STHDA

Statistical tools for high-throughput data analysis

Impressive package for 3D and 4D graph - R software and data visualization

In my previous articles, I already described how to make **3D graphs** in R using the package below:

- scatterplot3d, non interactive
- scatter3d, interactive
- rgl, interactive

To close the discussion about 3D, in this tutorial I'll describe the impressive **plot3D** package and its extension **plot3Drgl** package.

See More Resources

R Packages
factoextra
survminer
ggpubr
ggcorrplot
fastqcr

Our Books

plot3D, from Karline Soetaert, is an R package containing many functions for 2D and 3D plotting: *scatter3D*, *points3D*, *lines3D*,*text3D*, *ribbon3d*, *hist3D*, etc.

In addition to the x, y (and z) values, an **additional data dimension** can be represented by a color variable (argument *colvar*).

This **"4D"** plot (x, y, z, color) with a color legend is not (easily) possible using the packages mentioned above (scatterplot3d, scatter3d, rgl).

The package **plot3Drgl** allows to plot easily the graph generated with plot3D in openGL, as made available by package rgl. This is described at the end of the present article.

Install plot3D package

```
install.packages("plot3D")
```

Load plot3D package

```
library("plot3D")
```

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, y and z coordinates
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 and petal length and width, respectively, for 50 flowers from each of 3 species of iris. The species are Iris setosa, versicolor, and virginica.

Scatter plots

Functions for scatter plots and texts in 2D and 3D

The function below will be used:

```
scatter3D(x, y, z, ..., colvar = z, col = NULL, add = FALSE)
text3D(x, y, z, labels, colvar = NULL, add = FALSE)
points3D(x, y, z, ...)
lines3D(x, y, z, ...)
scatter2D(x, y, colvar = NULL, col = NULL, add = FALSE)
text2D(x, y, labels, colvar = NULL, col = NULL, add = FALSE)
```

- **x, y, z**: vectors of point coordinates

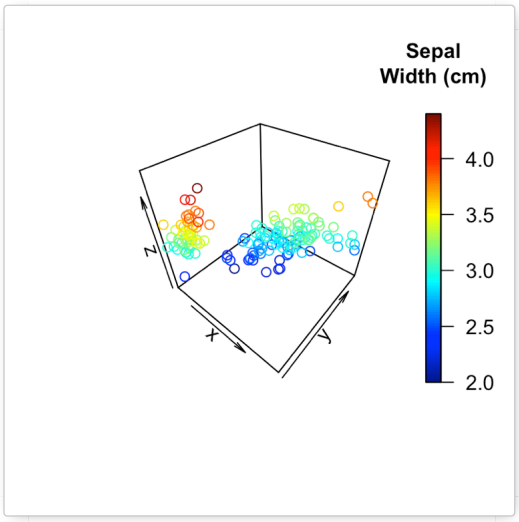
- **colvar**: a variable used for coloring
- **col**: color palette used for coloring the colvar variable
- **labels**: the text to be written
- **add**: logical. If TRUE, then the points will be added to the current plot. If FALSE a new plot is started
- **...**: additional *persp* arguments including xlim, ylim, zlim, xlab, ylab, zlab, main, sub, r, d, scale, expand, box, axes, nticks, tictype.

Note that:

- **points3D** and **lines3D** are shorthand for scatter3D(..., type ="p") and scatter3D(..., type = "l"), respectively.
- **points2D** and **lines2D** are shorthand for scatter2D(..., type = "p") and scatter2D(..., type ="l"), respectively.

Basic scatter plot

```
scatter3D(x, y, z, clab = c("Sepal", "Width (cm)"))
```



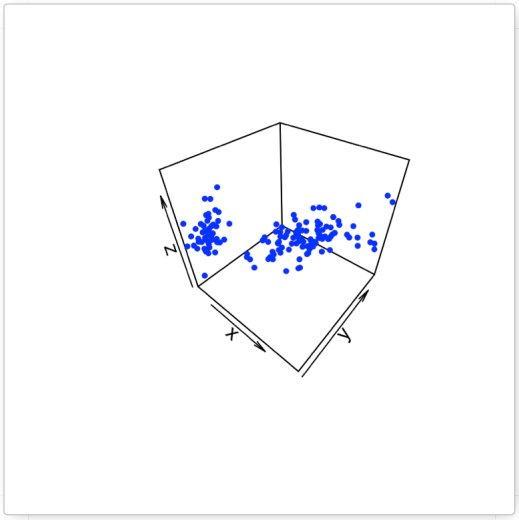
The argument *clab* is used to change the title of the color legend.

By default, the points are colored automatically using the variable *Z*

In the R code below:

- **colvar = NULL**: avoids coloring by z variable
- **col = "blue"**: changes point colors to blue
- **pch = 19**: changes point shapes
- **cex = 0.5**: changes the size of points

```
scatter3D(x, y, z, colvar = NULL, col = "blue",
          pch = 19, cex = 0.5)
```

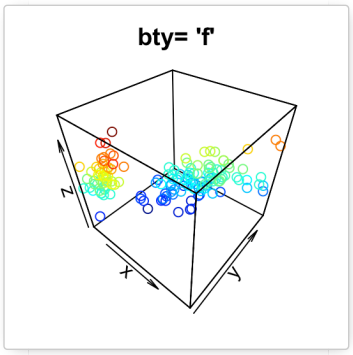


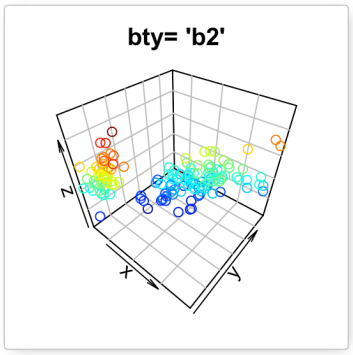
Change the type of the box around the plot

The argument **bty** is used. Allowed values are:

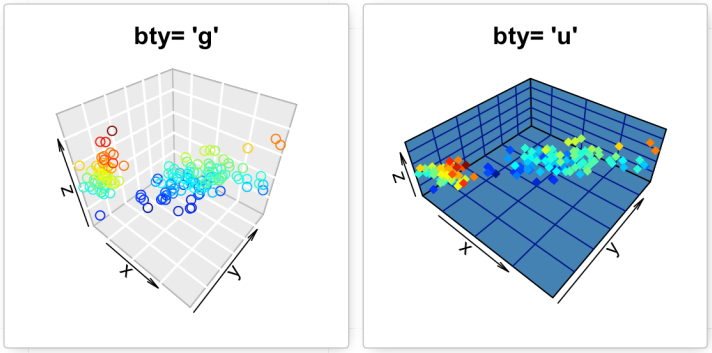
- "f": full box
- "b": default value. Only the back panels are visible
- "b2": back panels and grid lines are visible
- "g": grey background with white grid lines
- "bl": black background
- "bl2": black background with grey lines
- "u": means that the user will specify the arguments col.axis, col.panel, lwd.panel, col.grid, lwd.grid manually
- "n": no box will be drawn. This is the same as setting box = FALSE

```
# full box
scatter3D(x, y, z, bty = "f", colkey = FALSE, main ="bty= 'f'")
# back panels and grid lines are visible
scatter3D(x, y, z, bty = "b2", colkey = FALSE, main ="bty= 'b2'" )
```






```
# grey background with white grid lines
scatter3D(x, y, z, bty = "g", colkey = FALSE, main ="bty= 'g'")
# User defined
scatter3D(x, y, z, pch = 18, bty = "u", colkey = FALSE,
   main ="bty= 'u'", col.panel ="steelblue", expand =0.4,
   col.grid = "darkblue")
```



The argument **colkey = FALSE** is used to remove the legend.

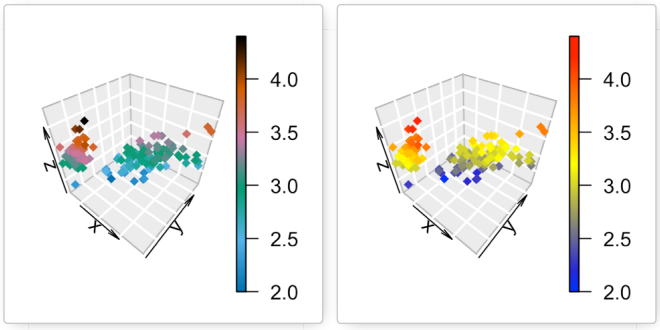
Color palettes

Several color palettes are available in **plot3D** package:

- **jet.col(n, alpha)**: generates the matlab-type colors. This is the default color palette used in plot3D
- **jet2.col(n, alpha)**: similar to *jet.col()* but lacks the deep blue colors
- **gg.col(n, alpha)** and **gg2.col(n, alpha)** generates gg-plot-like colors
- **ramp.col(col = c("grey", "black"), n, alpha)**: creates color schemes by interpolation
- **alpha.col(col = "grey", alpha)**: creates transparent colors

- **n**: Number of colors to generate. Default value is 100
- **alpha**: color transparency. Value in the range 0, 1. Default value is 1
- **col**: Colors to interpolate

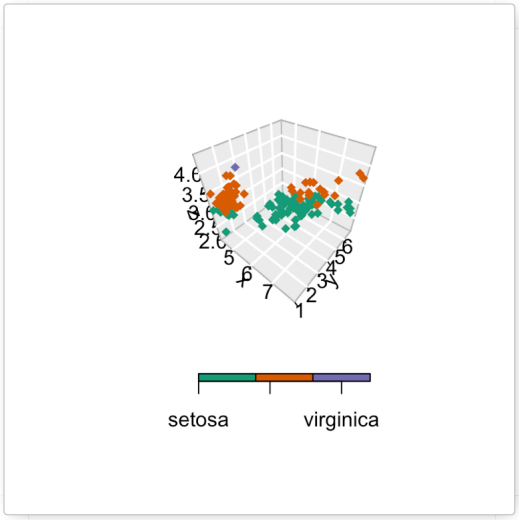
```
# gg.col: ggplot2 like color
scatter3D(x, y, z, bty = "g", pch = 18, col = gg.col(100))
# ramp.col: custom palettes
scatter3D(x, y, z, bty = "g", pch = 18,
          col = ramp.col(c("blue", "yellow", "red")) )
```



Change the color by groups

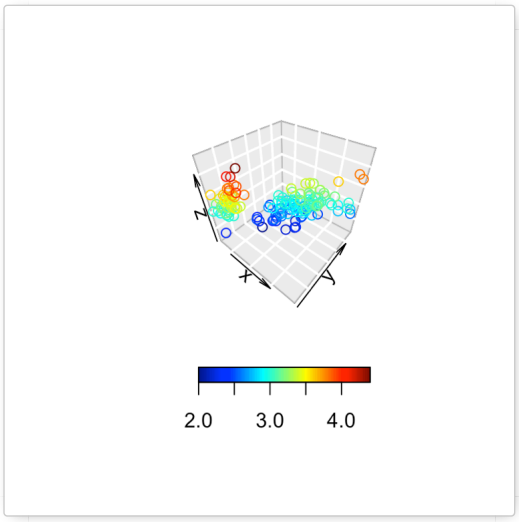
The **colkey** is customized (see **?colkey** for more details):

```
scatter3D(x, y, z, bty = "g", pch = 18,
          col.var = as.integer(iris$Species),
          col = c("#1B9E77", "#D95F02", "#7570B3"),
          pch = 18, ticktype = "detailed",
          colkey = list(at = c(2, 3, 4), side = 1,
          addlines = TRUE, length = 0.5, width = 0.5,
          labels = c("setosa", "versicolor", "virginica")) )
```



Change the position of the legend

```
# Bottom colkey
scatter3D(x, y, z, bty = "g",
          colkey = list(side = 1, length = 0.5))
```

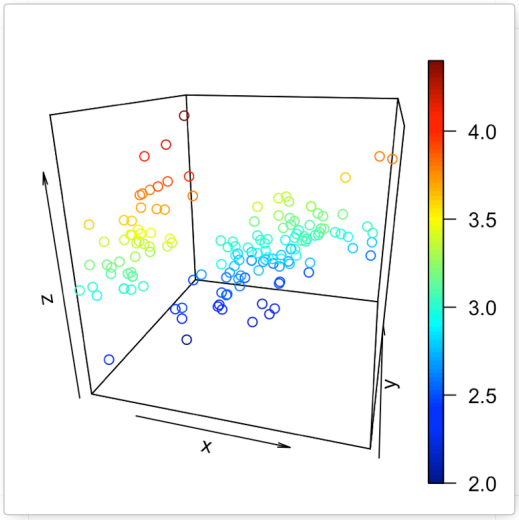


The argument *side* is used to specify the colkey position: 1: for bottom, 2: for left, 3: for top, 4: for right.

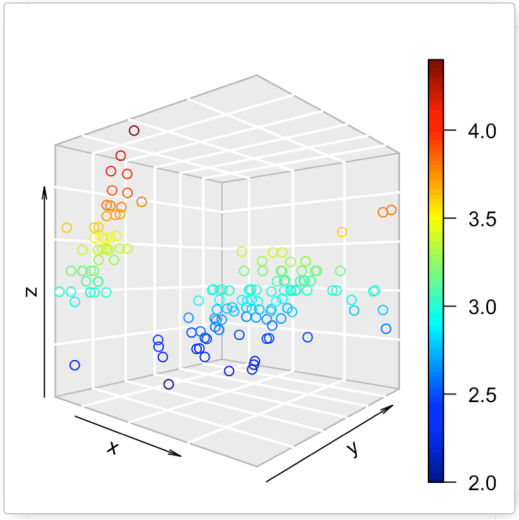
3D viewing direction

The arguments *theta* and *phi* can be used to define the angles for the viewing direction. *theta* is the azimuthal direction and *phi* the co-latitude.

```
scatter3D(x, y, z, theta = 15, phi = 20)
```



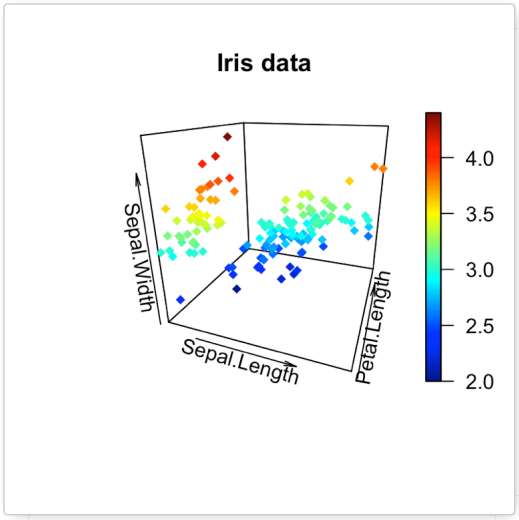

```
scatter3D(x, y, z, phi = 0, bty ="g")
```



The default values for theta and phi are 40.

Titles and axis labels

```
scatter3D(x, y, z, pch = 18,  theta = 20, phi = 20,
          main = "Iris data", xlab = "Sepal.Length",
          ylab ="Petal.Length", zlab = "Sepal.Width")
```



Tick marks and labels

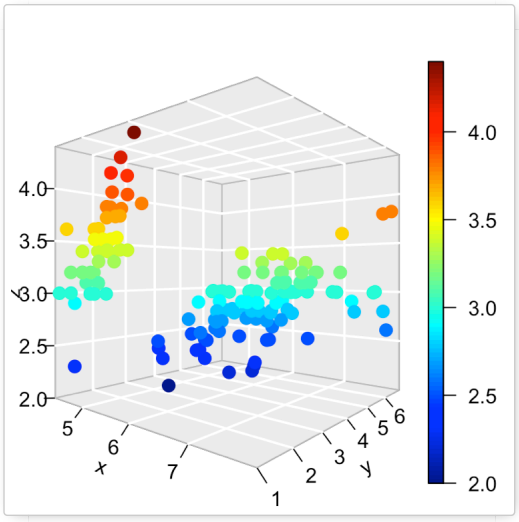
The arguments below can be used:

1. **ticktype**: Possible values are

- *"simple"* draws just an arrow parallel to the axis to indicate direction of increase
- *"detailed"* draws normal ticks and labels

2. **nticks**: the number of tick marks to draw on the axes. It has no effect if ticktype ="simple".

```
scatter3D(x, y, z, phi = 0, bty = "g",
       pch = 20, cex = 2, ticktype = "detailed")
```



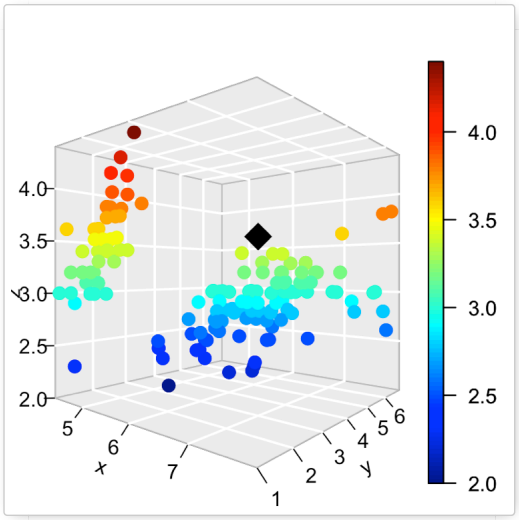
Add points and text to an existing plot

The functions below can be used:

- **scatter3D(x, y, z,..., add = TRUE)**: Adds points
- **text3D(x, y, z, labels, ..., add = TRUE)**: Adds texts

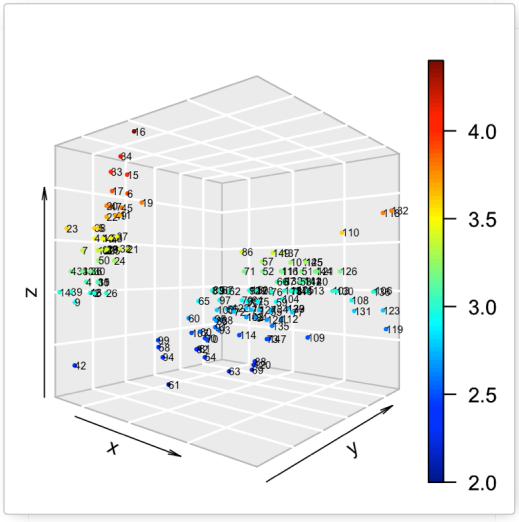
1. **Add points** to an existing plot:

```
# Create a scatter plot
 scatter3D(x, y, z, phi = 0, bty = "g",
        pch = 20, cex = 2, ticktype = "detailed")
# Add another point (black color)
scatter3D(x = 7, y = 3, z = 3.5, add = TRUE, colkey = FALSE,
         pch = 18, cex = 3, col = "black")
```



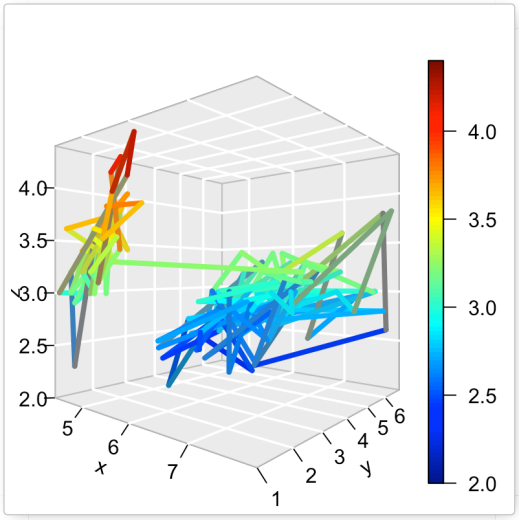
2. **Add texts** to an existing plot:

```
# Create a scatter plot
 scatter3D(x, y, z, phi = 0, bty = "g", pch = 20, cex = 0.5)
# Add text
text3D(x, y, z,  labels = rownames(iris),
        add = TRUE, colkey = FALSE, cex = 0.5)
```

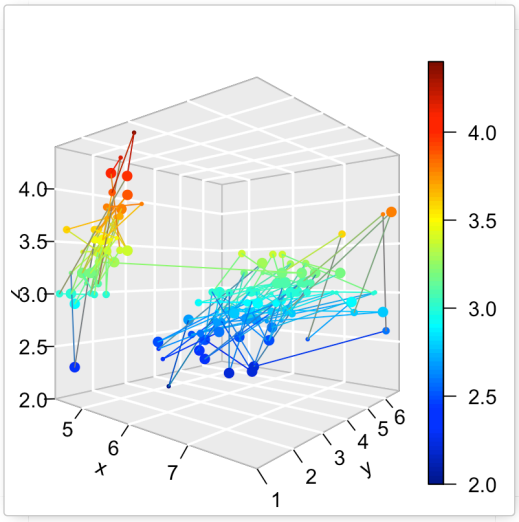


Line plots

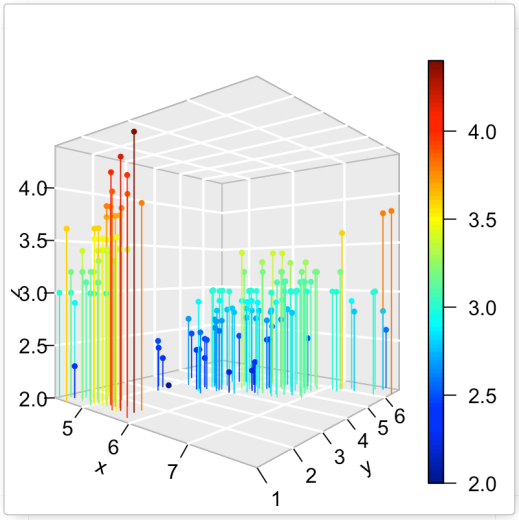
```
# type ="l" for lines only
 scatter3D(x, y, z, phi = 0, bty = "g", type = "l",
           ticktype = "detailed", lwd = 4)
```




```
# type ="b" for both points and lines
 scatter3D(x, y, z, phi = 0, bty = "g", type = "b",
           ticktype = "detailed", pch = 20,
           cex = c(0.5, 1, 1.5))
```




```
# type ="h" for vertical lines
scatter3D(x, y, z, phi = 0, bty = "g",  type = "h",
           ticktype = "detailed", pch = 19, cex = 0.5)
```



Vertical lines are useful to see clearly the x-y location of points.

Add confidence interval

The argument **CI** is used. It's a list containing the parameters and values for the confidence intervals or NULL.

If *CI* is a list, it should contain at least the item x, y or z (latter for scatter3D).These should be 2-columned matrices, defining the left/right intervals.

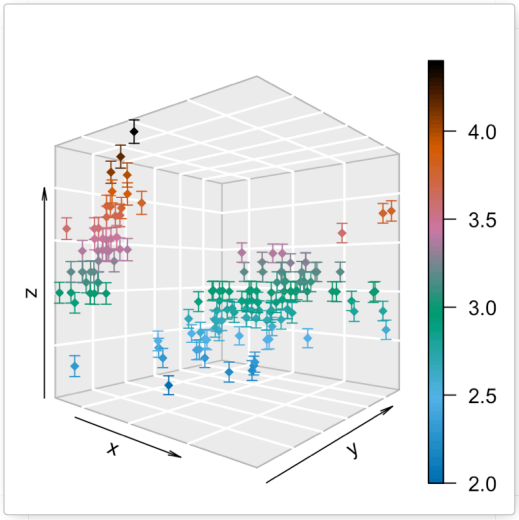
Other parameters should be one of: alen = 0.01, lty = par("lty"), lwd = par("lwd"), col = NULL, to set the length of the arrow head, the line type and width, and the color.

If *col* is *NULL*, then the colors as specified by *colvar* are used.

```
# Confidence interval
CI <- list(z = matrix(nrow = length(x),
                      data = rep(0.1, 2*length(x))))
head(CI$z)
```

```
     [,1] [,2]
[1,]  0.1  0.1
[2,]  0.1  0.1
[3,]  0.1  0.1
[4,]  0.1  0.1
[5,]  0.1  0.1
[6,]  0.1  0.1
```

```
# 3D Scatter plot with CI
scatter3D(x, y, z, phi = 0, bty = "g", col = gg.col(100),
          pch = 18, CI = CI)
```



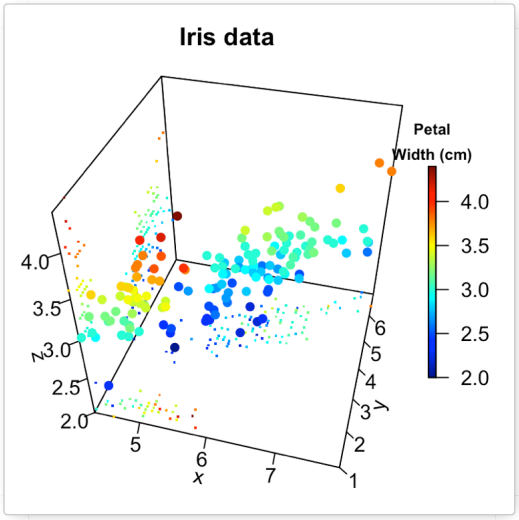
3D fancy Scatter plot with small dots on basal plane

A helper function **scatter3D_fancy()** is used:

```
# Add small dots on basal plane and on the depth plane
scatter3D_fancy <- function(x, y, z,..., colvar = z)
  {
   panelfirst <- function(pmat) {
      XY <- trans3D(x, y, z = rep(min(z), length(z)), pmat = pmat)
      scatter2D(XY$x, XY$y, colvar = colvar, pch = ".",
              cex = 2, add = TRUE, colkey = FALSE)

      XY <- trans3D(x = rep(min(x), length(x)), y, z, pmat = pmat)
      scatter2D(XY$x, XY$y, colvar = colvar, pch = ".",
              cex = 2, add = TRUE, colkey = FALSE)
  }
  scatter3D(x, y, z, ..., colvar = colvar, panel.first=panelfirst,
    colkey = list(length = 0.5, width = 0.5, cex.clab = 0.75))
}
```

Fancy scatter plot:

```
scatter3D_fancy(x, y, z, pch = 16,
    ticktype = "detailed", theta = 15, d = 2,
    main = "Iris data",  clab = c("Petal", "Width (cm)") )
```



Regression plane

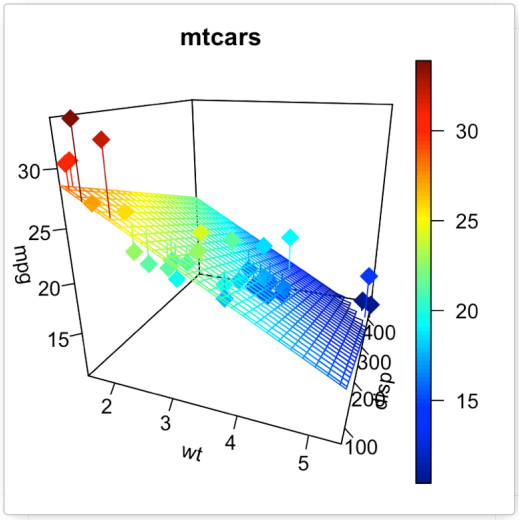
The mtcars data will be used:

```
data(mtcars)
head(mtcars[, 1:6])
```

```
                   mpg cyl disp  hp drat    wt
Mazda RX4         21.0   6  160 110 3.90 2.620
Mazda RX4 Wag     21.0   6  160 110 3.90 2.875
Datsun 710        22.8   4  108  93 3.85 2.320
Hornet 4 Drive    21.4   6  258 110 3.08 3.215
Hornet Sportabout 18.7   8  360 175 3.15 3.440
Valiant           18.1   6  225 105 2.76 3.460
```

1. Use the function *lm()* to compute a linear regression model: *ax + by + cz + d = 0*
2. Use the argument *surf* in **scatter3D()** function to add a regression surface.

```
# x, y, z variables
x <- mtcars$wt
y <- mtcars$disp
z <- mtcars$mpg
# Compute the linear regression (z = ax + by + d)
fit <- lm(z ~ x + y)
# predict values on regular xy grid
grid.lines = 26
x.pred <- seq(min(x), max(x), length.out = grid.lines)
y.pred <- seq(min(y), max(y), length.out = grid.lines)
xy <- expand.grid( x = x.pred, y = y.pred)
z.pred <- matrix(predict(fit, newdata = xy),
                 nrow = grid.lines, ncol = grid.lines)
# fitted points for droplines to surface
fitpoints <- predict(fit)
# scatter plot with regression plane
scatter3D(x, y, z, pch = 18, cex = 2,
    theta = 20, phi = 20, ticktype = "detailed",
    xlab = "wt", ylab = "disp", zlab = "mpg",
    surf = list(x = x.pred, y = y.pred, z = z.pred,
    facets = NA, fit = fitpoints), main = "mtcars")
```



surf is a list specifying a (fitted) surface to be added on the scatter plot. The list should include at least x, y, z, defining the surface.

Other optional parameters can be specified in the *surf* argument including: colvar, col, NAcol, border, facets, lwd, resfac, clim, ltheta, lphi, shade, lighting, fit. (**see ?surf3D** for more details on these parameters)

- Note that, by default **colvar = z**.
- The argument **fit** should give the fitted *z-values*, in the same order as the z-values of the scatter points, for instance produced by *predict()*. When present, this will produce droplines from points to the fitted surface.

Note that, the function **expand.grid()**, in the R code above, creates a data frame from all combinations of factors

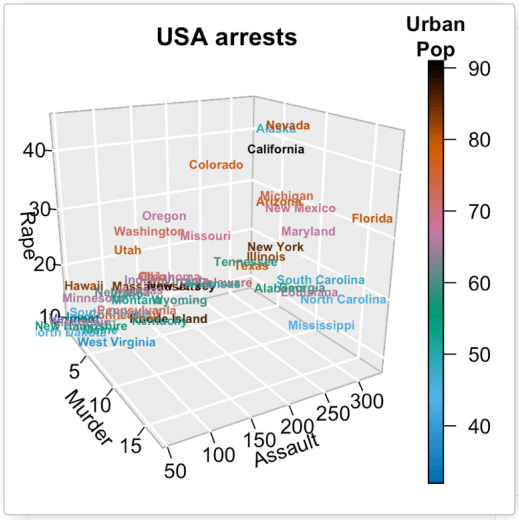
text3D: plot 3-dimensionnal texts

The function **text3D()** is used as follow:

```
text3D(x, y, z, labels, ...)
```

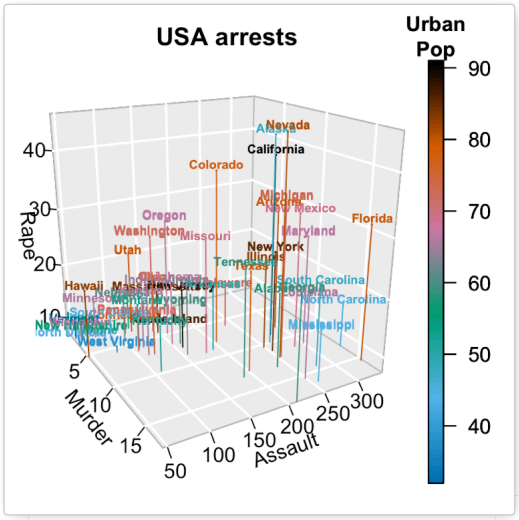
The USArrests data sets will be used in the example below:

```
data(USArrests)
with(USArrests, text3D(Murder, Assault, Rape,
  labels = rownames(USArrests), colvar = UrbanPop,
  col = gg.col(100), theta = 60, phi = 20,
  xlab = "Murder", ylab = "Assault", zlab = "Rape",
  main = "USA arrests", cex = 0.6,
  bty = "g", ticktype = "detailed", d = 2,
  clab = c("Urban","Pop"), adj = 0.5, font = 2))
```

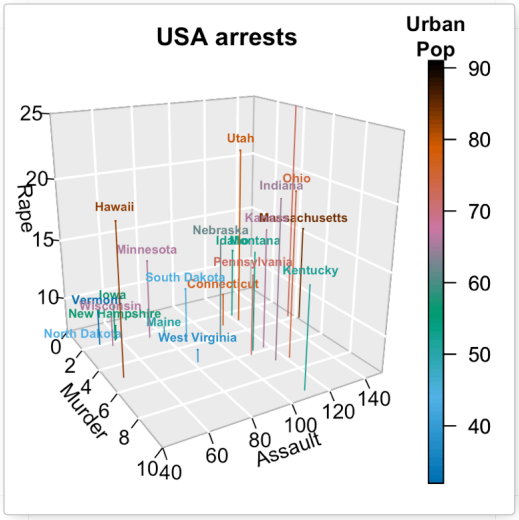


text3D and scatter3D

```
# Plot texts
with(USArrests, text3D(Murder, Assault, Rape,
  labels = rownames(USArrests), colvar = UrbanPop,
  col = gg.col(100), theta = 60, phi = 20,
  xlab = "Murder", ylab = "Assault", zlab = "Rape",
  main = "USA arrests", cex = 0.6,
  bty = "g", ticktype = "detailed", d = 2,
  clab = c("Urban","Pop"), adj = 0.5, font = 2))
# Add points
 with(USArrests, scatter3D(Murder, Assault, Rape - 1,
    colvar = UrbanPop, col = gg.col(100),
    type = "h", pch = ".", add = TRUE))
```




```
# Zoom near origin: choose suitable ranges
 plotdev(xlim = c(0, 10), ylim = c(40, 150),
         zlim = c(7, 25))
```



Note that, in order to choose suitable ranges for zooming, you can display axis ranges as follow:

```
# display axis ranges
 getplist()[c("xlim","ylim","zlim")]
```

```
$xlim
[1]  0.8 17.4
$ylim
[1]  45 337
$zlim
[1]  7.3 46.0
```

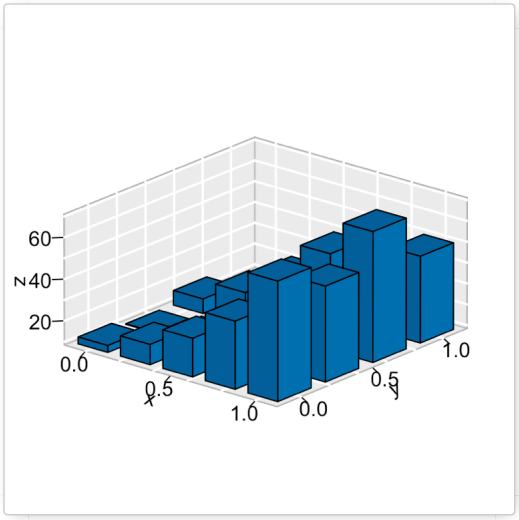
3D Histogram

The function **hist3D()** is used:

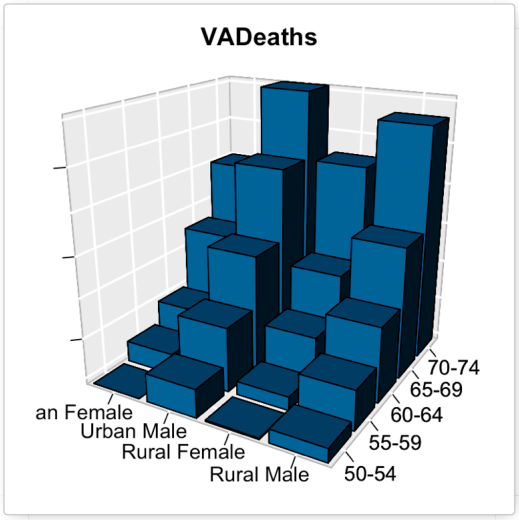
```
hist3D (x, y, z, ..., colvar = z,
      col = NULL,  add = FALSE)
```

- **z**: Matrix containing the values to be plotted
- **x, y** vectors with x and y values. *x* should be of length equal to nrow(z) and y should be equal to ncol(z)
- **colvar**: the variable used for coloring. If present, it should have the same dimension as z.
- **col**: color palette to be used for the colvar variable. By default a *red-yellow-blue* color scheme (?jet.col) is used
- **add**: Logical. If TRUE, then the surfaces will be added to the current plot. If FALSE a new plot is started.

```
data(VADeaths)
#  hist3D and ribbon3D with greyish background, rotated, rescaled,...
hist3D(z = VADeaths, scale = FALSE, expand = 0.01, bty = "g", phi = 20,
        col = "#0072B2", border = "black", shade = 0.2, ltheta = 90,
        space = 0.3, ticktype = "detailed", d = 2)
```



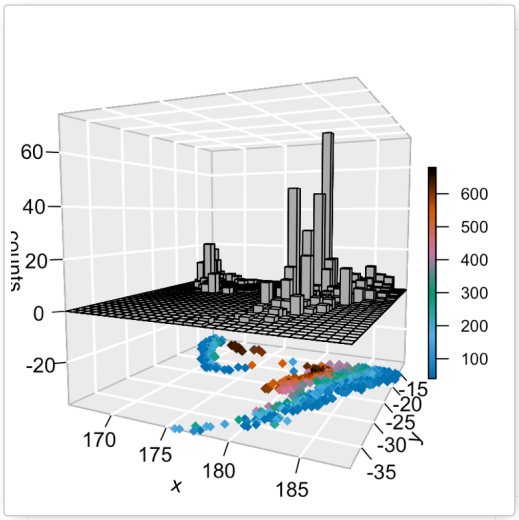

```
hist3D (x = 1:5, y = 1:4, z = VADeaths,
        bty = "g", phi = 20,  theta = -60,
        xlab = "", ylab = "", zlab = "", main = "VADeaths",
        col = "#0072B2", border = "black", shade = 0.8,
        ticktype = "detailed", space = 0.15, d = 2, cex.axis = 1e-9)
# Use text3D to label x axis
 text3D(x = 1:5, y = rep(0.5, 5), z = rep(3, 5),
       labels = rownames(VADeaths),
       add = TRUE, adj = 0)
# Use text3D to label y axis
 text3D(x = rep(1, 4),   y = 1:4, z = rep(0, 4),
       labels  = colnames(VADeaths),
       add = TRUE, adj = 1)
```



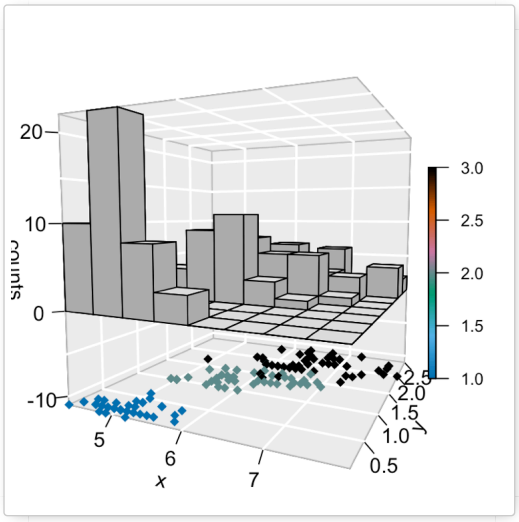
fancy 3D histograms

```
  # Compute the number of classes for a histogram
  break.func <- break.func [1]
  if(is.null(breaks)){
    x.breaks <- switch(break.func,
                       Sturges = nclass.Sturges(x),
                       scott = nclass.scott(x),
                       FD = nclass.FD(x))
    y.breaks <- switch(break.func,
                       Sturges = nclass.Sturges(y),
                       scott = nclass.scott(y),
                       FD = nclass.FD(y))
  } else x.breaks <- y.breaks <- breaks

  # Cut x and y variables in bins for counting
  x.bin <- seq(min(x), max(x), length.out = x.breaks)
  y.bin <- seq(min(y), max(y), length.out = y.breaks)
  xy <- table(cut(x, x.bin), cut(y, y.bin))
  z <- xy

  xmid <- 0.5*(x.bin[-1] + x.bin[-length(x.bin)])
  ymid <- 0.5*(y.bin[-1] + y.bin[-length(y.bin)])

  oldmar <- par("mar")
  par (mar = par("mar") + c(0, 0, 0, 2))
  hist3D(x = xmid, y = ymid, z = xy, ...,
    zlim = c(-max(z)/2, max(z)), zlab = "counts", bty= "g",
    phi = phi, theta = theta,
    shade = 0.2, col = col, border = "black",
    d = 1, ticktype = "detailed")

  scatter3D(x, y,
    z = rep(-max(z)/2, length.out = length(x)),
    colvar = colvar, col = gg.col(100),
    add = TRUE, pch = 18, clab = clab,
    colkey = list(length = 0.5, width = 0.5,
       dist = 0.05, cex.axis = 0.8, cex.clab = 0.8)
       )
  par(mar = oldmar)
}
```

```
hist3D_fancy(quakes$long, quakes$lat, colvar=quakes$depth,
             breaks =30)
```



```
hist3D_fancy(iris$Sepal.Length, iris$Petal.Width,
             colvar=as.numeric(iris$Species))
```



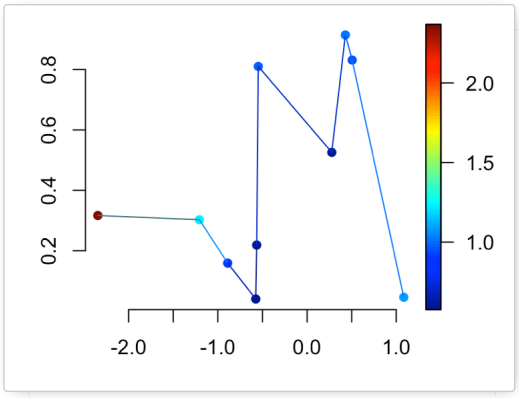
scatter2D: 2D scatter plot

Create some data:

```
# x, y coordinates
set.seed(1234)
x  <- sort(rnorm(10))
y  <- runif(10)
# Variable for coloring points
col.v <- sqrt(x^2 + y^2)
```

Basic 2D scatter plot:

```
scatter2D(x, y, colvar = col.v, pch = 16, bty ="n",
          type ="b")
```



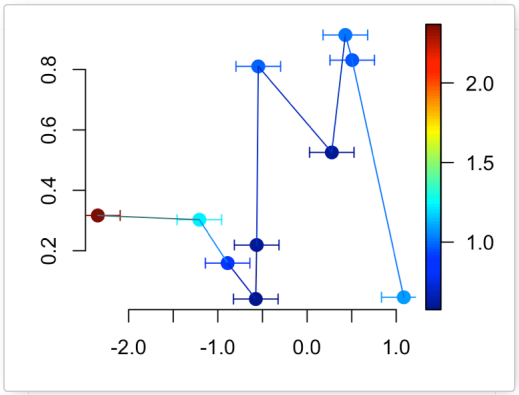
1. **type**: plot types. Allowed values are:

- **"b"** to draw both points and line
- **"h"** for vertical line
- **"l"** for line only
- **"p"** for points only

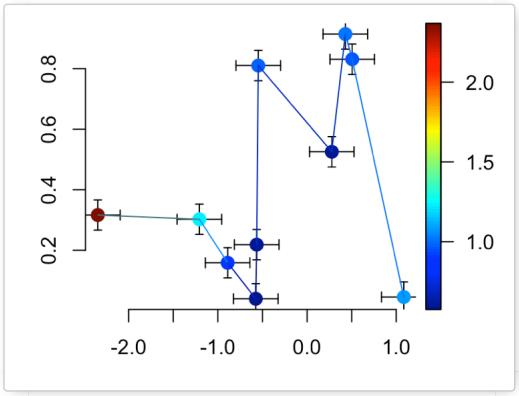
1. **bty**: box type

2D scatter plot with confidence interval:

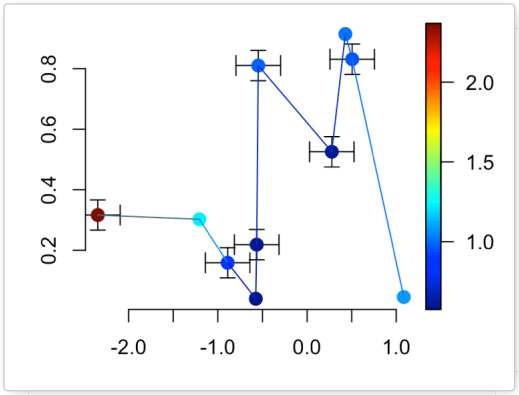
```
# Confidence interval for x variable only
CI <- list()
CI$x <- matrix(nrow = length(x), data = c(rep(0.25, 2*length(x))))
scatter2D(x, y, colvar = col.v, pch = 16, bty ="n", cex = 1.5,
          CI = CI, type = "b")
```




```
# Confidence interval for both x and y variables
CI$y <- matrix (nrow = length(y), data = c(rep(0.05, 2*length(y))))
CI$col <- "black"
scatter2D(x, y, colvar = col.v, pch = 16,  bty ="n", cex = 1.5,
          CI = CI, type ="b")
```

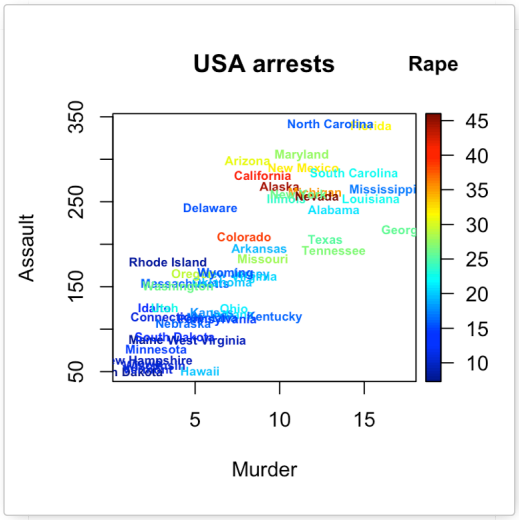



```
CI$y[c(2,4,8,10), ] <- NA  # Some points have no CI
CI$x[c(2,4,8,10), ] <- NA  # Some points have no CI
CI$alen <- 0.02            # increase arrow head
scatter2D(x, y, colvar = col.v, pch = 16,  bty ="n", cex = 1.5,
          CI = CI, type ="b")
```

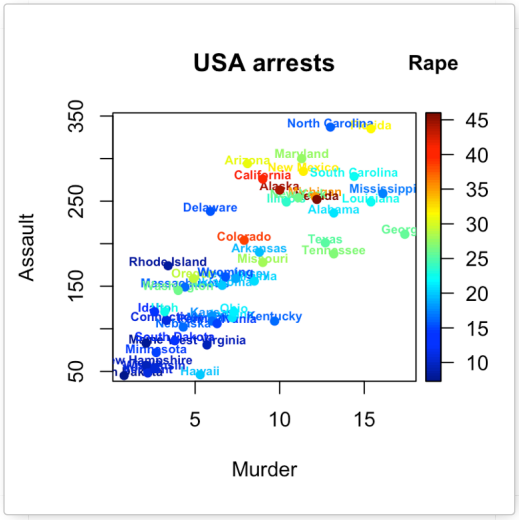


text2D

```
# Only text
with(USArrests, text2D(x = Murder, y = Assault + 5, colvar = Rape,
     xlab = "Murder", ylab = "Assault", clab = "Rape",
     main = "USA arrests", labels = rownames(USArrests), cex = 0.6,
     adj = 0.5, font = 2))
```




```
# text with point
 with(USArrests, text2D(x = Murder, y = Assault + 5, colvar = Rape,
     xlab = "Murder", ylab = "Assault", clab = "Rape",
     main = "USA arrests", labels = rownames(USArrests), cex = 0.6,
     adj = 0.5, font = 2))
 with(USArrests, scatter2D(x = Murder, y = Assault, colvar = Rape,
     pch = 16, add = TRUE, colkey = FALSE))
```



Other functions

It's also possible to draw arrows, segments and rectangles in a 3D or 2D plot using the functions below:

```
arrows3D(x0, y0, z0, x1, y1, z1, ..., colvar = NULL,
         col = NULL, type = "triangle", add = FALSE)
segments3D(x0, y0, z0, x1, y1, z1, ..., colvar = NULL,
           col = NULL, add = "FALSE")
rect3D(x0, y0, y0, x1, y1, z1, ..., colvar = NULL,
       col = NULL, add = FALSE)
arrows2D(x0, y0, z0, x1, y1, z1, ..., colvar = NULL,
         col = NULL, type = "triangle", add = FALSE)
segments2D(x0, y0, z0, x1, y1, z1, ..., colvar = NULL,
           col = NULL, add = "FALSE")
rect2D(x0, y0, y0, x1, y1, z1, ..., colvar = NULL,
       col = NULL, add = FALSE)
```

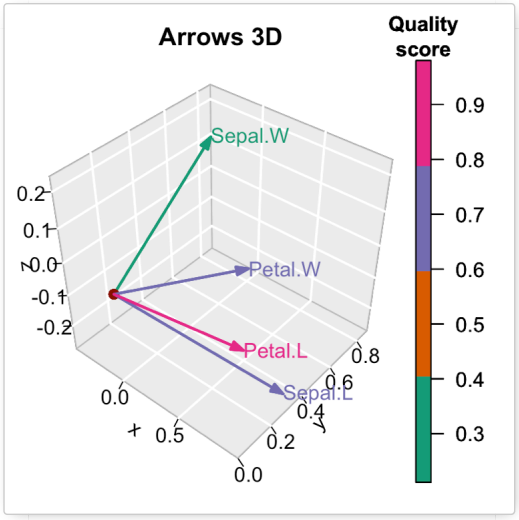
- **x0, y0, z0**: coordinates of points from which to draw
- **x1**, **y1**, **z1**: coordinates of points to which to draw. For arrows3D and segments3D, at least one must be supplied. For rect3D exactly one must be NULL.
- **colvar**: The variable used for coloring.
- **col**: color palette to be used for coloring. Default is *red-yellow-blue* color scheme.
- **add**: Logical. If TRUE, then the arrows, segments, ... will be added to the current plot. If FALSE a new plot is started.

Prepare the data: we want to plot 4 arrows starting from the point of coordinates c(x0, y0, z0) and ending at c(x1, y1, z1)

```
x0 <- c(0, 0, 0, 0)
y0 <- c(0, 0, 0, 0)
z0 <- c(0, 0, 0, 0)
x1 <- c(0.89, -0.46, 0.99, 0.96)
y1 <- c(0.36,  0.88, 0.02, 0.06)
z1 <- c(-0.28, 0.09, 0.05, 0.24)
cols <- c("#1B9E77", "#D95F02", "#7570B3", "#E7298A")
```

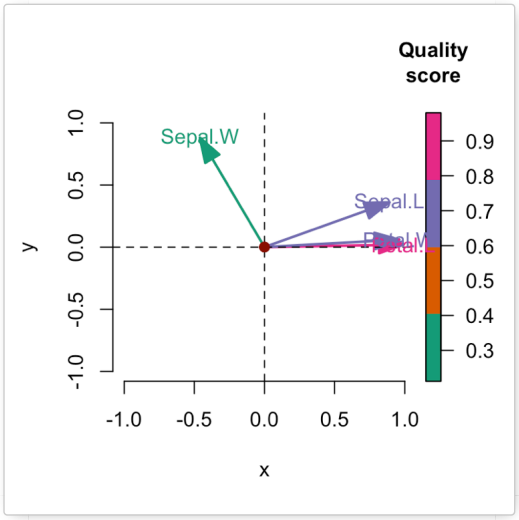
3D Arrows:

```
arrows3D(x0, y0, z0, x1, y1, z1, colvar = x1^2, col = cols,
         lwd = 2, d = 3, clab = c("Quality", "score"),
         main = "Arrows 3D", bty ="g", ticktype = "detailed")
# Add starting point of arrow
points3D(x0, y0, z0, add = TRUE, col="darkred",
          colkey = FALSE, pch = 19, cex = 1)
# Add labels to the arrows
text3D(x1, y1, z1, c("Sepal.L", "Sepal.W", "Petal.L", "Petal.W"),
       colvar = x1^2, col = cols, add=TRUE, colkey = FALSE)
```



2D arrows:

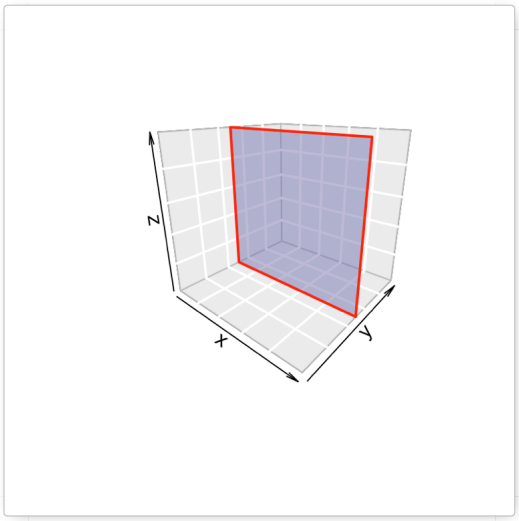
```
arrows2D(x0, y0,  x1, y1,  colvar = x1^2, col = cols,
         lwd = 2, clab = c("Quality", "score"),
          bty ="n", xlim = c(-1, 1), ylim = c(-1, 1))
# Add vertical and horizontal lines at c(0,0)
abline(h =0, v = 0, lty = 2)
# Add starting point of arrow
points2D(x0, y0, add = TRUE, col="darkred",
          colkey = FALSE, pch = 19, cex = 1)
# Add labels to the arrows
text2D(x1, y1, c("Sepal.L", "Sepal.W", "Petal.L", "Petal.W"),
       colvar = x1^2, col = cols, add=TRUE, colkey = FALSE)
```



Note that, **segments3D()** and **segments2D()** are very similar to **arrows3D()** and **arrows2D()** and you can play with them also.

3D rectangle: the R code below creates a rectangle with a transparent fill color (alpha = 0.5)

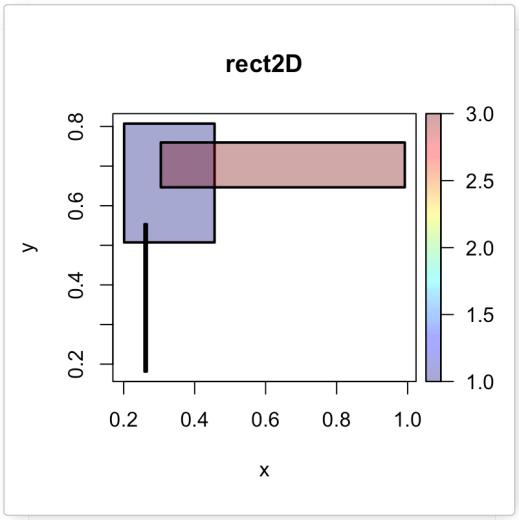
```
rect3D(x0 = 0, y0 = 0.5, z0 = 0, x1 = 1, z1 = 5,
       ylim = c(0, 1), bty = "g", facets = TRUE,
       border = "red", col ="#7570B3", alpha=0.5,
       lwd = 2, phi = 20)
```



In the R code above, *facets = FALSE* will remove the rectangle fill color.

2D rectangle:

```
rect2D(x0 = runif(3), y0 = runif(3),
       x1 = runif(3), y1 = runif(3), colvar = 1:3,
       alpha = 0.4, lwd = 2, main = "rect2D")
```



Interactive plot

To draw an interactive **3D plot** the package **plot3Drgl** can be used.

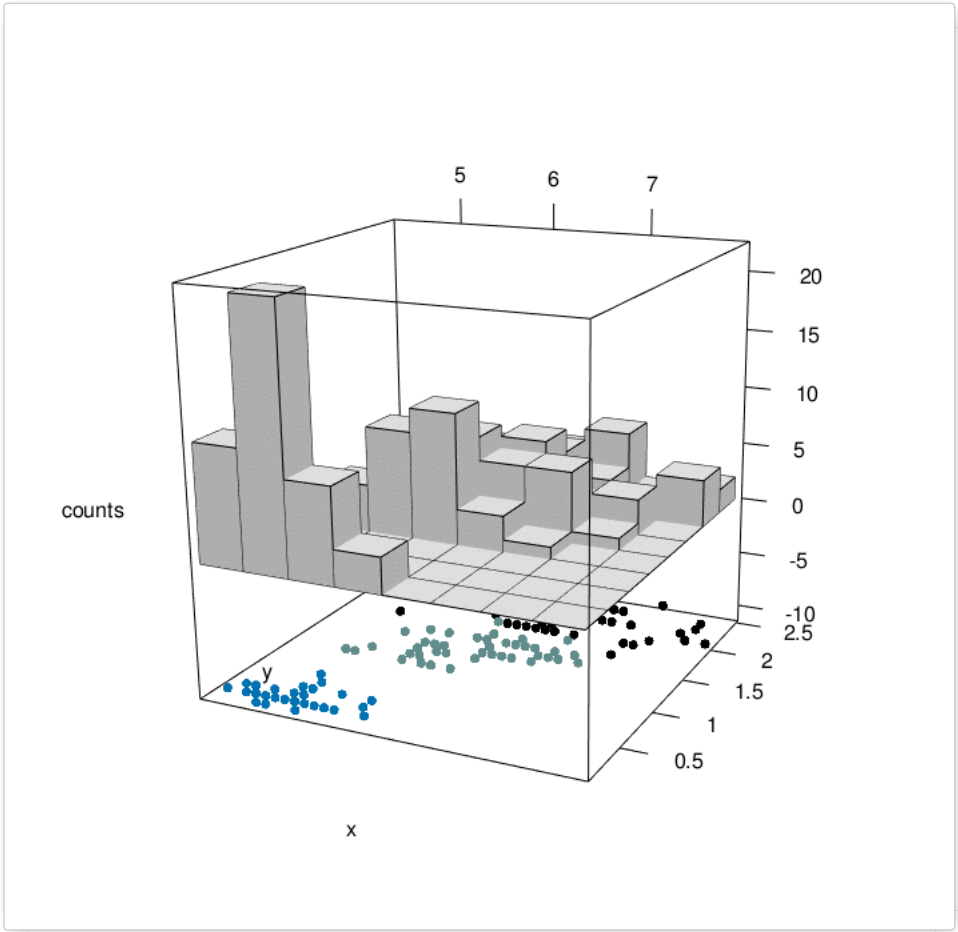
The package **plot3Drgl** allows to plot the graph generated with **plot3D** in openGL, as made available by package rgl.

The simplest way is to do as follow:

1. Create base R-graphics using plot3D package
2. Then use the function plotrgl() to draw the same figure in rgl

The package **rgl** allows to interactively rotate, zoom the graphs. However it's not yet possible to plot a colorkey

```
# Create his3D using plot3D
hist3D_fancy(iris$Sepal.Length, iris$Petal.Width, colvar=as.numeric(iris$Species))
# Make the rgl version
library("plot3Drgl")
plotrgl()
```



Note that, after creating the rgl plot you can use the functions below:

- croprgl(xlim, ylim, zlim, ...) to modify the ranges
- cutrgl(...) to zoom in on a selected region of the plot. The current plot will be overwritten
- uncutrgl(...) and uncroprgl(...) restore the original plot.
- ...: any arguments for par3d, open3d or material3d in rgl package.

Infos

This analysis has been performed using **R software** (ver. 3.1.2) and **plot3D** (ver. 1.0-2)

References:

- Karline Soetaert. plot3D: Tools for plotting 3-D and 2-D data. http://cran.r-

project.org/web/packages/plot3D/vignettes/plot3D.pdf

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