  label = "dark text\nwhite halo",
  x = 385, y = 195, z = 20,
  offset = c(-16, -34),
  hjust = 0.5,
  vjust = 1,
  size = 16,
  color = "#111111",
  lineheight = 1.05,
  background_alpha = 0,
  just = "right",
  halo_color = "white",
  halo_expand = 6,
  halo_alpha = 0.72,
  halo_offset = c(-1, 2),
  halo_blur = 1.5,
  halo_edge_softness = 10,
  halo_gap_fill = 3,
  halo_gap_fill_alpha_threshold = 0.35,

```

```

    occlusion = TRUE,
    occlusion_mode = "label",
    occlusion_tolerance = 0.01
)

# A floor label shows multi-line text, custom justification, and partial occlusion.
floor_label = screen_text(
  label = "floor label\n\nnocclusion",
  point = matrix(c(280, 0, 50), ncol = 3),
  offset = c(0, 18),
  hjust = 0.5,
  vjust = 0.7,
  size = 15,
  color = "#222222",
  lineheight = 1,
  background_color = "#fff7cc",
  background_alpha = 0.65,
  just = "center",
  clip = FALSE,
  halo_color = "white",
  halo_expand = 3,
  halo_alpha = 0.7,
  halo_blur = 0,
  halo_edge_softness = 0.25,
  halo_gap_fill = 2,
  halo_gap_fill_alpha_threshold = 0.25,
  occlusion = TRUE,
  occlusion_mode = "partial",
  occlusion_tolerance = 0.005
)

# Later list entries draw after earlier entries.
wall_label = screen_text(
  label = "back wall\nalways in front",
  x = 278, y = 330, z = 545,
  offset = c(0, -20),
  hjust = 0.5,
  vjust = 1,
  size = 12,
  color = "white",
  background_color = "black",
  background_alpha = 0.35,
  halo_color = "black",
  halo_expand = 2,
  clip = TRUE
)

text_layers = list(sphere_label, box_label, floor_label, wall_label)

render_scene(
  scene,
  samples = 32,
  clamp_value = 5,

```

```

    aperture = 0,
    fov = 50,
    ambient_light = FALSE,
    screen_text = text_layers
)

```

segment

Segment Object

Description

Similar to the cylinder object, but specified by start and end points.

Usage

```

segment(
  start = c(0, -1, 0),
  end = c(0, 1, 0),
  radius = 0.1,
  phi_min = 0,
  phi_max = 360,
  from_center = TRUE,
  direction = NA,
  material = diffuse(),
  capped = TRUE,
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

start	Default 'c(0, -1, 0)'. Start point of the cylinder segment, specifying 'x', 'y', 'z'.
end	Default 'c(0, 1, 0)'. End point of the cylinder segment, specifying 'x', 'y', 'z'.
radius	Default '1'. Radius of the segment.
phi_min	Default '0'. Minimum angle around the segment.
phi_max	Default '360'. Maximum angle around the segment.
from_center	Default 'TRUE'. If orientation specified via 'direction', setting this argument to 'FALSE' will make 'start' specify the bottom of the segment, instead of the middle.
direction	Default 'NA'. Alternative to 'start' and 'end', specify the direction (via a length-3 vector) of the segment. Segment will be centered at 'start', and the length will be determined by the magnitude of the direction vector.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .

capped	Default 'TRUE'. Whether to add caps to the segment. Turned off when using the 'light()' material.
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Notes: this will change the stated start/end position of the segment. Emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the segment in the scene.

Examples

```
#Generate a segment in the cornell box.
generate_cornell() |>
  add_object(segment(start = c(100, 100, 100), end = c(455, 455, 455), radius = 50)) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
    ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

# Draw a line graph representing a normal distribution, but with metal:
xvals = seq(-3, 3, length.out = 30)
yvals = dnorm(xvals)

scene_list = list()
for(i in 1:(length(xvals) - 1)) {
  scene_list[[i]] = segment(start = c(555/2 + xvals[i] * 80, yvals[i] * 800, 555/2),
    end = c(555/2 + xvals[i + 1] * 80, yvals[i + 1] * 800, 555/2),
    radius = 10,
    material = metal())
}
scene_segments = do.call(rbind,scene_list)
generate_cornell() |>
  add_object(scene_segments) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
    ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

#Draw the outline of a cube:

cube_outline = segment(start = c(100, 100, 100), end = c(100, 100, 455), radius = 10) |>
  add_object(segment(start = c(100, 100, 100), end = c(100, 455, 100), radius = 10)) |>
  add_object(segment(start = c(100, 100, 100), end = c(455, 100, 100), radius = 10)) |>
  add_object(segment(start = c(100, 100, 455), end = c(100, 455, 455), radius = 10)) |>
  add_object(segment(start = c(100, 100, 455), end = c(455, 100, 455), radius = 10)) |>
  add_object(segment(start = c(100, 455, 455), end = c(100, 455, 100), radius = 10)) |>
  add_object(segment(start = c(100, 455, 455), end = c(455, 455, 455), radius = 10)) |>
  add_object(segment(start = c(455, 455, 100), end = c(455, 100, 100), radius = 10)) |>
  add_object(segment(start = c(455, 455, 100), end = c(455, 455, 455), radius = 10)) |>
  add_object(segment(start = c(455, 100, 100), end = c(455, 100, 455), radius = 10)) |>
  add_object(segment(start = c(455, 100, 455), end = c(455, 455, 455), radius = 10)) |>
  add_object(segment(start = c(100, 455, 100), end = c(455, 455, 100), radius = 10))
```

```
generate_cornell() |>
  add_object(cube_outline) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

#Shrink and rotate the cube
generate_cornell() |>
  add_object(group_objects(cube_outline, pivot_point = c(555/2, 555/2, 555/2),
                        angle = c(45,45,45), scale = c(0.5,0.5,0.5))) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

set_scene_material *Set Material for All Objects*

Description

Set Material for All Objects

Usage

```
set_scene_material(scene, material)
```

Arguments

scene	A ray_scene object.
material	A material specification created by diffuse(), metal(), dielectric(), etc.

Value

A modified ray_scene with the new material applied to all objects

Examples

```
# Create a scene with different materials
scene = generate_cornell() |>
  add_object(sphere(x=555/2, y=555/2, z=555/2, radius=100))

# Set all objects to be metallic
scene = set_scene_material(scene, metal(color="gold"))

# Set all objects to be glass
scene = set_scene_material(scene, dielectric())
```

 sphere

Sphere Object

Description

Sphere Object

Usage

```
sphere(
  x = 0,
  y = 0,
  z = 0,
  radius = 1,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

x	Default '0'. x-coordinate of the center of the sphere.
y	Default '0'. y-coordinate of the center of the sphere.
z	Default '0'. z-coordinate of the center of the sphere.
radius	Default '1'. Radius of the sphere.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the sphere in the scene.

Examples

```
#Generate a sphere in the cornell box.
generate_cornell() |>
  add_object(sphere(x = 555/2, y = 555/2, z = 555/2, radius = 100)) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, clamp_value = 5)

#Generate a gold sphere in the cornell box
generate_cornell() |>
  add_object(sphere(x = 555/2, y = 100, z = 555/2, radius = 100,
                  material = microfacet(color = "gold"))) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, clamp_value = 5)
```

text3d

Text Object

Description

Text Object

Usage

```
text3d(
  label,
  x = 0,
  y = 0,
  z = 0,
  text_height = 1,
  orientation = "xy",
  material = diffuse(),
  font = "sans",
  font_style = "plain",
  font_color = "black",
  font_lineheight = 1,
  font_size = 100,
  background_color = "white",
  background_alpha = 0,
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

label	Text string.
x	Default '0'. x-coordinate of the center of the label.
y	Default '0'. y-coordinate of the center of the label.
z	Default '0'. z-coordinate of the center of the label.
text_height	Default '1'. Height of the text.
orientation	Default 'xy'. Orientation of the plane. Other options are 'yz' and 'xz'.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
font	Default "sans". A character string specifying the font family (e.g., "Arial", "Times", "Helvetica").
font_style	A character string specifying the font style, such as "plain", "italic", or "bold". Default is "plain".
font_color	Default "black". The font color.
font_lineheight	Default '12'. The lineheight for strings with newlines.
font_size	Default '100'. The size of the font. Note that this does not control the size of the text, just the resolution as rendered in the texture.
background_color	Default "white". The background color.
background_alpha	Default '0'. The background opacity. '1' is fully opaque.
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the text in the scene.

Examples

```
#Generate a label in the cornell box.
generate_cornell() |>
  add_object(text3d(label="Cornell Box", x=555/2,y=555/2,z=555/2,text_height=60,
                    material=diffuse(color="grey10"), angle=c(0,0,0))) |>
  render_scene(samples=16)
#Change the orientation
generate_cornell() |>
```

```

add_object(text3d(label="YZ Plane", x=550,y=555/2,z=555/2,text_height=200,
  orientation = "yz",
  material=diffuse(color="grey10"), angle=c(0,0,0))) |>
add_object(text3d(label="XY Plane", z=550,y=555/2,x=555/2,text_height=200,
  orientation = "xy",
  material=diffuse(color="grey10"), angle=c(0,0,0))) |>
add_object(text3d(label="XZ Plane", z=555/2,y=5,x=555/2,text_height=200,
  orientation = "xz",
  material=diffuse(color="grey10"))) |>
  render_scene(samples=16)
#Add an label in front of a sphere
generate_cornell() |>
  add_object(text3d(label="Cornell Box", x=555/2,y=555/2,z=555/2,text_height=90,
    material=diffuse(color="grey10"), angle=c(0,0,0))) |>
  add_object(text3d(label="Sphere", x=555/2,y=100,z=100,text_height=60,
    material=diffuse(color="white"), angle=c(0,0,0))) |>
  add_object(sphere(y=100,radius=100,z=555/2,x=555/2,
    material=glossy(color="purple"))) |>
  add_object(sphere(y=555,radius=100,z=-1000,x=555/2,
    material=light(intensity=100,
      spotlight_focus=c(555/2,100,100)))) |>
  render_scene(samples=16)

#A room full of bees
bee_list = list()
for(i in 1:100) {
  bee_list[[i]] = text3d("B", x=20+runif(1)*525, y=20+runif(1)*525, z=20+runif(1)*525,
    text_height = 50, angle=c(0,0,0))
}
bees = do.call(rbind,bee_list)
generate_cornell() |>
  add_object(bees) |>
  render_scene(samples=16)
# If you have ragg installed, you can also use color emojis.
library(rayrender)
generate_cornell(light_position = c(555/2,554,10),
  lightwidth = 10, lightdepth = 100,
  lightintensity = 800) |>
  add_object(text3d(label="\U1F30A",font_size = 500,angle=c(0,0,0),
    x=555/2,y=555/2,z=260,text_height=1000)) |>
  add_object(text3d(label="\U1F6A3", x=180,y=140,z=260-50,
    text_height=400, font_size = 500,
    material=diffuse(color="black"),
    angle=c(0,0,30))) |>
  add_object(text3d(label="\U1F5FB", x=180,y=230,z=260+50,text_height=300,
    font_size = 500,material=diffuse(color="black"),
    angle=c(0,0,0))) |>
  render_scene(samples=16)

```

triangle

*Triangle Object***Description**

Triangle Object

Usage

```
triangle(
  v1 = c(1, 0, 0),
  v2 = c(0, 1, 0),
  v3 = c(-1, 0, 0),
  n1 = rep(NA, 3),
  n2 = rep(NA, 3),
  n3 = rep(NA, 3),
  color1 = rep(NA, 3),
  color2 = rep(NA, 3),
  color3 = rep(NA, 3),
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  reversed = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

v1	Default 'c(1, 0, 0)'. Length-3 vector indicating the x, y, and z coordinate of the first triangle vertex.
v2	Default 'c(0, 1, 0)'. Length-3 vector indicating the x, y, and z coordinate of the second triangle vertex.
v3	Default 'c(-1, 0, 0)'. Length-3 vector indicating the x, y, and z coordinate of the third triangle vertex.
n1	Default 'NA'. Length-3 vector indicating the normal vector associated with the first triangle vertex.
n2	Default 'NA'. Length-3 vector indicating the normal vector associated with the second triangle vertex.
n3	Default 'NA'. Length-3 vector indicating the normal vector associated with the third triangle vertex.
color1	Default 'NA'. Length-3 vector or string indicating the color associated with the first triangle vertex. If NA but other vertices specified, color inherits from material.

color2	Default 'NA'. Length-3 vector or string indicating the color associated with the second triangle vertex. If NA but other vertices specified, color inherits from material.
color3	Default 'NA'. Length-3 vector or string indicating the color associated with the third triangle vertex. If NA but other vertices specified, color inherits from material.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
reversed	Default 'FALSE'. Similar to the 'flipped' argument, but this reverses the handedness of the triangle so it will be oriented in the opposite direction.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the XZ plane in the scene.

Examples

```
#Generate a triangle in the Cornell box.
generate_cornell() |>
  add_object(triangle(v1 = c(100, 100, 100), v2 = c(555/2, 455, 455), v3 = c(455, 100, 100),
                    material = diffuse(color = "purple"))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
#Pass individual colors to each vertex:
generate_cornell() |>
  add_object(triangle(v1 = c(100, 100, 100), v2 = c(555/2, 455, 455), v3 = c(455, 100, 100),
                    color1 = "green", color2 = "yellow", color3 = "red")) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

xy_rect

Rectangular XY Plane Object

Description

Rectangular XY Plane Object

Usage

```
xy_rect(
  x = 0,
  y = 0,
  z = 0,
  xwidth = 1,
  ywidth = 1,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

<code>x</code>	Default '0'. x-coordinate of the center of the rectangle.
<code>y</code>	Default '0'. x-coordinate of the center of the rectangle.
<code>z</code>	Default '0'. z-coordinate of the center of the rectangle.
<code>xwidth</code>	Default '1'. x-width of the rectangle.
<code>ywidth</code>	Default '1'. y-width of the rectangle.
<code>material</code>	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
<code>angle</code>	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
<code>order_rotation</code>	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
<code>flipped</code>	Default 'FALSE'. Whether to flip the normals.
<code>scale</code>	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the XY plane in the scene.

Examples

```
#Generate a purple rectangle in the cornell box.
generate_cornell() |>
  add_object(xy_rect(x = 555/2, y = 100, z = 555/2, xwidth = 200, ywidth = 200,
    material = diffuse(color = "purple"))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
    ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

#Generate a gold plane in the cornell box
generate_cornell() |>
```

```

add_object(xy_rect(x = 555/2, y = 100, z = 555/2,
                  xwidth = 200, ywidth = 200, angle = c(0, 30, 0),
                  material = metal(color = "gold"))) |>
render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
             ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

```

xz_rect

*Rectangular XZ Plane Object***Description**

Rectangular XZ Plane Object

Usage

```

xz_rect(
  x = 0,
  xwidth = 1,
  z = 0,
  zwidth = 1,
  y = 0,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

x	Default '0'. x-coordinate of the center of the rectangle.
xwidth	Default '1'. x-width of the rectangle.
z	Default '0'. z-coordinate of the center of the rectangle.
zwidth	Default '1'. z-width of the rectangle.
y	Default '0'. y-coordinate of the center of the rectangle.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the XZ plane in the scene.

Examples

```
#Generate a purple rectangle in the cornell box.
generate_cornell() |>
  add_object(xz_rect(x = 555/2, y = 100, z = 555/2, xwidth = 200, zwidth = 200,
                    material = diffuse(color = "purple"))) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)

#Generate a gold plane in the cornell box
generate_cornell() |>
  add_object(xz_rect(x = 555/2, y = 100, z = 555/2,
                    xwidth = 200, zwidth = 200, angle = c(0, 30, 0),
                    material = metal(color = "gold"))) |>
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

yz_rect

Rectangular YZ Plane Object

Description

Rectangular YZ Plane Object

Usage

```
yz_rect(
  x = 0,
  y = 0,
  z = 0,
  ywidth = 1,
  zwidth = 1,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  flipped = FALSE,
  scale = c(1, 1, 1)
)
```

Arguments

x	Default '0'. x-coordinate of the center of the rectangle.
y	Default '0'. y-coordinate of the center of the rectangle.
z	Default '0'. z-coordinate of the center of the rectangle.

ywidth	Default '1'. y-width of the rectangle.
zwidth	Default '1'. z-width of the rectangle.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
angle	Default 'c(0, 0, 0)'. Angle of rotation around the x, y, and z axes, applied in the order specified in 'order_rotation'.
order_rotation	Default 'c(1, 2, 3)'. The order to apply the rotations, referring to "x", "y", and "z".
flipped	Default 'FALSE'. Whether to flip the normals.
scale	Default 'c(1, 1, 1)'. Scale transformation in the x, y, and z directions. If this is a single value, number, the object will be scaled uniformly. Note: emissive objects may not currently function correctly when scaled.

Value

Single row of a tibble describing the YZ plane in the scene.

Examples

```
#Generate a purple rectangle in the cornell box.
generate_cornell() |>
  add_object(yz_rect(x = 100, y = 100, z = 555/2, ywidth = 200, zwidth = 200,
                    material = diffuse(color = "purple"))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
#Generate a gold plane in the cornell box
generate_cornell() |>
  add_object(yz_rect(x = 100, y = 100, z = 555/2,
                    ywidth = 200, zwidth = 200, angle = c(0, 30, 0),
                    material = metal(color = "gold"))) |>
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
              ambient_light = FALSE, samples = 16, parallel = TRUE, clamp_value = 5)
```

Index

add_object, 3
animate_objects, 4
arrow, 7

bezier_curve, 9

cone, 11
create_instances, 13
csg_box, 16
csg_capsule, 17
csg_combine, 18
csg_cone, 20
csg_cylinder, 21
csg_ellipsoid, 22
csg_elongate, 23
csg_group, 25
csg_object, 26
csg_onion, 27
csg_plane, 29
csg_pyramid, 30
csg_rotate, 31
csg_round, 32
csg_rounded_cone, 33
csg_scale, 34
csg_sphere, 35
csg_torus, 36
csg_translate, 37
csg_triangle, 38
cube, 39
cylinder, 41

dielectric, 7, 10, 12, 14, 26, 40, 41, 42, 48, 49, 56, 66, 67, 79, 88, 90, 94, 96, 123, 126, 128, 131–133, 135
diffuse, 7, 10, 12, 14, 26, 40, 41, 44, 48, 49, 52, 56, 66, 67, 79, 88, 90, 94, 96, 123, 126, 128, 131–133, 135
disk, 47
ellipsoid, 49
extruded_path, 50
extruded_polygon, 55

generate_camera_motion, 61
generate_cornell, 64
generate_ground, 66
generate_studio, 67
get_saved_keyframes, 68
glossy, 68
group_objects, 71

hair, 73
has_denoiser, 75

lambertian, 75
light, 76

mesh3d_model, 78
metal, 7, 10, 12, 14, 26, 40, 41, 48, 49, 56, 66, 67, 79, 80, 88, 90, 94, 96, 123, 126, 128, 131–133, 135
microfacet, 83

obj_model, 86

path, 89
pig, 92
ply_model, 94

r_obj, 114
raymesh_model, 95
render_animation, 98
render_ao, 103
render_preview, 107
render_scene, 108

screen_line, 115
screen_text, 118
segment, 123
set_scene_material, 125
sphere, 126

text3d, [127](#)
triangle, [130](#)

xy_rect, [131](#)
xz_rect, [133](#)

yz_rect, [134](#)