

3D Data Visualization in R and Applications in Business

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Introduction

What is 3D visualization.

3D Visualization is the practice of representing Data in the 3 dimensional space (with X,Y and Z axes) to give a perception of Height, width and depth in the visualized information. It allows users to see relationship among three variables, instead of the usual 2D dimensions (X,Y)

R Ecosystem for 3D Visualization

Core 3D graphics packages:

rgl : it is a low-level 3D graphics, built with OpenGL/WebGL as the rendering backend.here is an axample:

```
1 library(rgl)
2 library(MASS)
3 # from the fitdistr example
4 set.seed(123)
5 x <- rgamma(100, shape = 5, rate = 0.1)
6 fit <- fitdistr(x, dgamma, list(shape = 1, rate = 0.1), lower = 0.001)
7 loglik <- function(shape, rate) sum(dgamma(x, shape=shape, rate=rate,
8                                     log=TRUE))
9 loglik <- Vectorize(loglik)
10 xlim <- fit$estimate[1]+4*fit$sd[1]*c(-1,1)
11 ylim <- fit$estimate[2]+4*fit$sd[2]*c(-1,1)
12
13 mffrow3d(1, 2, sharedMouse = TRUE)
14 persp3d(loglik,
15           xlim = xlim, ylim = ylim,
16           n = 30)
17 zlim <- fit$loglik + c(-qchisq(0.99, 2)/2, 0)
18 next3d()
```

scatterplot3d : Scatterplot3D is also used to create static 3D

scatter Plots using base R graphics. it generates a scatter plot in 3D space using parallel projection. Most features of the R graphics systems can be applied in Scatterplot3d, amoung them are vectorizing of colors or plotting symbols and mathematical annotation (Murrell and Ihaka, 2000)

Data Preparation for 3D Plots

- Pick three numeric variables that have a logical relationship; random triples variables rarely come up with useful patterns
- For 3D scatter plots, your data can stay in a data frame with only one column per variable (X,Y,Z) -Dropping rows if only a few values are missing -**Imputing** using mean/median or Model-based methods, being careful not to distort patterns.
- Large differences in scale can make the 3D plot hard to read, Normalization, standardization or Log transforms can help so all three axes are on comparable scales.

An example to fully understand how Scatterplot3d works in R

```
1 # Load the package for 3D scatterplots
2 library(scatterplot3d)
3
4 # Use the built-in mtcars dataset
5 # We will plot horsepower (hp), weight (wt), and miles per gallon (mpg)
6
7 # Assign variables for clarity in teaching
8 hp <- mtcars$hp      # X-axis: Horsepower
9 wt <- mtcars$wt      # Y-axis: Weight
10 mpg <- mtcars$mpg    # Z-axis: Miles per gallon
11
12 # Create a basic 3D scatterplot
13 scatterplot3d(
14   x = hp,
15   y = wt,
16   z = mpg,
17   pch = 19,           # Solid points
18   color = "blue".     # Point color
```

Basic 3D Plot Examples in R

- create a basic 3D plot

- define x and y

```
x <- -20:20 y <- -20:20
```

- we create a z value and have a correlation to x and y

```
z_val <- function(x, y) { sqrt(x ^ 2 + y ^ 2)}  
z<-outer(x, y, z_val)
```

- create a 3D plot

```
persp(x, y, z)
```

Business Application of 3D Visualization

3D visualizations in R is used communicate insights to non-technical stakeholders. It helps support better decisions in domains like risk, operations, marketing and finance.

- Marketing and Finance: 3D plots can show how sales depend on two variables at once, look at price and advertising spend.
- finance and Risk: visualization with axes such as risk, return and market cap or credit rating, this helps analysts see underperforming vs efficient assets.
- Operations: 3D plots helps mangers and operation

Pitfalls of 3D plot

- Harder to read accurately: perspective and depth make it harder to judge exact values and overlapping points or surfaces can hide data.
- Design and technical limitations :
 - base graphics as a static 3D plot lock into a single viewpoint, if the chosen angle is poor, important patterns are hidden.
 - labels, legends and color scales can be cluttered or hard to read when projected into 3D, especially when many categories are shown at once.

Summary

This mini project explores how R is used to create 3D visualizations to better understand complex business data. Main focus was on R packages like rgl and scatterplot3d that reveal relationship between three or more variables at once.

On the business side, it shows how 3D graphs support domains like sales and marketing analysis, risk and financial evaluation and operations optimization

References

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- Murrell, P., & Ihaka, R. (2000). An approach to providing mathematical annotation in plots. *Journal of Computational and Graphical Statistics*, 9(3), 582–599.
- Sutherland, I. (1963). *Sketchpad: A man-machine graphical communication system* (Unpublished doctoral dissertation). MIT Lincoln Laboratory.