

Week-1

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- Packages
 - devtools
 - tidyverse
 - here

```
# Include the script from the R directory
project_path <- here()
source(here("R", "utils.R"))
source(here("R", "distance_functions.R"))
```

Clustering

Given a clustering $C = \{C_1, C_2, \dots, C_k\}$, we need some scoring function that evaluates its quality or goodness. This sum of squared errors scoring function is defined as:

$$W(C) = \frac{1}{2} \sum_{k=1}^K \sum_{i: C(i)=k} \|x_i - \bar{x}_k\|^2$$

The goal is to find the clustering that minimizes:

$$C^* = \arg \min_C \{W(c)\}$$

K-means employs a greedy iterative approach to find a clustering that minimizes loss function.

Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.

```
euclidean_dist <- function(point1, point2) {
  squared_diff <- (point1 - point2)^2
  sqrt(sum(squared_diff))
}

x <- y <- seq(-1, 1, length = 20)
grid <- expand.grid(x = x, y = y) # Create a grid of points
z <- matrix(0, nrow = length(x), ncol = length(y)) # Initialize the z matrix

for (i in 1:length(x)) {
  for (j in 1:length(y)) {
```

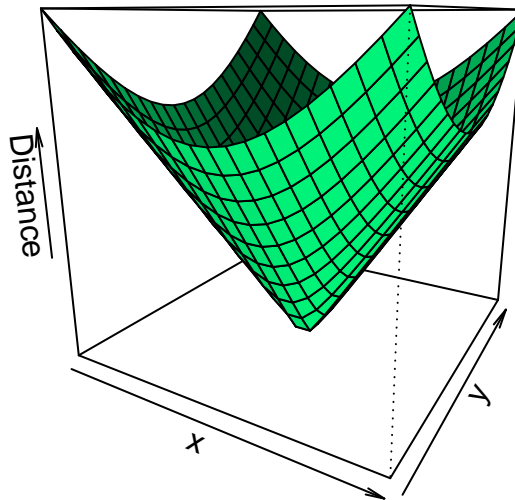
Algorithm 1: K-means Algorithm

Data: D, k, ε

```
1 K-means( $D, k, \varepsilon$ ):  
2  $t \leftarrow 0$ ;  
3 Randomly initialize  $k$  centroids:  $\mu_1^t, \mu_2^t, \dots, \mu_k^t \in \mathbb{R}^d$ ;  
4 repeat  
5    $t \leftarrow t + 1$ ;  
6    $C_i \leftarrow \emptyset$  for all  $i = 1, \dots, k$   
7   /* Cluster assignment step */  
8   for  $x_j \in D$  do  
9      $i^* \leftarrow \operatorname{argmin}_i \{\|x_j - \mu_i^{t-1}\|^2\}$ ;  
10    /* assign  $x_j$  to closest centroid */  
11     $C_{i^*} \leftarrow C_{i^*} \cup \{x_j\}$ ;  
12  end  
13  for  $i = 1, \dots, k$  do  
14     $\mu_i^t \leftarrow \frac{1}{|C_i|} \sum_{x_j \in C_i} x_j$   
15  end  
16 until  $\sum_{i=1}^k \|\mu_i^t - \mu_i^{t-1}\|^2 \leq \varepsilon$ ;
```

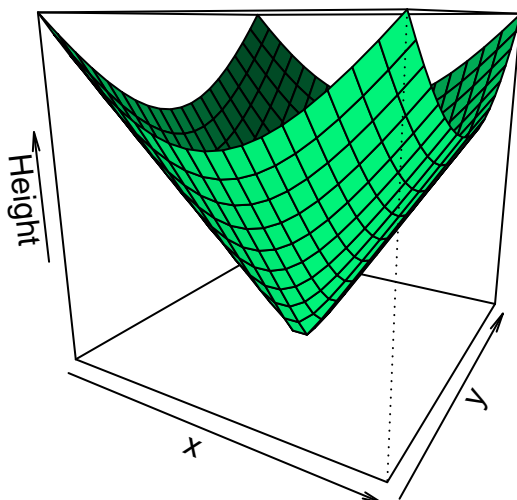
```
    z[i, j] <- euclidean_dist(c(x[i], y[j]), c(0, 0))  
  }  
}  
persp(x, y, z,  
      main = "3D Plot of Euclidean Distance",  
      zlab = "Distance",  
      theta = 30, phi = 15,  
      col = "springgreen", shade = 0.5)
```

3D Plot of Euclidean Distance



```
cone1 <- function(x, y){  
  sqrt(x^2+y^2)  
}  
  
x <- y <- seq(-1, 1, length= 20)  
z <- outer(x, y, cone1)  
  
persp(x, y, z,  
main="Perspective Plot of a Cone",  
zlab = "Height",  
theta = 30, phi = 15,  
col = "springgreen", shade = 0.5)
```

Perspective Plot of a Cone



```
euclidean_dist <- function(point1, point2) {  
  squared_diff <- (point1 - point2)^2  
  sqrt(sum(squared_diff))  
}  
  
manhattan_distance <- function(point1, point2) {  
  if (length(point1) != length(point2)) {  
    stop("Both points should have the same number of dimensions.")  
  }  
  
  abs_diff <- abs(point1 - point2)  
  distance <- sum(abs_diff)  
  return(distance)  
}  
  
x <- y <- seq(-1, 1, length = 20)  
grid <- expand.grid(x = x, y = y) # Create a grid of points  
z_euclidean <- matrix(0, nrow = length(x), ncol = length(y)) # Initialize the z matrix for Euclidean d  
z_manhattan <- matrix(0, nrow = length(x), ncol = length(y)) # Initialize the z matrix for Manhattan  
  
for (i in 1:length(x)) {  
  for (j in 1:length(y)) {  
    z_euclidean[i, j] <- euclidean_dist(c(x[i], y[j]), c(0, 0))  
    z_manhattan[i, j] <- manhattan_distance(c(x[i], y[j]), c(0, 0))  
  }  
}
```

```

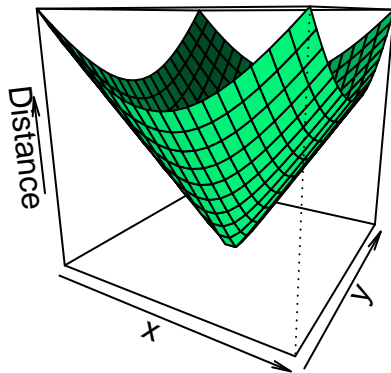
# Create a layout of subplots to show both Euclidean and Manhattan distances
par(mfrow = c(1, 2))

# Plot for Euclidean distance
persp(x, y, z_euclidean,
      main = "3D Plot of Euclidean Distance",
      zlab = "Distance",
      theta = 30, phi = 15,
      col = "springgreen", shade = 0.5)

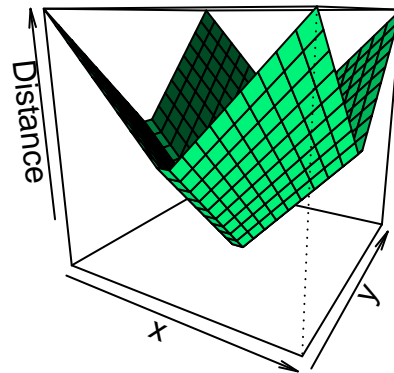
# Plot for Manhattan distance
persp(x, y, z_manhattan,
      main = "3D Plot of Manhattan Distance",
      zlab = "Distance",
      theta = 30, phi = 15,
      col = "springgreen", shade = 0.5)

```

3D Plot of Euclidean Distance



3D Plot of Manhattan Distance



```

# Reset the layout
par(mfrow = c(1, 1))

```

```

euclidean_dist <- function(point1, point2) {
  squared_diff <- (point1 - point2)^2
  sqrt(sum(squared_diff))
}

```

```

manhattan_distance <- function(point1, point2) {
  if (length(point1) != length(point2)) {
    stop("Both points should have the same number of dimensions.")
  }

  abs_diff <- abs(point1 - point2)
  distance <- sum(abs_diff)
  return(distance)
}

x <- y <- seq(-5, 5, length = 20)
grid <- expand.grid(x = x, y = y) # Create a grid of points

z_euclidean <- matrix(0, nrow = length(x), ncol = length(y)) # Initialize the z matrix for Euclidean d
z_manhattan <- matrix(0, nrow = length(x), ncol = length(y)) # Initialize the z matrix for Manhattan

for (i in 1:length(x)) {
  for (j in 1:length(y)) {
    z_euclidean[i, j] <- euclidean_dist(c(x[i], y[j]), c(0, 0))
    z_manhattan[i, j] <- manhattan_distance(c(x[i], y[j]), c(0, 0))
  }
}

# Combine the distances and choose different colors for each
combined_distances <- z_euclidean + z_manhattan
color_palette <- colorRampPalette(c("blue", "green"))(100) # Choose colors for mapping distances

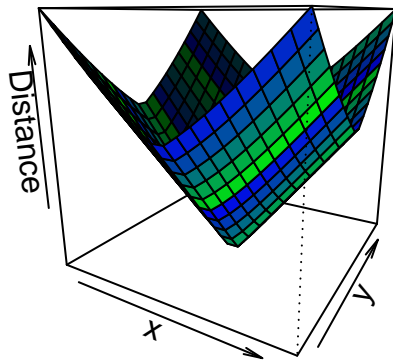
# Create a layout of subplots
layout(matrix(c(1, 2), nrow = 1))

# Plot both distances on the same 3D plane with different colors
persp(x, y, combined_distances,
      main = "3D Plot of Combined Distances",
      zlab = "Distance",
      theta = 30, phi = 15,
      col = color_palette, shade = 0.5)

# Reset the layout
layout(1)

```

3D Plot of Combined Distances



```
# Include the script from the R directory
project_path <- here()
source(here("R", "utils.R"))
```

```
?entropy
```

```
## No documentation for 'entropy' in specified packages and libraries:
## you could try '??entropy'
```

```
library("car")
```

```
## Loading required package: carData
```

```
##
```

```
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
##      recode
```

```
## The following object is masked from 'package:purrr':
```

```
##
```

```
##      some
```

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

```
## This build of rgl does not include OpenGL functions. Use  
## rglwidget() to display results, e.g. via options(rgl.printRglwidget = TRUE).
```

```
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
```

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

```
library("car")  
library("rgl")  
data(iris)  
sep.l <- iris$Sepal.Length  
sep.w <- iris$Sepal.Width  
pet.l <- iris$Petal.Length  
  
save <- getOption("rgl.useNULL")  
options(rgl.useNULL = TRUE)  
scatter3d(x = sep.l, y = pet.l, z = sep.w, groups = iris$Species,  
          surface = FALSE, ellipsoid = TRUE)
```

```
## Loading required namespace: mgcv
```

```
## Loading required namespace: MASS
```

```
widget <- rglwidget()
```

```
## Warning in snapshot3d(scene = x, width = width, height = height): webshot =  
## TRUE requires the webshot2 package and Chrome browser; using rgl.snapshot()  
## instead
```

```
## Warning in rgl.snapshot(filename, fmt, top): this build of rgl does not support  
## snapshots
```

```
# Explicitly set the elementId property  
widget$elementId <- "my-rgl-plot"
```

```
## Warning in widget$elementId <- "my-rgl-plot": Coercing LHS to a list
```



```
widget
```

```
## [[1]]  
## [1] "../../../tmp/Rtmpo8qGEg/file699161ea2a45.png"  
##  
## $elementId  
## [1] "my-rgl-plot"
```

```
#
```

```
library(rgl)  
  
# Load the Iris dataset  
data(iris)  
  
# Create an interactive 3D scatter plot  
scatter3d(x = iris$Sepal.Length, y = iris$Petal.Length, z = iris$Sepal.Width,  
          groups = iris$Species, surface = FALSE, ellipsoid = TRUE)  
  
# Display the interactive plot  
# rglwidget()
```