Complete Guide to 3D Plots in R: Static and interactive 3-dimension graphs
ggplot2: The Elements for Elegant Data Visualization in R

A complete guide to 3D visualization device system in R - R software and data visualization

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This **R tutorial** describes, step by step, how to build a **3D graphic** using **R software** and the **rgl** package. You'll learn also how to create a **movie** of your **3D scene** in **R**.

RGL is a **3D graphics** package that produces a real-time interactive **3D plot**. It allows to interactively rotate, zoom the graphics and select regions.

The **rgl package** includes also a *generic 3D interface* named **R3D**. **R3D** is a collection of generic 3D objects and functions which are described at the end of this article.

Install the RGL package

```
install.packages("rgl")
```

Note that, on Linux operating system, the **rgl** package can be installed as follow:

sudo apt-get install r-cran-rgl

Load the RGL package

```
library("rgl")
```

Prepare the data

We'll use the *iris* data set in the following examples:

```
data(iris)
head(iris)
```

```
  Sepal.Length Sepal.Width Petal.Length Petal.Width Species
1          5.1         3.5          1.4         0.2  setosa
2          4.9         3.0          1.4         0.2  setosa
3          4.7         3.2          1.3         0.2  setosa
4          4.6         3.1          1.5         0.2  setosa
5          5.0         3.6          1.4         0.2  setosa
6          5.4         3.9          1.7         0.4  setosa
```

```
x <- sep.l <- iris$Sepal.Length
y <- pet.l <- iris$Petal.Length
z <- sep.w <- iris$Sepal.Width
```

iris data set gives the measurements of the variables sepal length and width, petal length and width, respectively, for 50 flowers from each of 3 species of iris. The species are Iris setosa, versicolor, and virginica.

Start and close RGL device

To make a 3D plot with RGL, you should first start the RGL device in R.

The functions below are used to manage the **RGL** device:

- **rgl.open()**: Opens a new device
- **rgl.close()**: Closes the current device
- **rgl.clear()**: Clears the current device
- **rgl.cur()**: Returns the active device ID
- **rgl.quit()**: Shutdowns the RGL device system

In the first sections of this tutorial, I'll open a new RGL device for each plot.

Note that, you don't need to do the same thing.

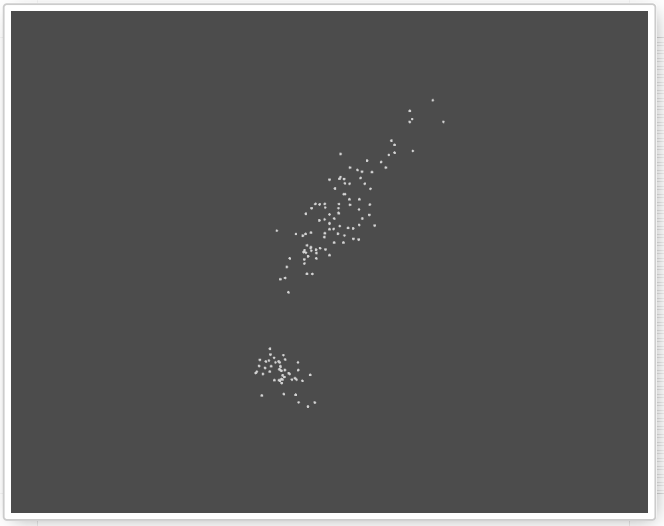
You can just use the function **rgl.open()** the first time -> then make your first 3D plot -> then use **rgl.clear()** to clear the scene -> and make a new plot again.

3D scatter plot

Basic graph

The function **rgl.points()** is used to draw a **3D scatter plot**:

```
rgl.open() # Open a new RGL device
rgl.points(x, y, z, color ="lightgray") # Scatter plot
```



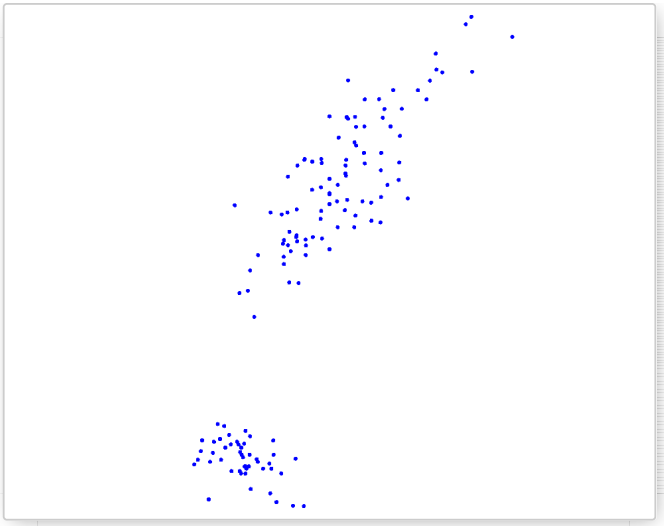
- **x, y, z** : Numeric vector specifying the coordinates of points to be drawn. The arguments y and z are optional when:
- *x* is a matrix or a data frame containing at least 3 columns which will be used as the x, y and z coordinates. Ex: *rgl.points(iris)*
- *x* is a formula of form zvar ~ xvar + yvar (see **?xyz.coords**). Ex: *rgl.points(z ~ x + y)*.
- ...: Material properties. See **?rgl.material** for details.

Change the background and point colors

- The function **rgl.bg(color)** can be used to setup the background environment of the scene
- The argument *color* is used in the function *rgl.points()* to change point colors

! Note that, it's also possible to change the **size of points** using the argument **size**

```
rgl.open()# Open a new RGL device
rgl.bg(color = "white") # Setup the background color
rgl.points(x, y, z, color = "blue", size = 5) # Scatter plot
```



Note that, the equivalent of the functions above for the *3d interface* is:

- **open3d()**: Open a new 3D device
- **bg3d(color)**: Set up the background environment of the scene
- **points3d(x, y, Z, ...)**: plot points of coordinates x, y, z

Change the shape of points

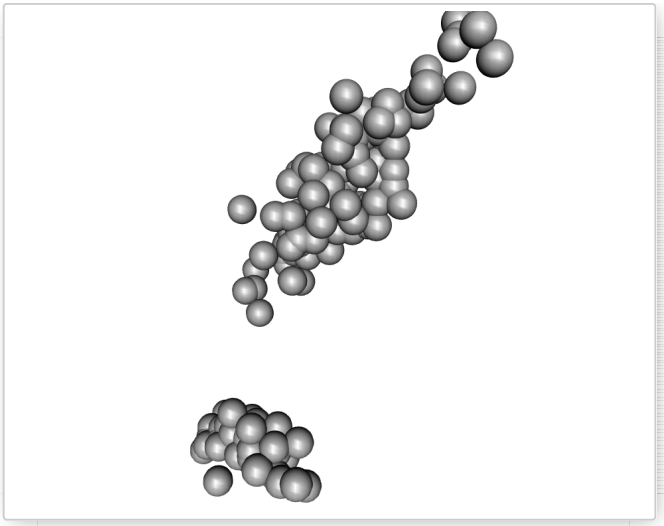
It's possible to draw **spheres** using the functions **rgl.spheres()** or **spheres3d()**:

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

rgl.spheres(x, y = NULL, z = NULL, r, ...)
```

rgl.spheres() draws spheres with center (x, y, z) and radius r.

- **x, y, z** : Numeric vector specifying the coordinates for the center of each sphere. The arguments y and z are optional when:
- *x* is a matrix or a data frame containing at least 3 columns which will be used as the x, y and z coordinates. Ex: *rgl.spheres(iris, r = 0.2)*
- *x* is a formula of form zvar ~ xvar + yvar (see **?xyz.coords**). Ex: *rgl.spheres(z ~ x + y, r = 0.2)*.
- **radius**: a vector or single value indicating the radius of spheres
- ...: Material properties. See **?rgl.material** for details.

```
rgl.open()# Open a new RGL device
rgl.bg(color = "white") # Setup the background color
rgl.spheres(x, y, z, r = 0.2, color = "grey")
```



Note that, an **rgl** plot can be manually rotated by holding down on the mouse or touchpad. It can be also zoomed using the scroll wheel on a mouse or pressing ctrl + using the touchpad on a PC or two fingers (up or down) on a mac.

rgl_init(): A custom function to initialize RGL device

The function **rgl_init()** will create a new **RGL** device if requested or if there is no opened device:

```
#' @param new.device a logical value. If TRUE, creates a new device
#' @param bg the background color of the device
#' @param width the width of the device
rgl_init <- function(new.device = FALSE, bg = "white", width = 640) {
  if( new.device | rgl.cur() == 0 ) {
    rgl.open()
    par3d(windowRect = 50 + c( 0, 0, width, width ) )
    rgl.bg(color = bg )
  }
  rgl.clear(type = c("shapes", "bboxdeco"))
  rgl.viewpoint(theta = 15, phi = 20, zoom = 0.7)
}
```

Description of the used RGL functions:

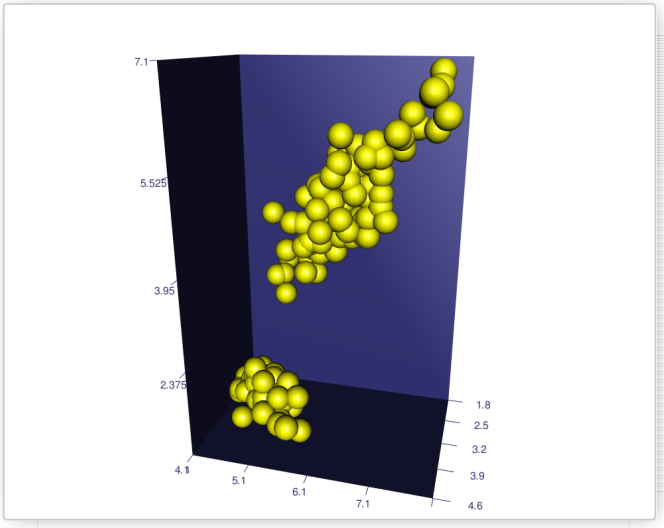
- **rgl.open()**: open a new device
- **rgl.cur()**: returns active device ID
- **par3d(windowRect)**: set the window size
- **rgl.viewpoint(theta, phi, fov, zoom)**: set up viewpoint. The arguments *theta* and *phi* are polar coordinates.
- **theta** and **phi** are the polar coordinates. Default values are 0 and 15, respectively
- **fov** is the field-of-view angle in degrees. Default value is 60
- **zoom** is the zoom factor. Default value is 1
- **rgl.bg(color)**: define the background color of the device
- **rgl.clear(type)**: Clears the scene from the specified stack ("shapes", "lights", "bboxdeco", "background")

In the **R code** above, I used the function **rgl.viewpoint()** to set automatically the viewpoint orientation and the zoom. As you already know, the **RGL** device is interactive and you can adjust the viewpoint and zoom the plot using your mouse.

Add a bounding box decoration

The function **rgl.bbox()** is used:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")  # Scatter plot
rgl.bbox(color = "#333377") # Add bounding box decoration
```

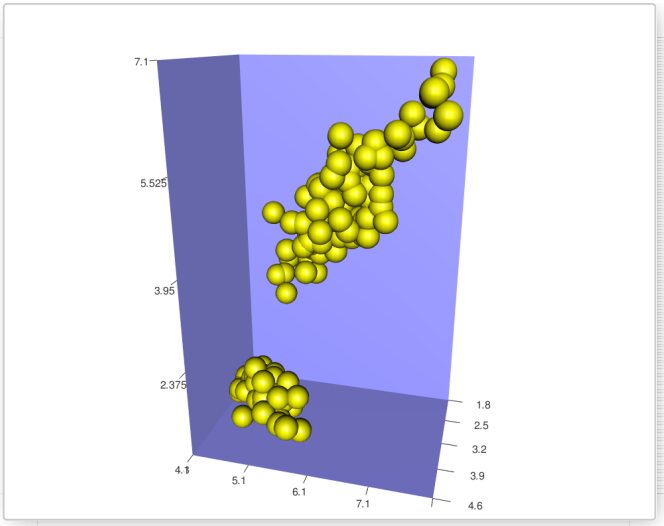


A simplified format of the function **rgl.bbox()** is:

```
rgl.bbox(xlen=5, ylen=5, zlen=5, marklen=15.9, ...)
```

- **xlen**, **ylen**, **zlen**: values specifying the number of tickmarks on x, y and Z axes, respectively
- **marklen**: value specifying the length of the tickmarks
- **...**: other rgl material properties (see *?rgl.material*) including:
- **color**: a vector of colors. The first color is used for the background color of the bounding box. The second color is used for the tick mark labels.
- **emission**, **specular**, **shininess**: properties for lighting calculation
- **alpha**: value specifying the color transparency. The value should be between 0.0 (fully transparent) and 1.0 (opaque)

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
# Add bounding box decoration
rgl.bbox(color=c("#333377","black"), emission="#333377",
         specular="#3333FF", shininess=5, alpha=0.8 )
```



Add axis lines and labels

- The function **rgl.lines(x, y = NULL, z = NULL, ...)** can be used to add axis lines.
- The function **rgl.texts(x, y = NULL, z = NULL, text)** is used to add axis labels

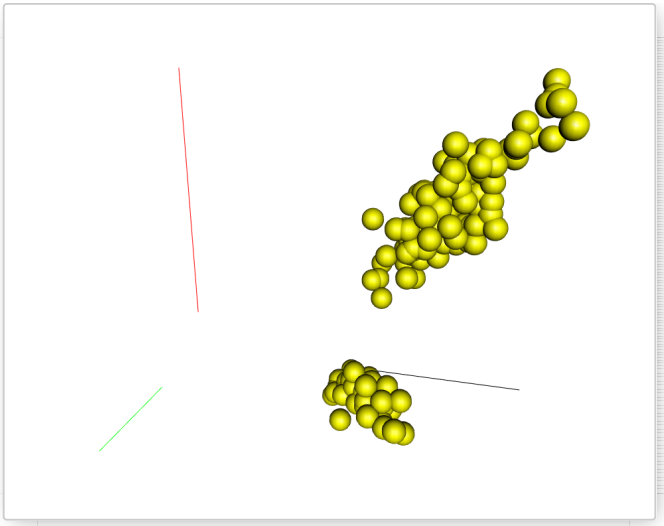
For the function **rgl.lines()**, the arguments x, y, and z are numeric vectors of length 2 (i.e, : x = c(x1,x2), y = c(y1, y2), z = c(z1, z2)).

- The values x1, y1 and y3 are the **3D coordinates** of the line starting point.
- The values x2, y2 and y3 corresponds to the **3D coordinates** of the line ending point.

Note also that, the argument ***x*** can be a matrix or a data frame containing, at least, 3 columns corresponding to the x, y and z coordinates, respectively. In this case, the argument ***y*** and ***z*** can be omitted.

To draw an axis, you should specify the range (minimum and the maximum) of the axis to the function **rgl.lines()**:

```
# Make a scatter plot
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
# Add x, y, and z Axes
rgl.lines(c(min(x), max(x)), c(0, 0), c(0, 0), color = "black")
rgl.lines(c(0, 0), c(min(y),max(y)), c(0, 0), color = "red")
rgl.lines(c(0, 0), c(0, 0), c(min(z),max(z)), color = "green")
```



As you can see, the axes are drawn but the problem is that they don't cross at the point c(0, 0, 0)

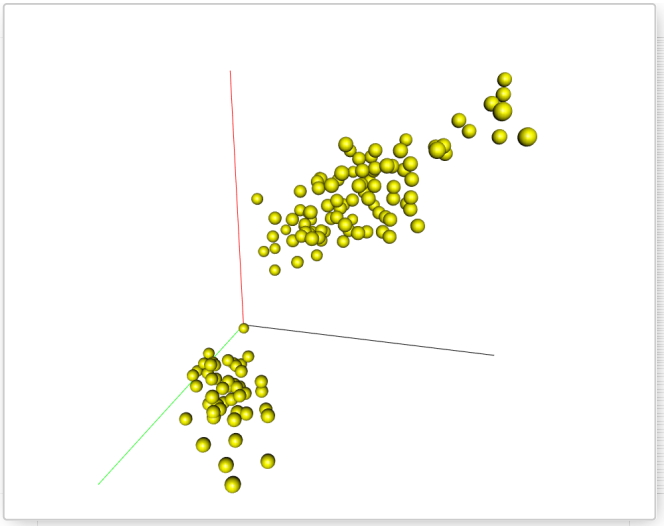
There are two solutions to handle this situation:

- **Scale the data** to make things easy. Transform the x, y and z variables so that their min = 0 and their max = 1
- **Use c(-max, +max)** as the ranges of the axes

Scale the data

```
x1 <- (x - min(x))/(max(x) - min(x))
y1 <- (y - min(y))/(max(y) - min(y))
z1 <- (z - min(z))/(max(z) - min(z))
```

```
# Make a scatter plot
rgl_init()
rgl.spheres(x1, y1, z1, r = 0.02, color = "yellow")
# Add x, y, and z Axes
rgl.lines(c(0, 1), c(0, 0), c(0, 0), color = "black")
rgl.lines(c(0, 0), c(0,1), c(0, 0), color = "red")
rgl.lines(c(0, 0), c(0, 0), c(0,1), color = "green")
```

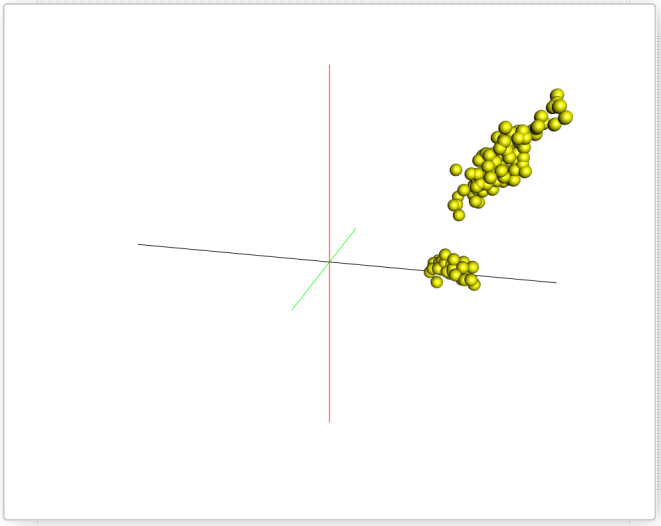


Use c(-max, max)

Let's define a helper function to calculate the axis limits:

```
lim <- function(x){c(-max(abs(x)), max(abs(x))) * 1.1}
```

```
# Make a scatter plot
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
# Add x, y, and z Axes
rgl.lines(lim(x), c(0, 0), c(0, 0), color = "black")
rgl.lines(c(0, 0), lim(y), c(0, 0), color = "red")
rgl.lines(c(0, 0), c(0, 0), lim(z), color = "green")
```



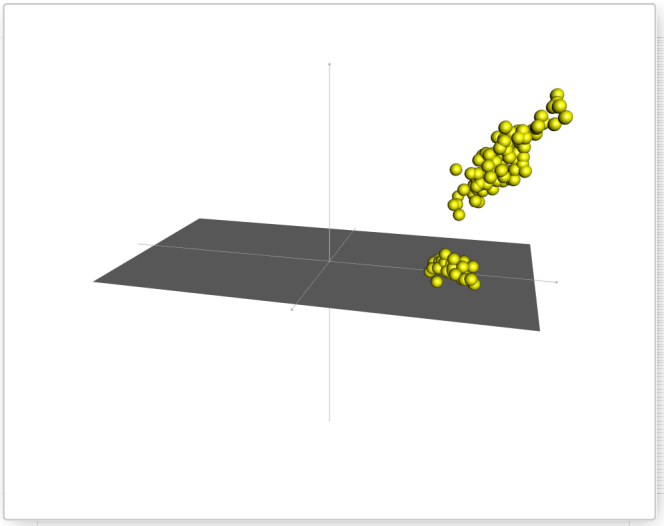
rgl_add_axes(): A custom function to add x, y and z axes

```
# x, y, z : numeric vectors corresponding to
```

```
#  the coordinates of points
# axis.col : axis colors
# xlab, ylab, zlab: axis labels
# show.plane : add axis planes
# show.bbox : add the bounding box decoration
# bbox.col: the bounding box colors. The first color is the
# the background color; the second color is the color of tick marks
rgl_add_axes <- function(x, y, z, axis.col = "grey",
                xlab = "", ylab="", zlab="", show.plane = TRUE,
                show.bbox = FALSE, bbox.col = c("#333377","black"))
  {

  lim <- function(x){c(-max(abs(x)), max(abs(x))) * 1.1}
  # Add axes
  xlim <- lim(x); ylim <- lim(y); zlim <- lim(z)
  rgl.lines(xlim, c(0, 0), c(0, 0), color = axis.col)
  rgl.lines(c(0, 0), ylim, c(0, 0), color = axis.col)
  rgl.lines(c(0, 0), c(0, 0), zlim, color = axis.col)

   # Add a point at the end of each axes to specify the direction
   axes <- rbind(c(xlim[2], 0, 0), c(0, ylim[2], 0),
                 c(0, 0, zlim[2]))
   rgl.points(axes, color = axis.col, size = 3)

  # Add axis labels
  rgl.texts(axes, text = c(xlab, ylab, zlab), color = axis.col,
            adj = c(0.5, -0.8), size = 2)

  # Add plane
  if(show.plane)
    xlim <- xlim/1.1; zlim <- zlim /1.1
    rgl.quads( x = rep(xlim, each = 2), y = c(0, 0, 0, 0),
              z = c(zlim[1], zlim[2], zlim[2], zlim[1]))

  # Add bounding box decoration
  if(show.bbox){
    rgl.bbox(color=c(bbox.col[1],bbox.col[2]), alpha = 0.5,
          emission=bbox.col[1], specular=bbox.col[1], shininess=5,
          xlen = 3, ylen = 3, zlen = 3)
  }
```

- The function **rgl.texts(x, y, z, text)** is used to add texts to an **RGL plot**.
- **rgl.quads(x, y, z)** is used to add planes. x, y and z are numeric vectors of length four specifying the coordinates of the four nodes of the quad.

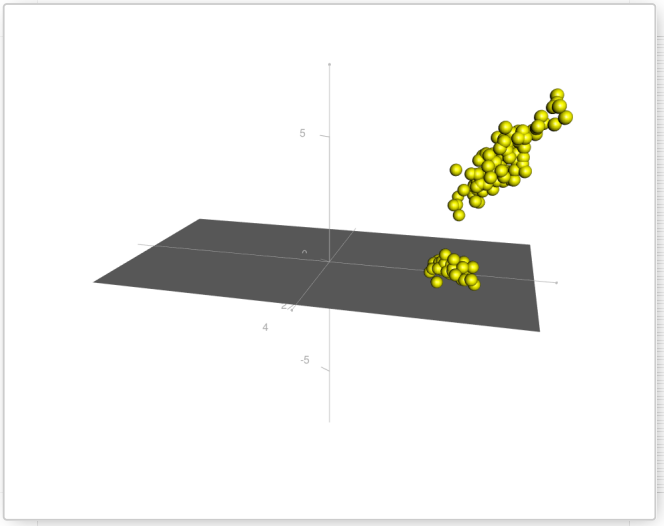
```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
rgl_add_axes(x, y, z)
```



Show scales: tick marks

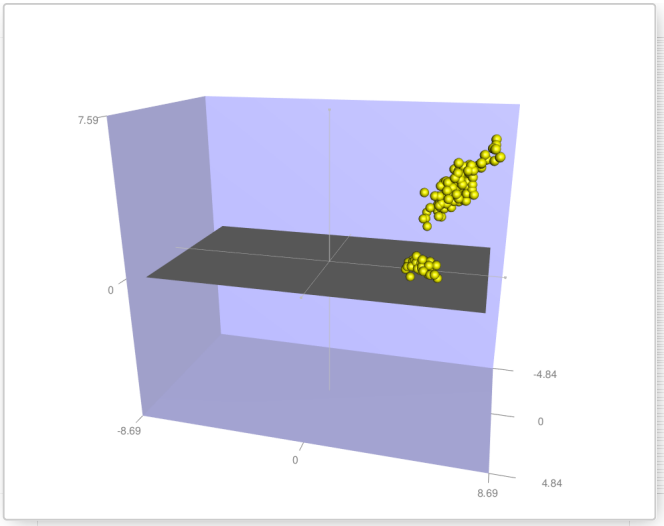
The function **axis3d()** can be used as follow:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
rgl_add_axes(x, y, z)
# Show tick marks
axis3d('x', pos=c( NA, 0, 0 ), col = "darkgrey")
axis3d('y', pos=c( 0, NA, 0 ), col = "darkgrey")
axis3d('z', pos=c( 0, 0, NA ), col = "darkgrey")
```



It's easier to just add a bounding box decoration:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
rgl_add_axes(x, y, z, show.bbox = TRUE)
```



Set the aspect ratios of the x, y and z axes

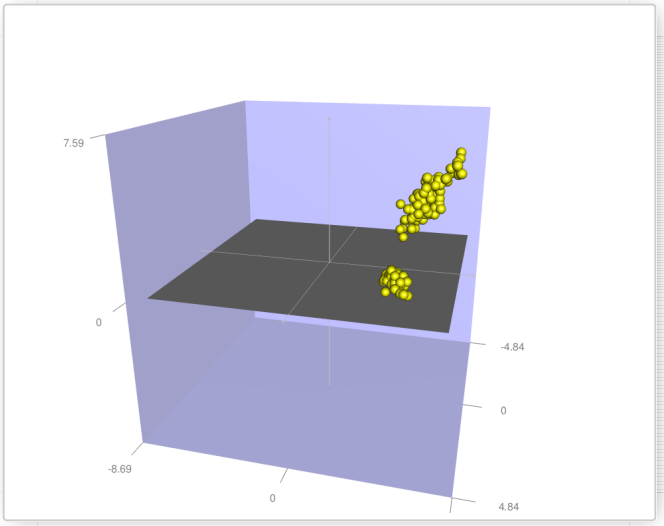
In the plot above, the bounding box is displayed as rectangle. All the coordinates are displayed at the same scale (*iso-metric*).

The function **aspect3d(x, y = NULL, z = NULL)** can be used to set the apparent ratios of the x, y and z axes for the current plot.

x, y and z are the ratio for x, y and z axes, respectively. x can be a vector of length 3, specifying the ratio for the 3 axes.

If the ratios are (1, 1, 1), the bounding box will be displayed as a cube.

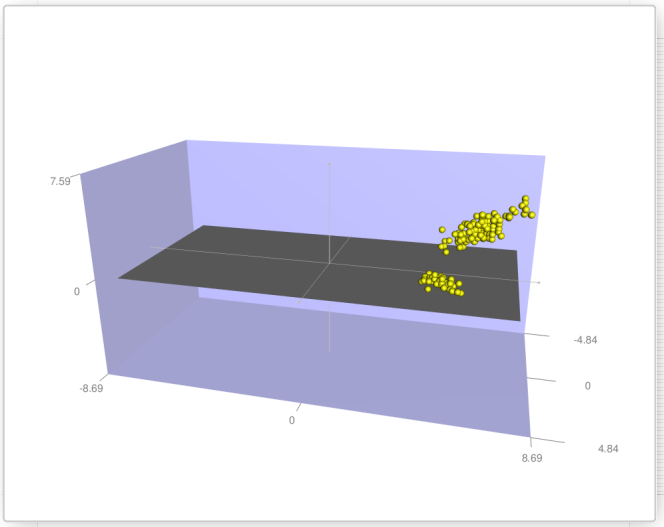
```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
rgl_add_axes(x, y, z, show.bbox = TRUE)
aspect3d(1,1,1)
```



Note that, the default display corresponds to the aspect “iso”: *aspect3d(“iso”)*.

The values of the ratios can be set larger or smaller to zoom on a given axis:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "yellow")
rgl_add_axes(x, y, z, show.bbox = TRUE)
aspect3d(2,1,1) # zoom on x axis
```



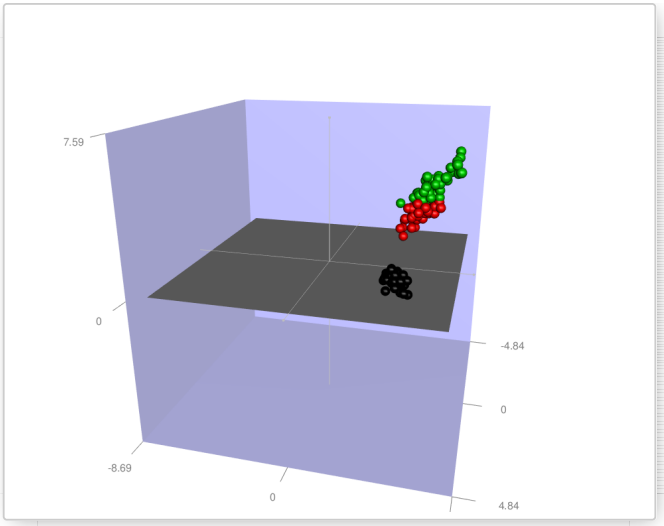
Change the color of points by groups

A helper function can be used to select automatically a color for each group:

```
#' Get colors for the different levels of
#' a factor variable
#'
#' @param groups a factor variable containing the groups
#'  of observations
#' @param colors a vector containing the names of
#   the default colors to be used
get_colors <- function(groups, group.col = palette()){
  groups <- as.factor(groups)
  ngrps <- length(levels(groups))
  if(ngrps > length(group.col))
    group.col <- rep(group.col, ngrps)
  color <- group.col[as.numeric(groups)]
  names(color) <- as.vector(groups)
  return(color)
}
```

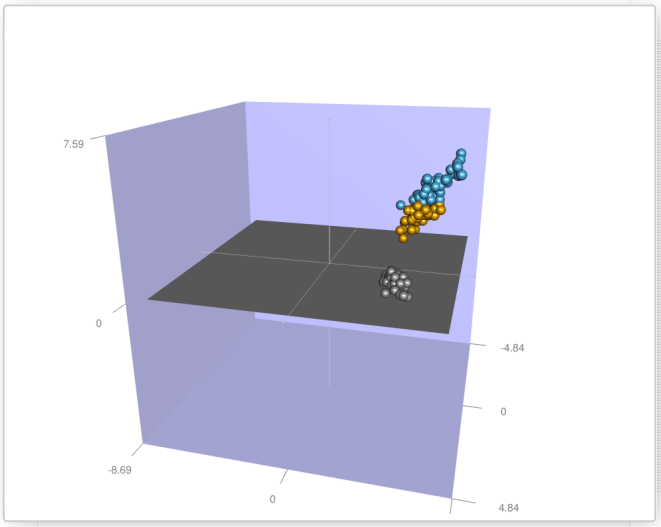
Change colors by groups :

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2,
          color = get_colors(iris$Species))
rgl_add_axes(x, y, z, show.bbox = TRUE)
aspect3d(1,1,1)
```



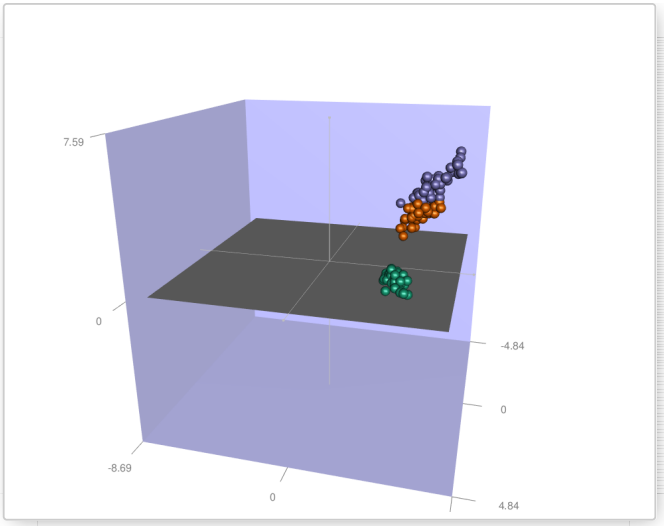
Use custom colors:

```
cols <- get_colors(iris$Species, c("#999999", "#E69F00", "#56B4E9"))
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = cols)
rgl_add_axes(x, y, z, show.bbox = TRUE)
aspect3d(1,1,1)
```



It's also possible to use color palettes from the **RColorBrewer** package:

```
library("RColorBrewer")
cols <- get_colors(iris$Species, brewer.pal(n=3, name="Dark2") )
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = cols)
rgl_add_axes(x, y, z, show.bbox = TRUE)
aspect3d(1,1,1)
```

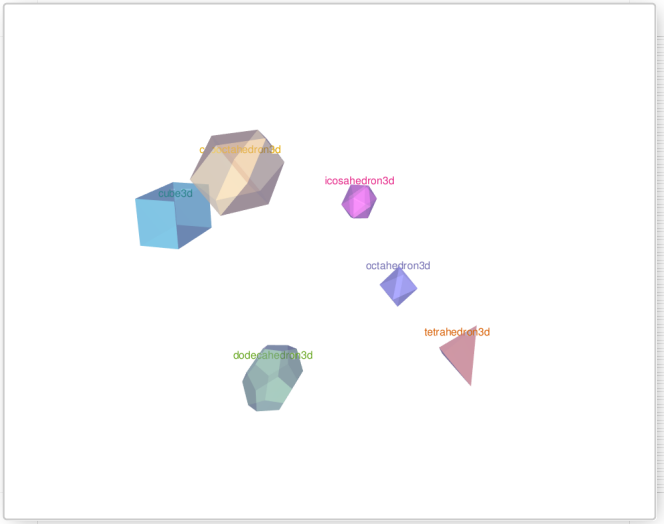


Read more about colors in R: colors in R

Change the shape of points

6 mesh objects are available in RGL package and can be used as point shapes:

- **cube3d()**
- **tetrahedron3d()**
- **octahedron3d()**
- **icosahedron3d()**
- **dodecahedron3d()**
- **cuboctahedron3d()**

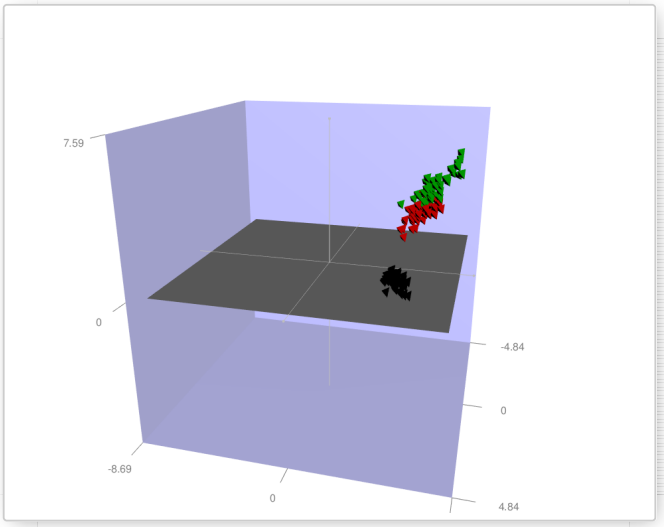


To make a plot using the objects above, the function **shapelist3d()** can be used as follow:

```
shapelist3d(shapes, x, y, z)
```

- **shapes**: a single shape3d (ex: shapes = cube3d()) object or a list of them (ex: shapes = list(cube3d(), icosahedron3d()))
- **x, y, z**: the coordinates of the points to be plotted

```
rgl_init()
shapelist3d(tetrahedron3d(), x, y, z, size =  0.15,
            color = get_colors(iris$Species))
rgl_add_axes(x, y, z, show.bbox = TRUE)
aspect3d(1,1,1)
```



Add an ellipse of concentration

The function **ellipse3d()** is used to estimate the ellipse of concentration. A simplified format is:

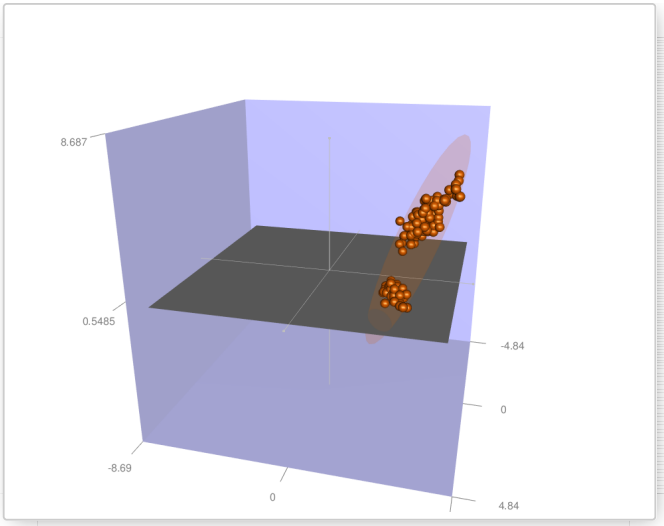
```
ellipse3d(x, scale = c(1,1,1), centre = c(0,0,0),
          level = 0.95, ...)
```

- **x**: the correlation or covariance matrix between x, y and z
- **scale**: If x is a correlation matrix, then the standard deviations of each parameter can be given in the scale parameter. This defaults to c(1, 1, 1), so no rescaling will be done.
- **centre**: The center of the ellipse will be at this position.
- **level**: The confidence level of a confidence region. This is used to control the size of the ellipsoid.

The function **ellipse3d()** returns an object of class **mesh3d** which can be drawn using the function **shade3d()** and/or **wired3d()**

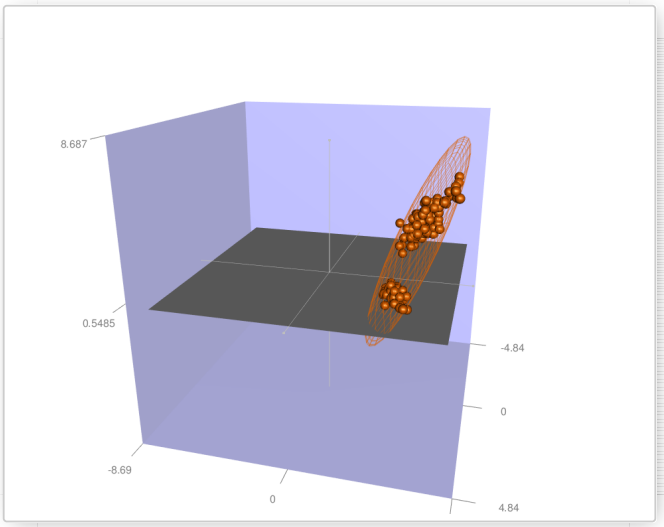
1. Draw the ellipse using the function **shade3d()**:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = TRUE)
# Compute and draw the ellipse of concentration
ellips <- ellipse3d(cov(cbind(x,y,z)),
            centre=c(mean(x), mean(y), mean(z)), level = 0.95)
shade3d(ellips, col = "#D95F02", alpha = 0.1, lit = FALSE)
aspect3d(1,1,1)
```



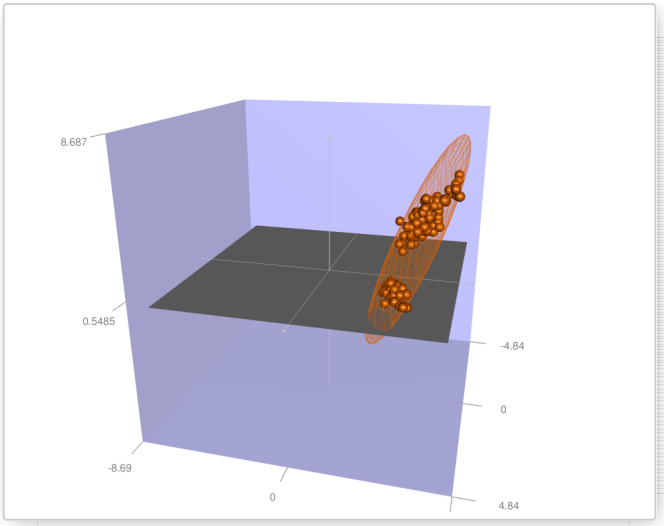
2. Draw the ellipse using the function **wired3d()**:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = TRUE)
# Compute and draw the ellipse of concentration
ellips <- ellipse3d(cov(cbind(x,y,z)),
            centre=c(mean(x), mean(y), mean(z)), level = 0.95)
wire3d(ellips, col = "#D95F02",  lit = FALSE)
aspect3d(1,1,1)
```



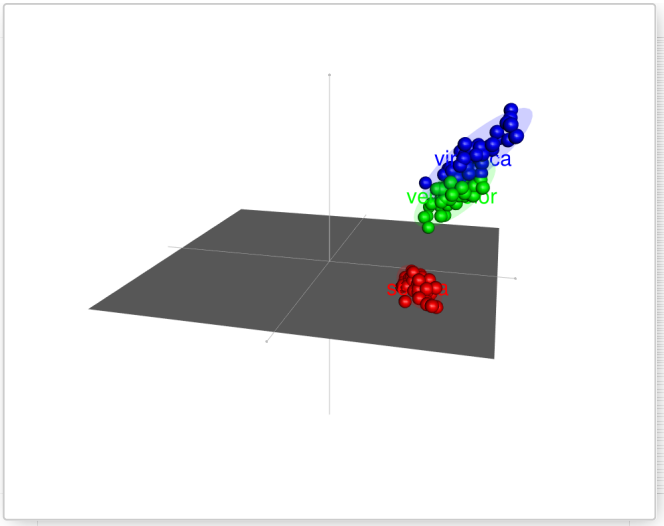
3. Combine **shade3d()** and **wired3d()**:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = TRUE)
# Compute and draw the ellipse of concentration
ellips <- ellipse3d(cov(cbind(x,y,z)),
            centre=c(mean(x), mean(y), mean(z)), level = 0.95)
shade3d(ellips, col = "#D95F02", alpha = 0.1, lit = FALSE)
wire3d(ellips, col = "#D95F02",  lit = FALSE)
aspect3d(1,1,1)
```



4. **Add ellipse for each group:**

```
# Groups
groups <- iris$Species
levs <- levels(groups)
group.col <- c("red", "green", "blue")
# Plot observations
rgl_init()
rgl.spheres(x, y, z, r = 0.2,
            color = group.col[as.numeric(groups)])
rgl_add_axes(x, y, z, show.bbox = FALSE)
# Compute ellipse for each group
for (i in 1:length(levs)) {
    group <- levs[i]
    selected <- groups == group
    xx <- x[selected]; yy <- y[selected]; zz <- z[selected]
    ellips <- ellipse3d(cov(cbind(xx,yy,zz)),
              centre=c(mean(xx), mean(yy), mean(zz)), level = 0.95)
    shade3d(ellips, col = group.col[i], alpha = 0.1, lit = FALSE)
    # show group labels
    texts3d(mean(xx),mean(yy), mean(zz), text = group,
            col= group.col[i], cex = 2)
  }
aspect3d(1,1,1)
```



Regression plane

The function **planes3d()** or **rgl.planes()** can be used to add regression plane into 3D rgl plot:

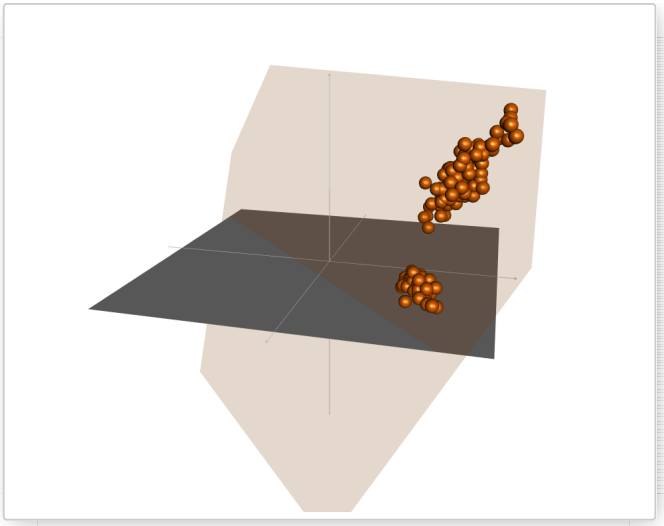
```
rgl.planes(a, b = NULL, c = NULL, d = 0, ...)

planes3d(a, b = NULL, c = NULL, d = 0, ...)
```

planes3d() and **rgl.planes()** draw planes using the parameter *ax + by + cz + d = 0*.

- **a, b, c**: coordinates of the normal to the plane
- **d**: coordinates of the offset

Example of usage:

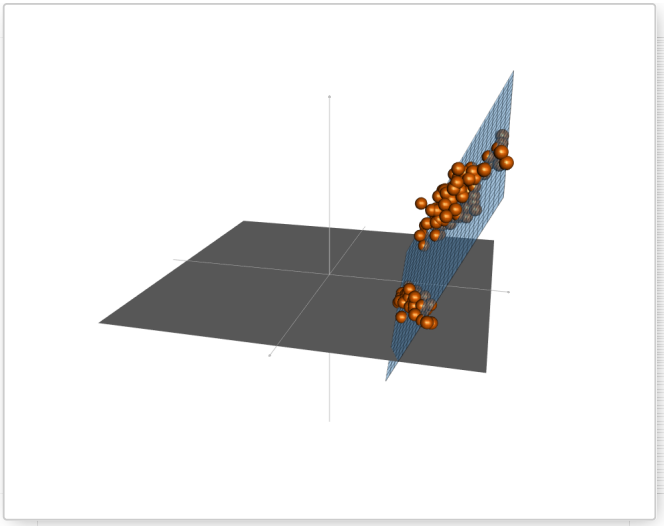
```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = FALSE)
aspect3d(1,1,1)
# Linear model
fit <- lm(z ~ x + y)
coefs <- coef(fit)
a <- coefs["x"]; b <- coefs["y"]; c <- -1
d <- coefs["(Intercept)"]
rgl.planes(a, b, c, d, alpha=0.2, color = "#D95F02")
```



The regression plane above is very ugly. Let's try to do a custom one. The steps below are followed:

1. Use the function *lm()* to compute a linear regression model: *ax + by + cz + d = 0*
2. Use the argument **rgl.surface()** to add a regression surface.

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = FALSE)
aspect3d(1,1,1)
# Compute the linear regression (y = ax + bz + d)
fit <- lm(y ~ x + z)
# predict values on regular xz grid
grid.lines = 26
x.pred <- seq(min(x), max(x), length.out = grid.lines)
z.pred <- seq(min(z), max(z), length.out = grid.lines)
xz <- expand.grid( x = x.pred, z = z.pred)
y.pred <- matrix(predict(fit, newdata = xz),
                 nrow = grid.lines, ncol = grid.lines)
# Add regression surface
rgl.surface(x.pred, z.pred, y.pred, color = "steelblue",
                alpha = 0.5, lit = FALSE)
# Add grid lines
rgl.surface(x.pred, z.pred, y.pred, color = "black",
    alpha = 0.5, lit = FALSE, front = "lines", back = "lines")
```



Create a movie of RGL scene

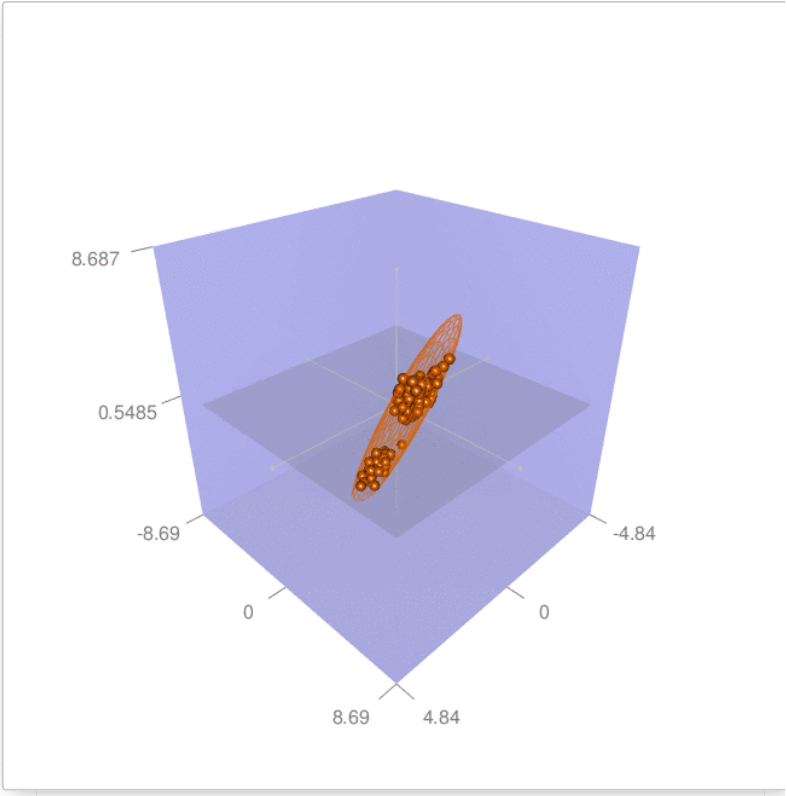
The function **movie3d()** can be used as follow:

```
movie3d(f, duration, dir = tempdir(), convert = TRUE)
```

- **f** a function created using **spin3d(axis)**
- **axis**: the desired axis of rotation. Default value is c(0, 0, 1).
- **duration** : the duration of the animation
- **dir**: A directory in which to create temporary files for each frame of the movie
- **convert**: If TRUE, tries to convert the frames to a single GIF movie. It uses **ImageMagick** for the image conversion.

You should install *ImageMagick* (http://www.imagemagick.org/) to be able to create a movie from a list of png file.

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = TRUE)
# Compute and draw the ellipse of concentration
ellips <- ellipse3d(cov(cbind(x,y,z)),
            centre=c(mean(x), mean(y), mean(z)), level = 0.95)
wire3d(ellips, col = "#D95F02",  lit = FALSE)
aspect3d(1,1,1)
# Create a movie
movie3d(spin3d(axis = c(0, 0, 1)), duration = 3,
        dir = getwd())
```



Export images as png or pdf

The plot can be saved as png or pdf.

- The function **rgl.snapshot()** is used to save the screenshot as png file:

```
rgl.snapshot(filename = "plot.png")
```

- The function **rgl.postscript()** is used to save the screenshot to a file in **ps, eps, tex, pdf, svg or pgf** format:

```
rgl.postscript("plot.pdf",fmt="pdf")
```

Example of usage:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = T)
aspect3d(1,1,1)
rg.snapshot("plot.png")
```

Export the plot into an interactive HTML file

The function **writeWebGL()** is used to write the current scene to HTML:

```
writeWebGL(dir = "webGL", filename = file.path(dir, "index.html"))
```

- **dir**: Where to write the files

- **filename**: The file name to use for the main file

The R code below, writes a copy of the scene and then displays it in a browser:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2,
          color = get_colors(iris$Species))
rgl_add_axes(x, y, z, show.bbox = FALSE)
# This writes a copy into temporary directory 'webGL',
# and then displays it
browseURL(
  paste("file://", writeWebGL(dir=file.path(tempdir(), "webGL"),
  width=500), sep="")
  )
```

Select a rectangle in an RGL scene

The functions **rgl.select3d()** or **select3d()** can be used to select **3-dimensional** regions.

They return a function f(x, y, z) which tests whether each of the points (x, y, z) is in the selected region.

The R code below, allows the user to select some points, and then redraw them in a different color:

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = F)
aspect3d(1,1,1)
# Select a point
 f <- select3d()
 sel <- f(x,y,z)
rgl.clear("shapes")
# Redraw the points
rgl.spheres(x[!sel],y[!sel], z[!sel], r = 0.2, color = "#D95F02")
rgl.spheres(x[sel],y[sel], z[sel], r = 0.2, color = "green")
```

Identify points in a plot

The function **identify3d()** is used:

```
identify3d(x, y = NULL, z = NULL, labels, n)
```

- **x, y, z** : Numeric vector specifying the coordinates of points. The arguments y and z are optional when:
- *x* is a matrix or a data frame containing at least 3 columns which will be used as the x, y and z coordinates.
- *x* is a formula of form zvar ~ xvar + yvar (see **?xyz.coords**).
- **labels** an optional character vector giving labels for points
- *n* the maximum number of points to be identified

The function identify3d(), works similarly to the identify function in base graphics.

The R code below, allow the user to identify 5 points :

```
rgl_init()
rgl.spheres(x, y, z, r = 0.2, color = "#D95F02")
rgl_add_axes(x, y, z, show.bbox = F)
```

```
aspect3d(1,1,1)
rgl.material(color = "blue")
identify3d(x, y, z, labels = rownames(iris), n = 5)
```


Use the right button to select, the middle button to quit.

R3D Interface

The **rgl** package also includes a higher level interface called **r3d**. This interface is designed to act more like classic 2D R graphics.

The next sections describe how to make 3D graphics using the R3D interface.

3D Scatter plot

The function **plot3d()** is used:

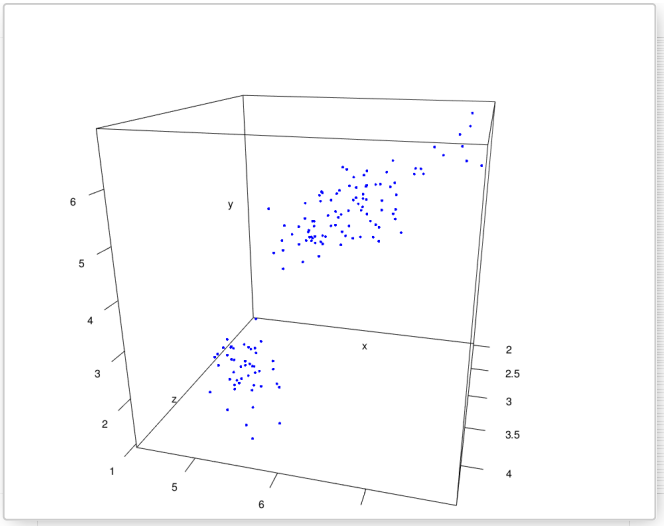
```
## Default method
plot3d(x, y, z, xlab, ylab, zlab, type = "p", col,
        size, lwd, radius, add = FALSE, aspect = !add, ...)

## Method for class 'mesh3d'
plot3d(x, xlab = "x", ylab = "y", zlab = "z",
       type = c("shade", "wire", "dots"), add = FALSE, ...)

decorate3d(xlim, ylim, zlim,
  xlab = "x", ylab = "y", zlab = "z",
    box = TRUE, axes = TRUE, main = NULL, sub = NULL,
    top = TRUE, aspect = FALSE, expand = 1.03, ...)
```

- **x, y, z**: vectors of points to be drawn. Any reasonable way of defining the coordinates is acceptable. See the function **xyz.coords** for details
- **xlab, yab, zlab**: x, y and z axis labels
- **type**:
- **For the default method**: Allowed values are: ‘p’ for points, ‘s’ for spheres, ‘l’ for lines, ‘h’ for line segments from z = 0, and ‘n’ for nothing.
- **For the mesh3d method**, one of ‘shade’, ‘wire’, or ‘dots’
- **col**: the color to be used for plotted items
- **size**: size of points
- **lwd**: the line width for plotted item
- **radius**: the radius of sphere
- **add**: whether to add the points to an existing plot
- **aspect**: either a logical indicating whether to adjust the aspect ratio, or a new ratio
- **...**: additional parameters which will be passed to par3d, material3d or decorate3d
- **box, axes**: whether to draw a box and axes.
- **main, sub**: main title and subtitle
- **top**: whether to bring the window to the top when done

Note that, it’s recommended to use the function **open3d()** to initialize the *3d interface. However, in the following R code chunks, I’ll continue to use the custom function **rgl_init()**.

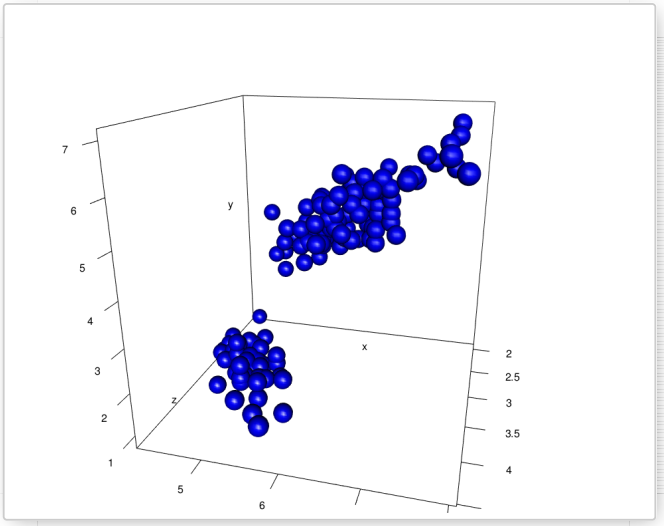
Draw points:

```
rgl_init()
plot3d(x, y, z, col="blue", type ="p")
```



Remove the box and draw spheres:

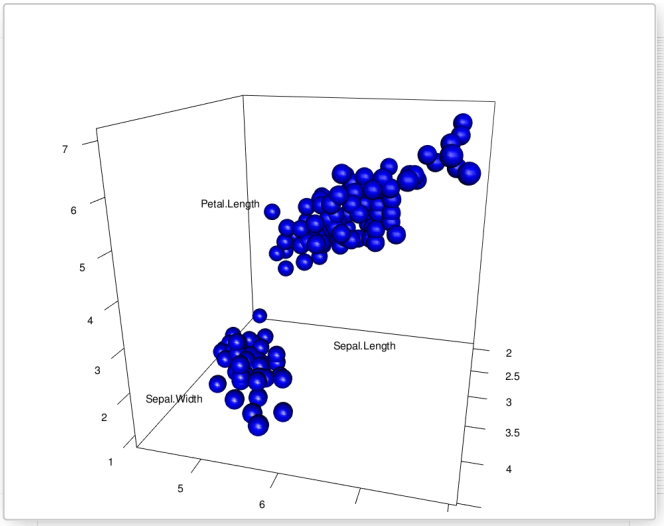
```
rgl_init()
plot3d(x, y, z, col="blue", box = FALSE,
       type ="s", radius = 0.15)
```



! To remove the axes, use the argument **axes = FALSE**.

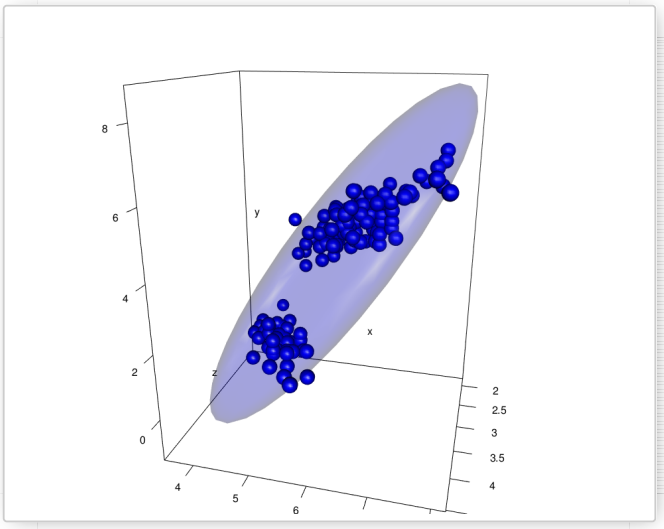
Axis labels:

```
rgl_init()
plot3d(x, y, z, col="blue", box = FALSE,
       type ="s", radius = 0.15, xlab ="Sepal.Length",
       ylab = "Petal.Length", zlab = "Sepal.Width")
```



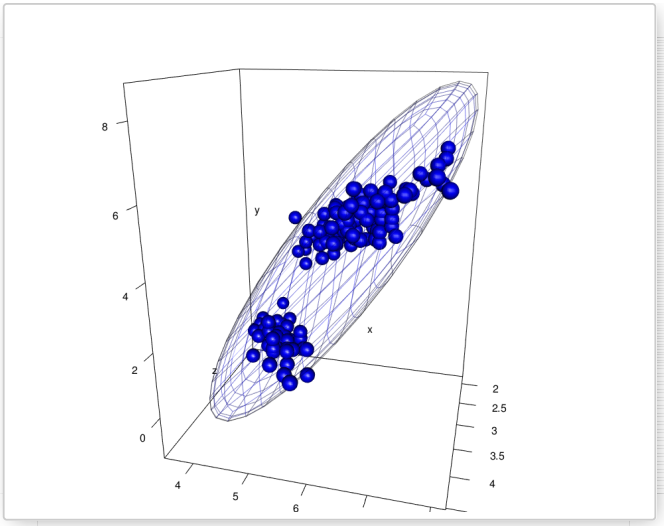
Add ellipse of concentration:

```
rgl_init()
plot3d(x, y, z, col="blue", box = FALSE,
       type ="s", radius = 0.15)
ellips <- ellipse3d(cov(cbind(x,y,z)),
            centre=c(mean(x), mean(y), mean(z)), level = 0.95)
plot3d(ellips, col = "blue", alpha = 0.2, add = TRUE, box = FALSE)
```



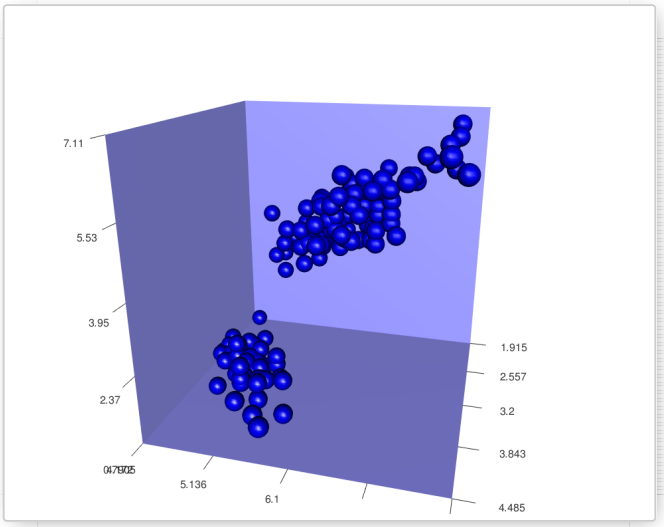
Change the ellipse type: possible values for the argument **type = c("shade", "wire", "dots")**

```
rgl_init()
plot3d(x, y, z, col="blue", box = FALSE,
       type ="s", radius = 0.15)
ellips <- ellipse3d(cov(cbind(x,y,z)),
            centre = c(mean(x), mean(y), mean(z)), level = 0.95)
plot3d(ellips, col = "blue", alpha = 0.5, add = TRUE, type = "wire")
```



bbox3d(): Add bounding box decoration

```
rgl_init()
plot3d(x, y, z, col="blue", box = FALSE,
       type ="s", radius = 0.15)
# Add bounding box decoration
rgl.bbox(color=c("#333377","black"), emission="#333377",
         specular="#3333FF", shininess=5, alpha=0.8, nticks = 3 )
# Change the axis aspect ratios
aspect3d(1,1,1)
```



Some important functions

- **open3d()**: Open a new device
- **Add a shape to the current scene:**
- points3d(x, y, z, ...)
- lines3d(x, y, z, ...)
- segments3d(x, y, z, ...)
- quads3d(x, y, z, ...)
- **texts3d(x, y, z, text)**: Adds text
- **Draw boxes, axes and other text:**
- **axes3d()**: Add standard axes
- **title3d(main, sub, xlab, ylab, zlab)**: Add titles

- **box3d()**: Draws a box around the plot
- **mtext3d()**: to put a text in the plot margin(s)

RGL functions

Some important functions for managing RGL device are listed below:

Device management

Functions	Description
rgl.open()	Opens a new device
rgl.close()	Closes the current device
rgl.cur()	Returns the ID of the active device
rgl.dev.list()	Returns all device IDs
rgl.set(which)	Set a device as active
rgl.quit()	Shutdown the RGL device system

The equivalents in r3d interface:

Shape functions

Adds a shape node to the current scene.

Functions	Description
rgl.points(x, y, z, ...)	Draws a point at x, y and z
rgl.lines(x, y, z, ...)	Draws line segments based on pairs of vertices (x = c(x1,x2), y = c(y1,y2), z = c(z1, z2))
rgl.triangles(x, y, z, ...)	Draws triangles with nodes (xi, yi, zi), i = 1, 2, 3
rgl.quads(x, y, z)	Draws quads with nodes (xi, yi, zi), i = 1, 2, 3, 4
rgl.spheres(x, y, z, r, ...)	Draws spheres with center (x, y, z) and radius r
rgl.texts(x, y, z, text, ...)	Adds text to the scene
rgl.surface(x, y, z, ...)	Adds surface to the current scene. x and y are two vectors defining the grid. z is a matrix defining the height of each grid point

Scene management

Functions	Description
rgl.clear(type = “shapes”)	Clears the scene from the specified stack (“shapes”, “lights”, “bboxdeco”, “background”)
rgl.pop(type = “shapes”)	removes the last-added node from stack

Setup the environment

Functions	Description

Functions	Description
rgl.viewpoint(theta, phi, fov, zoom, ...)	Set the viewpoint orientation. *theta* and *phi* are the polar coordinates. *fov* is the field-of-view angle in degrees. *zoom*: zoom factor.
rgl.light(theta, phi, ...)	Adds a light source to the scene
rgl.bg(...)	Setup the background environment of the scene
rgl.bbox(...)	Setup the bounding box decoration

Appearance setup

Functions	Description
rgl.material(...)	Set material properties for geometry appearance
aspect3d(x, y, z)	Set the aspect ratios of the x, y and z axes

Export screenshot

Functions	Description
rgl.snapshot("plot.png")	Saves a screenshot as png file
rgl.postscript("plot.pdf",fmt="pdf")	Saves the screenshot to a file in **ps, eps, tex, pdf, svg or pgf** format.

Assign focus to an RGL window

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

Infos

References:

- Daniel Alder et al., RGL: A R-library for 3D visualization with OpenGL, http://rgl.neoscientists.org/arc/doc/RGL_INTERFACE03.pdf

This analysis has been performed using **R software** (ver. 3.1.2) and **rgl** (ver. 0.93.1098)

Suggestions

- Impressive package for 3D and 4D graph - R software and data visualization
- Amazing interactive 3D scatter plots - R software and data visualization
- Scatterplot3d: 3D graphics - R software and data visualization
- R graphics