

Package ‘rayrender’

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Type Package

Title Build and Raytrace 3D Scenes

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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>>.

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Imports Rcpp (>= 1.0.0), parallel, assertthat, tibble, magrittr, purrr, png, raster, decido, rayimage, stats, progress

Suggests sf, spData, dplyr, Rvcg

LinkingTo Rcpp, RcppThread, progress, spacefillr

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

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add_object *Add Object*

Description

Add Object

Usage

add_object(scene, objects)

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,noisecolor="purple",color="black",noise=45),
    angle=c(0,-30,0))) %>%
  add_object(sphere(x=-0.7,radius=0.5,material=metal(color="gold")))

render_scene(scene,parallel=TRUE)
```

 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(),
  velocity = 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 arrow, specifying <code>'x'</code> , <code>'y'</code> , <code>'z'</code> .
<code>end</code>	Default <code>'c(0, 1, 0)'</code> . Tip of the arrow, specifying <code>'x'</code> , <code>'y'</code> , <code>'z'</code> .
<code>radius_top</code>	Default <code>'0.5'</code> . Radius of the top of the arrow.
<code>radius_tail</code>	Default <code>'0.2'</code> . Radius of the tail of the arrow.
<code>tail_proportion</code>	Default <code>'0.5'</code> . Proportion of the arrow that is the tail.
<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 arrow. Arrow 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>velocity</code>	Default <code>'c(0, 0, 0)'</code> . Velocity of the segment.
<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

```
#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=400)

#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=400)

#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=400)

#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=400,
    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=400,
               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),
    velocity = c(0, 0, 0),
    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 diffuse . The material, called from one of the material functions diffuse , metal , or dielectric .
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".
velocity	Default 'c(0, 0, 0)'. Velocity of the cube.
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=-0.1) %>%
  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=500)

#Change the control points to change the direction of the curve. Here, we place spheres
#at the control point locations.
generate_studio(depth=-0.1) %>%
  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=500)

#We can make the curve flat (always facing the camera) by setting the type to `flat`
generate_studio(depth=-0.1) %>%
  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=500)

#We can also plot a ribbon, which is further specified by a start and end orientation with
#two surface normals.
generate_studio(depth=-0.1) %>%
  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=500)

#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),
  velocity = c(0, 0, 0),
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

start	Default 'c(0, 0, 0)'. Base of the cone, specifying 'x', 'y', 'z'.
end	Default 'c(0, 1, 0)'. Tip of the cone, specifying 'x', 'y', 'z'.
radius	Default '1'. Radius of the bottom of the cone.
direction	Default 'NA'. Alternative to 'start' and 'end', specify the direction (via a length-3 vector) of the cone. Cone will be centered at 'start', and the length will be determined by the magnitude of the direction vector.
from_center	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.
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)'. Rotation angle. Note: This will change the 'start' and 'end' coordinates.

velocity	Default 'c(0, 0, 0)'. Velocity of the segment.
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 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=400,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=400,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=400,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=400)
```

#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=400)

```

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,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,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,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,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,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,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)

```

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,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,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,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,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,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,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,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,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,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,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,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)
```

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,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,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,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	<i>CSG Ellipsoid</i>
---------------	----------------------

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,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,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,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)
```

csg_elongate	<i>CSG Elongate</i>
--------------	---------------------

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,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,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,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,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,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,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,
  radius = 1,
  material = diffuse(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  velocity = c(0, 0, 0),
  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.
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".
velocity	Default 'c(0, 0, 0)'. Velocity of the sphere, used for motion blur.
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))

#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))

#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))

```

csg_onion

CSG Onion

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,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,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)

#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)
```

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)

#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)

#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)
```

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,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,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,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,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,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,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)

```

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)
```

```

#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)

#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)

#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)

#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)

```

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,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,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,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)
```

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,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,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,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,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,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),
  velocity = c(0, 0, 0),
  flipped = FALSE,
  scale = c(1, 1, 1)
)

```

Arguments

<code>x</code>	Default '0'. x-coordinate of the center of the cube
<code>y</code>	Default '0'. y-coordinate of the center of the cube
<code>z</code>	Default '0'. z-coordinate of the center of the cube
<code>width</code>	Default '1'. Cube width.
<code>xwidth</code>	Default '1'. x-width of the cube. Overrides 'width' argument for x-axis.
<code>ywidth</code>	Default '1'. y-width of the cube. Overrides 'width' argument for y-axis.
<code>zwidth</code>	Default '1'. z-width of the cube. Overrides 'width' 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 '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>velocity</code>	Default 'c(0, 0, 0)'. Velocity of the cube.
<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 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 = 500, 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 = 500, 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 = 500, 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),
```

```

velocity = c(0, 0, 0),
flipped = FALSE,
scale = c(1, 1, 1)
)

```

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".
velocity	Default 'c(0, 0, 0)'. Velocity of the cylinder.
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 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 = 400, 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 = 400, parallel = TRUE, clamp_value = 5)

# Only render a subtended arc of the cylinder,

generate_cornell(lightintensity=3) %>%
  add_object(cylinder(x = 555/2, y = 250, z = 555/2,
                    length = 300, radius = 100, angle = c(45, 0, 0), phi_min = 0, phi_max = 180,
                    material = diffuse())) %>%
  render_scene(lookfrom = c(278, 278, -800) ,lookat = c(278, 278, 0), fov = 40,
             ambient_light = FALSE, samples = 400, 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),
  priority = 0,
  importance_sample = FALSE,
  bump_texture = NA,
  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. Note: This assumes the object has a closed surface.
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 'NA'. 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)

#Add a glass sphere

scene %>%
  add_object(sphere(x=-0.5, radius=0.5, material=dielectric())) %>%
  render_scene(parallel=TRUE, samples=400)

#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=400)

#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=1000)

#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 = 1000)

#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 = 400,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(6,6,2),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 = 400,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 = NA,
image_repeat = 1,
alpha_texture = NA,
bump_texture = NA,
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.
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 'NA'. 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 'NA'. A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
bump_texture	Default 'NA'. 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.
fog	Default 'FALSE'. If 'TRUE', the object will be a volumetric scatterer.
fogdensity	Default '0.01'. The density of the fog. Higher values will produce more opaque objects.
sigma	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.
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 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=500,
  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=500,
  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=500,
  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=500,
  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=500,
  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),
velocity = c(0, 0, 0),
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".
velocity	Default 'c(0, 0, 0)'. Velocity of the disk.
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 = 400, 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 = 400, 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 = 400, parallel = TRUE, clamp_value = 5)

```

ellipsoid

Ellipsoid Object

Description

Note: light importance sampling for this shape is currently approximated by a sphere. This will fail for ellipsoids with large differences between axes.

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),
  velocity = c(0, 0, 0),
  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".
velocity	Default 'c(0, 0, 0)'. Velocity of the segment.
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 = 500, 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 = 500, 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 = 500, parallel = TRUE, clamp_value = 5)
```

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),
  pivot_point = c(0, 0, 0),
  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),
  material_id = NA
)
```

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.
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".
pivot_point	Default 'c(0,0,0)'. Point at which to rotate the polygon around.
material	Default <code>diffuse</code> . The material, called from one of the material functions <code>diffuse</code> , <code>metal</code> , or <code>dielectric</code> .
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.
material_id	Default 'NA'. A unique label/number to ensure the material is shared between all triangles that make up the extruded polygon. Required if the material is 'dielectric()'.

Value

Multiple row tibble describing the extruded polygon in the scene.

Examples

#Manually create a polygon object, here a star:

```

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=400, 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=400,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=400,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=400,lookat=c(0,0.9,0),fov=40)

#We can also directly pass in sf polygons:
if("spData" %in% rownames(utils::installed.packages())) {
  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=400,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="lightblue",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=400,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="lightblue",intensity=250))) %>%
  add_object(sphere(y=30,x=100,z=-60,radius=10,
                  material=light(color="orange",intensity=250))) %>%
  render_scene(parallel=TRUE,lookfrom = c(-60,50,-40),lookat=c(0,-5,0),samples=400,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 = "bezier",
  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,
  progress = TRUE
)
```

Arguments

<code>positions</code>	A list or 3-column XYZ matrix of camera positions. These will serve as key frames for the camera position.
<code>lookats</code>	Default <code>'NULL'</code> , which sets the camera lookat to the origin <code>'c(0,0,0)'</code> for the animation. A list or 3-column XYZ matrix of <code>'lookat'</code> points. Must be the same number of points as <code>'positions'</code> .
<code>apertures</code>	Default <code>'0'</code> . A numeric vector of aperture values.
<code>fovs</code>	Default <code>'40'</code> . A numeric vector of field of view values.
<code>focal_distances</code>	Default <code>'NULL'</code> , automatically the distance between positions and lookats. Numeric vector of focal distances.
<code>ortho_dims</code>	Default <code>'NULL'</code> , which results in <code>'c(1,1)'</code> orthographic dimensions. A list or 2-column matrix of orthographic dimensions.
<code>camera_ups</code>	Default <code>'NULL'</code> , which gives an up vector of <code>'c(0,1,0)'</code> . Camera up orientation.
<code>type</code>	Default <code>'bezier'</code> . Type of transition between keyframes. Other options are <code>'linear'</code> , <code>'quad'</code> , <code>'cubic'</code> , <code>'exp'</code> , and <code>'manual'</code> . <code>'manual'</code> just returns the values passed in, properly formatted to be passed to <code>'render_animation()'</code> .

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.
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=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)

#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=-10,scale_obj=3, angle=c(0,-45,0),
                     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,-20), 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,
                  clamp_value=10, width=400, height=400)

```

generate_cornell	<i>Generate Cornell Box</i>
------------------	-----------------------------

Description

Generate Cornell Box

Usage

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

Arguments

light	Default 'TRUE'. Whether to include a light on the ceiling of the box.
lightintensity	Default '5'. The intensity of the light.
lightcolor	Default 'white'. The color the of the light.
lightwidth	Default '332'. Width (z) of the light.
lightdepth	Default '343'. Depth (x) of the light.
sigma	Default '0'. Oren-Nayar microfacet angle.
leftcolor	Default '#1f7326' (green).
rightcolor	Default '#a60d0d' (red).
roomcolor	Default '#bababa' (light grey).
importance_sample	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.
scene = generate_cornell()

render_scene(scene, samples=400,aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#Make a much smaller light in the center of the room.
scene = generate_cornell(lightwidth=200,lightdepth=200)

render_scene(scene, samples=400,aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#Place a sphere in the middle of the box.
scene = scene %>%
  add_object(sphere(x=555/2,y=555/2,z=555/2,radius=555/4))

render_scene(scene, samples=400,aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

#Reduce "fireflies" by setting a clamp_value in render_scene()

render_scene(scene, samples=400,aperture=0, fov=40, ambient_light=FALSE,
  parallel=TRUE,clamp_value=3)

# Change the color scheme of the cornell box

new_cornell = generate_cornell(leftcolor="purple", rightcolor="yellow")
render_scene(new_cornell, samples=400,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= "#cfff00"'</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=-1,x=0.7,material=glossy(color="darkred"),angle=c(0,-20,0))) %>%
  add_object(sphere(x=-0.7,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),fov=20,clamp_value=10,samples=500)

#Zooming out to show the full default scene

render_scene(scene, parallel=TRUE,lookfrom=c(0,200,400),clamp_value=10,samples=500)
```

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,
gradient_point_end = NA,
gradient_type = "hsv",
image_texture = NA,
image_repeat = 1,
alpha_texture = NA,
bump_texture = NA,
bump_intensity = 1,
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 'NA'. 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 'NA'. A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
<code>bump_texture</code>	Default 'NA'. 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>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=500)

#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=500,fov=40)
```

```

#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=500,fov=40)

#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=500,fov=40)

#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(),z=1,y=-0.05,scale_obj=0.45,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=500)

```

group_objects

Group Objects

Description

Group and transform objects together. Currently only supports a single level of grouping.

Usage

```

group_objects(
  scene,
  pivot_point = c(0, 0, 0),
  group_translate = c(0, 0, 0),
  group_angle = c(0, 0, 0),
  group_order_rotation = c(1, 2, 3),
  group_scale = c(1, 1, 1)
)

```

Arguments

scene	Tibble of pre-existing object locations and properties to group together.
pivot_point	Defaults to the mean location of all the objects. The point about which to pivot and move the group.

group_translate	Default 'c(0,0,0)'. Vector indicating where to offset the group.
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'.
group_order_rotation	Default 'c(1,2,3)'. The order to apply the rotations, referring to "x", "y", and "z".
group_scale	Default 'c(1,1,1)'. Scaling factor for x, y, and z directions for all objects in group.

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=500, 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),
  group_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=500, 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, group_translate = c(0,50,0),group_angle = c(0,45,0)))

render_scene(scene3,lookfrom=c(278,278,-800),lookat = c(278,278,0), aperture=0,
  samples=500, fov=50, parallel=TRUE, clamp_value=5)

#Flatten and stretch the cubes together on two axes
scene4 = generate_cornell() %>%
  add_object(group_objects(twocubes, group_translate = c(0,-40,0),
    group_angle = c(0,45,0), group_scale = c(2,0.5,1)))
```

```
render_scene(scene4,lookfrom=c(278,278,-800),lookat = c(278,278,0), aperture=0,
             samples=500, 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

pigment	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.
red_pigment	Default '0'. Concentration of the pheomelanin pigment in the hair. Pheomelanin makes red hair red.
color	Default 'NA'. Approximate color. Overrides 'pigment'/'redness' arguments.
sigma_a	Default 'NA'. Attenuation. Overrides 'color' and 'pigment'/'redness' arguments.
eta	Default '1.55'. Index of refraction of the hair medium.
beta_m	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.
beta_n	Default '0.3'. Azimuthal roughness of the hair. Should be between 0 and 1.
alpha	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=64, lookfrom=c(0,3,10),clamp_value = 10,
              fov=20)

#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=64, lookfrom=c(0,3,10),clamp_value = 10,
             fov=20)
```

lambertian

Lambertian Material (deprecated)

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=10,
             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 = NA,
  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 'NA'. 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 'NA'. 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=500,
  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=500,
  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=0.5,material=light(intensity=5,color="red"))) %>%
  add_object(obj_model(r_obj(), z=-3,x=-1.5,y=-1, angle=c(0,45,0))) %>%
  add_object(pig(scale=0.3, x=1.5,z=-2,y=-1.5,angle=c(0,-135,0)))

render_scene(scene, samples=500, parallel=TRUE, clamp_value=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,
  scale_mesh = 1,
  verbose = 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.
scale_mesh	Default '1'. Amount to scale the size of the mesh in all directions.
verbose	Default 'FALSE'. If 'TRUE', prints information about the mesh to the console.
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:
if("Rvcg" %in% rownames(utils::installed.packages())) {
  library(Rvcg)
  data(humface)

  generate_studio() %>%
    add_object(mesh3d_model(humface, y=-0.3, x=0, z=0,
                           material=glossy(color="dodgerblue4"), scale_mesh = 1/70)) %>%
    add_object(sphere(y=5, x=5, z=5, material=light(intensity=50))) %>%
    render_scene(samples=500, 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 = NA,
image_repeat = 1,
alpha_texture = NA,
bump_texture = NA,
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 'NA'. 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 'NA'. A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
bump_texture	Default 'NA'. 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=50,
  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=500,
  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=500,
            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=500,
            aperture=0, fov=40, ambient_light=FALSE, parallel=TRUE)

```

microfacet

Microfacet Material

Description

Microfacet Material

Usage

```

microfacet(
  color = "white",
  roughness = 1e-04,
  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,
  gradient_point_end = NA,
  gradient_type = "hsv",
  image_texture = NA,
  image_repeat = 1,

```



```

    alpha_texture = NA,
    bump_texture = NA,
    bump_intensity = 1,
    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.
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.
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 'NA'. 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 'NA'. A matrix or filename (specifying a greyscale image) to be used to specify the transparency.
bump_texture	Default 'NA'. 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 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=555/2,555/2,y=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=500,
    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=555-150,555/2,y=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=150,555/2,y=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=500,
             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(),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=500,
             aperture=0, fov=40, parallel=TRUE,clamp_value=10)

#Increase the roughness
generate_cornell() %>%
  add_object(obj_model(r_obj(),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=500,
             aperture=0, fov=40, parallel=TRUE,clamp_value=10)

```

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,
  texture = FALSE,
  vertex_colors = 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 '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.
texture	Default 'FALSE'. Whether to load the obj file texture.
vertex_colors	Default 'FALSE'. Set to 'TRUE' if the OBJ file has vertex colors to apply them to the model.
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

```

#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.

```

```

generate_ground(material = diffuse(checkercolor = "grey50")) %>%
  add_object(obj_model(y = -0.8, filename = r_obj(),
                      material = metal(color = "gold", fuzz = 0.025))) %>%
  add_object(obj_model(x = 1.8, y = -0.8, filename = r_obj(),
                      material = diffuse(color = "lightblue"))) %>%
  add_object(obj_model(x = -1.8, y = -0.8, filename = r_obj(),
                      material = dielectric(color = "pink"))) %>%
  add_object(sphere(z = 20, x = 20, y = 20, radius = 10,

```

```

        material = light(intensity = 20))) %>%
render_scene(parallel = TRUE, samples = 500,
             tonemap = "reinhold", aperture = 0.05, fov = 32, lookfrom = c(0, 2, 10))

#Use scale_obj to make objects bigger--this is more robust than the generic scale argument.

generate_ground(material = diffuse(checkercolor = "grey50")) %>%
  add_object(obj_model(y = -0.8, filename = r_obj(), scale_obj = 2,
                    material = diffuse(noise = TRUE, noiseintensity = 10,noisephase=45))) %>%
  add_object(sphere(z = 20, x = 20, y = 20, radius = 10,
                  material = light(intensity = 10))) %>%
  render_scene(parallel = TRUE, samples = 500, ambient = TRUE,
              backgroundhigh="blue", backgroundlow="red",
              aperture = 0.05, fov = 32, lookfrom = c(0, 2, 10),
              lookat = c(0,1,0))

```

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,
  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),
  velocity = c(0, 0, 0),
  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', a final segment will be added that connects the first and last points (unless they are already the same). Note: This final connection does not have continuous 1st and 2nd derivatives.
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".
velocity	Default 'c(0, 0, 0)'. Velocity of the cube.
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=500, 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=500, 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=500, 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=500, 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() %>%
  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=500, clamp_value=10)

#Here, we'll render only the first third of the pretzel by setting `u_max = 0.33`
generate_studio() %>%
  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=500, clamp_value=10)

```

```

#Here's the last third, by setting `u_min = 0.66`
generate_studio() %>%
  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=500, clamp_value=10)

#Here's the full pretzel, decomposed into thirds using the u_min and u_max coordinates
generate_studio() %>%
  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=500, 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=400,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=500,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=400, emotion = "angry",
    scale=c(100,100,100),angle=c(30,90,0), order_rotation=c(2,1,3)))

render_scene(many_pigs_scene,parallel=TRUE,clamp_value=10, samples=500,
  sample_method="stratified")

#Render spiderpig
generate_studio() %>%
  add_object(pig(y=-1,angle=c(0,-100,0), scale=1/2,spider=TRUE)) %>%
  add_object(sphere(y=5,z=5,x=5,material=light(intensity=100))) %>%
  render_scene(samples=500,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,
    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.
material	Default diffuse . The material, called from one of the material functions diffuse , metal , or dielectric .
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).

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,  
  width = 400,  
  height = 400,  
  samples = 100,  
  min_variance = 5e-05,  
  min_adaptive_size = 8,  
  sample_method = "sobol",  
  max_depth = 50,  
  roulette_active_depth = 10,  
  ambient_light = FALSE,  
  clamp_value = Inf,  
  filename = "rayimage",  
  backgroundhigh = "#80b4ff",  
  backgroundlow = "#ffffff",  
  shutteropen = 0,  
  shutterclose = 1,  
  focal_distance = NULL,  
  ortho_dimensions = c(1, 1),  
  tonemap = "gamma",  
  bloom = TRUE,  
  parallel = TRUE,  
  bvh_type = "sah",  
  environment_light = NULL,  
  rotate_env = 0,  
  intensity_env = 1,  
  debug_channel = "none",  
  return_raw_array = FALSE,
```

```

    progress = interactive(),
    verbose = FALSE,
    preview_light_direction = c(0, -1, 0),
    preview_exponent = 6
  )

```

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.
width	Default '400'. Width of the render, in pixels.
height	Default '400'. Height of the render, in pixels.
samples	Default '100'. The maximum number of samples for each pixel. If this is a length-2 vector and the <code>sample_method</code> 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 '0.00005'. 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 simple), 'stratified' (only implemented for completion), and 'sobol_blue' (best option for sample counts below 256).
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 'NULL'. If present, the renderer will write to the filename instead of the current device.
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 <code>'#ffffff'</code> . The "low" color in the background gradient. Can be either a hexadecimal code, or a numeric rgb vector listing three intensities between <code>'0'</code> and <code>'1'</code> .
shutteropen	Default <code>'0'</code> . Time at which the shutter is open. Only affects moving objects.
shutterclose	Default <code>'1'</code> . Time at which the shutter is open. Only affects moving objects.
focal_distance	Default <code>'NULL'</code> , automatically set to the <code>'lookfrom-lookat'</code> distance unless otherwise specified.
ortho_dimensions	Default <code>'c(1,1)'</code> . Width and height of the orthographic camera. Will only be used if <code>'fov = 0'</code> .
tonemap	Default <code>'gamma'</code> . Choose the tone mapping function, Default <code>'gamma'</code> solely adjusts for gamma and clamps values greater than 1 to 1. <code>'reinhold'</code> scales values by their individual color channels <code>'color/(1+color)'</code> and then performs the gamma adjustment. <code>'uncharted'</code> uses the mapping developed for Uncharted 2 by John Hable. <code>'hbd'</code> uses an optimized formula by Jim Hejl and Richard Burgess-Dawson. Note: If set to anything other than <code>'gamma'</code> , objects with material <code>'light()'</code> may not be anti-aliased. If <code>'raw'</code> , the raw array of HDR values will be returned, rather than an image or a plot.
bloom	Default <code>'TRUE'</code> . Set to <code>'FALSE'</code> 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 <code>'FALSE'</code> . If <code>'TRUE'</code> , it will use all available cores to render the image (or the number specified in <code>'options("cores")'</code> if that option is not <code>'NULL'</code>).
bvh_type	Default <code>"sah"</code> , "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 <code>'NULL'</code> . An image to be used for the background for rays that escape the scene. Supports both HDR (<code>' .hdr'</code>) and low-dynamic range (<code>' .png'</code> , <code>' .jpg'</code>) images.
rotate_env	Default <code>'0'</code> . The number of degrees to rotate the environment map around the scene.
intensity_env	Default <code>'1'</code> . 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 <code>'none'</code> . If <code>'depth'</code> , function will return a depth map of rays into the scene instead of an image. If <code>'normals'</code> , function will return an image of scene normals, mapped from 0 to 1. If <code>'uv'</code> , function will return an image of the uv coords. If <code>'variance'</code> , function will return an image showing the number of samples needed to take for each block to converge. If <code>'dpdu'</code> or <code>'dpdv'</code> , function will return an image showing the differential <code>'u'</code> and <code>'v'</code> coordinates. If <code>'color'</code> , function will return the raw albedo values (with white for <code>'metal'</code> and

‘dielectric’ materials). If ‘preview’, an image rendered with ‘render_preview()’ will be returned.

`return_raw_array` Default ‘FALSE’. If ‘TRUE’, function will return raw array with RGB intensity information.

`progress` Default ‘TRUE’ if interactive session, ‘FALSE’ otherwise.

`verbose` Default ‘FALSE’. Prints information and timing information about scene construction and raytracing progress.

`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.

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)

#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=-10,scale_obj=3, angle=c(0,-45,0),
                    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,-20), 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=100,
                  sample_method="sobol_blue",
                  clamp_value=10, width=400, height=400)

```

render_preview

Render Preview

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

Render Scene

Description

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

Usage

```
render_scene(
  scene,
  width = 400,
  height = 400,
  fov = 20,
  samples = 100,
  min_variance = 5e-05,
  min_adaptive_size = 8,
  sample_method = "sobol_blue",
  max_depth = 50,
  roulette_active_depth = 10,
  ambient_light = FALSE,
  lookfrom = c(0, 1, 10),
```



```

    lookat = c(0, 0, 0),
    camera_up = c(0, 1, 0),
    aperture = 0.1,
    clamp_value = Inf,
    filename = NULL,
    backgroundhigh = "#80b4ff",
    backgroundlow = "#ffffff",
    shutteropen = 0,
    shutterclose = 1,
    focal_distance = NULL,
    ortho_dimensions = c(1, 1),
    tonemap = "gamma",
    bloom = TRUE,
    parallel = TRUE,
    bvh_type = "sah",
    environment_light = NULL,
    rotate_env = 0,
    intensity_env = 1,
    debug_channel = "none",
    return_raw_array = FALSE,
    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.
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 '0.00005'. 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 'sobel_blue'. 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 'sobel_blue' (best option for sam-

	ple counts below 256), and 'sobol' (better than 'sobol_blue' for sample counts greater than 256).
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).
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.
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 'gamma'. Choose the tone mapping function, Default 'gamma' solely adjusts for gamma and clamps values greater than 1 to 1. 'reinhold' 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. Note: If set to anything other than 'gamma', objects with material 'light()' may not be anti-aliased. If 'raw', the raw array of HDR values will be returned, rather than an image or a plot.
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).
return_raw_array	Default 'FALSE'. If 'TRUE', function will return raw array with RGB intensity information.
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.

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=500,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=500)

#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=500)

#Add a metallic gold sphere, using stratified sampling for a higher quality render

scene = scene %>%
  add_object(sphere(x=-1.1,y=0,z=0,radius=0.5,material = metal(color="gold",fuzz=0.1)))
render_scene(scene,fov=20,parallel=TRUE,samples=500)

#Lower the number of samples to render more quickly (here, we also use only one core).

render_scene(scene, samples=4)

#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(0,180,0),
    material = diffuse(image_texture = image_array)))
render_scene(scene,fov=20,parallel=TRUE,samples=500)

#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 night time ambiance

render_scene(scene,lookfrom = c(7,1.5,10),lookat = c(0,0.5,0),fov=15,
  backgroundhigh = "#282375", backgroundlow = "#7e77ea", parallel=TRUE,
  samples=500)

#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 = 0.5,parallel=TRUE,samples=500)

#We can also capture a 360 environment image by setting `fov = 360` (can be used for VR)

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(checkercolor="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(checkercolor = "white",
      checkerperiod=10,color="dodgerblue"))) %>%
  render_scene(lookfrom=c(278,278,30), lookat=c(278,278,500), clamp_value=10,
    fov = 360, samples = 500, width=800, height=400)

#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=1:30
xpos = 10 * sin(t*12*pi/180+pi/2)
zpos = 10 * cos(t*12*pi/180+pi/2)

#Save old par() settings
old.par = par(no.readonly = TRUE)
on.exit(par(old.par))
par(mfrow=c(5,6))
for(i in 1:30) {
  render_scene(scene, samples=16,
    lookfrom = c(xpos[i],1.5,zpos[i]),lookat = c(0,0.5,0), parallel=TRUE)
}

```

r_obj

R 3D Model

Description

3D obj model of the letter R, to be used with `obj_model()`

Usage

```
r_obj()
```

Value

File location of the R.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(), y = -1, material = diffuse(color="red"))) %>%
  render_scene(parallel=TRUE, lookfrom = c(0, 1, 10), clamp_value = 5, samples = 200)
```

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 = 1,
  phi_min = 0,
  phi_max = 360,
  from_center = TRUE,
  direction = NA,
  material = diffuse(),
  velocity = c(0, 0, 0),
  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> .
velocity	Default 'c(0, 0, 0)'. Velocity of the segment.
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 = 400, 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 = 400, 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 = 400, 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),
                          group_angle = c(45,45,45), group_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 = 400, parallel = TRUE, clamp_value = 5)

```

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),
  velocity = c(0, 0, 0),
  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".
velocity	Default 'c(0, 0, 0)'. Velocity of the sphere, used for motion blur.
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 = 400, 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 = 400, clamp_value = 5)
```

```
#Add motion blur and show the sphere moving
```

```
generate_cornell() %>%
  add_object(sphere(x = 555/2, y = 100, z = 555/2, radius = 100,
    material = microfacet(color = "gold"), velocity = c(50, 0, 0))) %>%
  render_scene(lookfrom = c(278, 278, -800), lookat = c(278, 278, 0), fov = 40,
    ambient_light = FALSE, samples = 400, 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(),
  angle = c(0, 0, 0),
  order_rotation = c(1, 2, 3),
  velocity = c(0, 0, 0),
  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 diffuse . The material, called from one of the material functions diffuse , metal , or dielectric .
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".
velocity	Default 'c(0, 0, 0)'. Velocity of the sphere, used for motion blur.
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(0,180,0))) %>%
  render_scene(samples=500, clamp_value=10)

#Change the orientation
generate_cornell() %>%
  add_object(text3d(label="YZ Plane", x=550,y=555/2,z=555/2,text_height=100,
                    orientation = "yz",
                    material=diffuse(color="grey10"), angle=c(0,180,0))) %>%
  add_object(text3d(label="XY Plane", z=550,y=555/2,x=555/2,text_height=100,
                    orientation = "xy",
                    material=diffuse(color="grey10"), angle=c(0,180,0))) %>%
  add_object(text3d(label="XZ Plane", z=555/2,y=5,x=555/2,text_height=100,
                    orientation = "xz",
                    material=diffuse(color="grey10"))) %>%
  render_scene(samples=500, clamp_value=10)

#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=60,
                    material=diffuse(color="grey10"), angle=c(0,180,0))) %>%
  add_object(text3d(label="Sphere", x=555/2,y=100,z=100,text_height=30,
                    material=diffuse(color="white"), angle=c(0,180,0))) %>%
  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=500, clamp_value=10)

#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(0,180,0))
}
bees = do.call(rbind,bee_list)
generate_cornell() %>%
  add_object(bees) %>%
  render_scene(samples=500, clamp_value=10)
```

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 = 400, 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 = 400, 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

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.
xwidth	Default '1'. x-width of the rectangle.
ywidth	Default '1'. y-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 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 = 400, 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 = 400, 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

<code>x</code>	Default '0'. x-coordinate of the center of the rectangle.
<code>xwidth</code>	Default '1'. x-width of the rectangle.
<code>z</code>	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 = 400, 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 = 400, 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 = 400, 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 = 400, parallel = TRUE, clamp_value = 5)
```

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