Implementation/Code

August 13, 2022

```
## Importing the data
customer_data=read.csv("C:/Users/mogal/OneDrive/Documents/edaproject/Project/Project/Code/Ma
customer_data
```

```
##     CustomerID Gender Age Annual.Income..k.. Spending.Score..1.100.
## 1            1   Male  19                 15                     39
## 2            2   Male  21                 15                     81
## 3            3 Female  20                 16                      6
## 4            4 Female  23                 16                     77
## 5            5 Female  31                 17                     40
## 6            6 Female  22                 17                     76
## 7            7 Female  35                 18                      6
## 8            8 Female  23                 18                     94
## 9            9   Male  64                 19                      3
## 10          10 Female  30                 19                     72
## 11          11   Male  67                 19                     14
## 12          12 Female  35                 19                     99
## 13          13 Female  58                 20                     15
## 14          14 Female  24                 20                     77
## 15          15   Male  37                 20                     13
## 16          16   Male  22                 20                     79
## 17          17 Female  35                 21                     35
## 18          18   Male  20                 21                     66
## 19          19   Male  52                 23                     29
## 20          20 Female  35                 23                     98
## 21          21   Male  35                 24                     35
## 22          22   Male  25                 24                     73
## 23          23 Female  46                 25                      5
## 24          24   Male  31                 25                     73
## 25          25 Female  54                 28                     14
## 26          26   Male  29                 28                     82
## 27          27 Female  45                 28                     32
## 28          28   Male  35                 28                     61
## 29          29 Female  40                 29                     31
```

```
## 30          30 Female  23                  29                  87
## 31          31   Male  60                  30                   4
## 32          32 Female  21                  30                  73
## 33          33   Male  53                  33                   4
## 34          34   Male  18                  33                  92
## 35          35 Female  49                  33                  14
## 36          36 Female  21                  33                  81
## 37          37 Female  42                  34                  17
## 38          38 Female  30                  34                  73
## 39          39 Female  36                  37                  26
## 40          40 Female  20                  37                  75
## 41          41 Female  65                  38                  35
## 42          42   Male  24                  38                  92
## 43          43   Male  48                  39                  36
## 44          44 Female  31                  39                  61
## 45          45 Female  49                  39                  28
## 46          46 Female  24                  39                  65
## 47          47 Female  50                  40                  55
## 48          48 Female  27                  40                  47
## 49          49 Female  29                  40                  42
## 50          50 Female  31                  40                  42
## 51          51 Female  49                  42                  52
## 52          52   Male  33                  42                  60
## 53          53 Female  31                  43                  54
## 54          54   Male  59                  43                  60
## 55          55 Female  50                  43                  45
## 56          56   Male  47                  43                  41
## 57          57 Female  51                  44                  50
## 58          58   Male  69                  44                  46
## 59          59 Female  27                  46                  51
## 60          60   Male  53                  46                  46
## 61          61   Male  70                  46                  56
## 62          62   Male  19                  46                  55
## 63          63 Female  67                  47                  52
## 64          64 Female  54                  47                  59
## 65          65   Male  63                  48                  51
## 66          66   Male  18                  48                  59
## 67          67 Female  43                  48                  50
## 68          68 Female  68                  48                  48
## 69          69   Male  19                  48                  59
## 70          70 Female  32                  48                  47
## 71          71   Male  70                  49                  55
## 72          72 Female  47                  49                  42
## 73          73 Female  60                  50                  49
## 74          74 Female  60                  50                  56
```

```
## 75          75   Male  59                54                47
## 76          76   Male  26                54                54
## 77          77 Female  45                54                53
## 78          78   Male  40                54                48
## 79          79 Female  23                54                52
## 80          80 Female  49                54                42
## 81          81   Male  57                54                51
## 82          82   Male  38                54                55
## 83          83   Male  67                54                41
## 84          84 Female  46                54                44
## 85          85 Female  21                54                57
## 86          86   Male  48                54                46
## 87          87 Female  55                57                58
## 88          88 Female  22                57                55
## 89          89 Female  34                58                60
## 90          90 Female  50                58                46
## 91          91 Female  68                59                55
## 92          92   Male  18                59                41
## 93          93   Male  48                60                49
## 94          94 Female  40                60                40
## 95          95 Female  32                60                42
## 96          96   Male  24                60                52
## 97          97 Female  47                60                47
## 98          98 Female  27                60                50
## 99          99   Male  48                61                42
## 100        100   Male  20                61                49
## 101        101 Female  23                62                41
## 102        102 Female  49                62                48
## 103        103   Male  67                62                59
## 104        104   Male  26                62                55
## 105        105   Male  49                62                56
## 106        106 Female  21                62                42
## 107        107 Female  66                63                50
## 108        108   Male  54                63                46
## 109        109   Male  68                63                43
## 110        110   Male  66                63                48
## 111        111   Male  65                63                52
## 112        112 Female  19                63                54
## 113        113 Female  38                64                42
## 114        114   Male  19                64                46
## 115        115 Female  18                65                48
## 116        116 Female  19                65                50
## 117        117 Female  63                65                43
## 118        118 Female  49                65                59
## 119        119 Female  51                67                43
```

```
## 120        120 Female  50                 67                 57
## 121        121   Male  27                 67                 56
## 122        122 Female  38                 67                 40
## 123        123 Female  40                 69                 58
## 124        124   Male  39                 69                 91
## 125        125 Female  23                 70                 29
## 126        126 Female  31                 70                 77
## 127        127   Male  43                 71                 35
## 128        128   Male  40                 71                 95
## 129        129   Male  59                 71                 11
## 130        130   Male  38                 71                 75
## 131        131   Male  47                 71                  9
## 132        132   Male  39                 71                 75
## 133        133 Female  25                 72                 34
## 134        134 Female  31                 72                 71
## 135        135   Male  20                 73                  5
## 136        136 Female  29                 73                 88
## 137        137 Female  44                 73                  7
## 138        138   Male  32                 73                 73
## 139        139   Male  19                 74                 10
## 140        140 Female  35                 74                 72
## 141        141 Female  57                 75                  5
## 142        142   Male  32                 75                 93
## 143        143 Female  28                 76                 40
## 144        144 Female  32                 76                 87
## 145        145   Male  25                 77                 12
## 146        146   Male  28                 77                 97
## 147        147   Male  48                 77                 36
## 148        148 Female  32                 77                 74
## 149        149 Female  34                 78                 22
## 150        150   Male  34                 78                 90
## 151        151   Male  43                 78                 17
## 152        152   Male  39                 78                 88
## 153        153 Female  44                 78                 20
## 154        154 Female  38                 78                 76
## 155        155 Female  47                 78                 16
## 156        156 Female  27                 78                 89
## 157        157   Male  37                 78                  1
## 158        158 Female  30                 78                 78
## 159        159   Male  34                 78                  1
## 160        160 Female  30                 78                 73
## 161        161 Female  56                 79                 35
## 162        162 Female  29                 79                 83
## 163        163   Male  19                 81                  5
## 164        164 Female  31                 81                 93
```

```
## 165        165   Male  50                 85                      26
## 166        166 Female  36                 85                      75
## 167        167   Male  42                 86                      20
## 168        168 Female  33                 86                      95
## 169        169 Female  36                 87                      27
## 170        170   Male  32                 87                      63
## 171        171   Male  40                 87                      13
## 172        172   Male  28                 87                      75
## 173        173   Male  36                 87                      10
## 174        174   Male  36                 87                      92
## 175        175 Female  52                 88                      13
## 176        176 Female  30                 88                      86
## 177        177   Male  58                 88                      15
## 178        178   Male  27                 88                      69
## 179        179   Male  59                 93                      14
## 180        180   Male  35                 93                      90
## 181        181 Female  37                 97                      32
## 182        182 Female  32                 97                      86
## 183        183   Male  46                 98                      15
## 184        184 Female  29                 98                      88
## 185        185 Female  41                 99                      39
## 186        186   Male  30                 99                      97
## 187        187 Female  54                101                      24
## 188        188   Male  28                101                      68
## 189        189 Female  41                103                      17
## 190        190 Female  36                103                      85
## 191        191 Female  34                103                      23
## 192        192 Female  32                103                      69
## 193        193   Male  33                113                       8
## 194        194 Female  38                113                      91
## 195        195 Female  47                120                      16
## 196        196 Female  35                120                      79
## 197        197 Female  45                126                      28
## 198        198   Male  32                126                      74
## 199        199   Male  32                137                      18
## 200        200   Male  30                137                      83
```

```
str(customer_data)
```

```
## 'data.frame': 200 obs. of  5 variables:
##  $ CustomerID           : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Gender               : chr  "Male" "Male" "Female" "Female" ...
##  $ Age                  : int  19 21 20 23 31 22 35 23 64 30 ...
##  $ Annual.Income..k..   : int  15 15 16 16 17 17 18 18 19 19 ...
##  $ Spending.Score..1.100.: int  39 81 6 77 40 76 6 94 3 72 ...
```

```
names(customer_data)
```

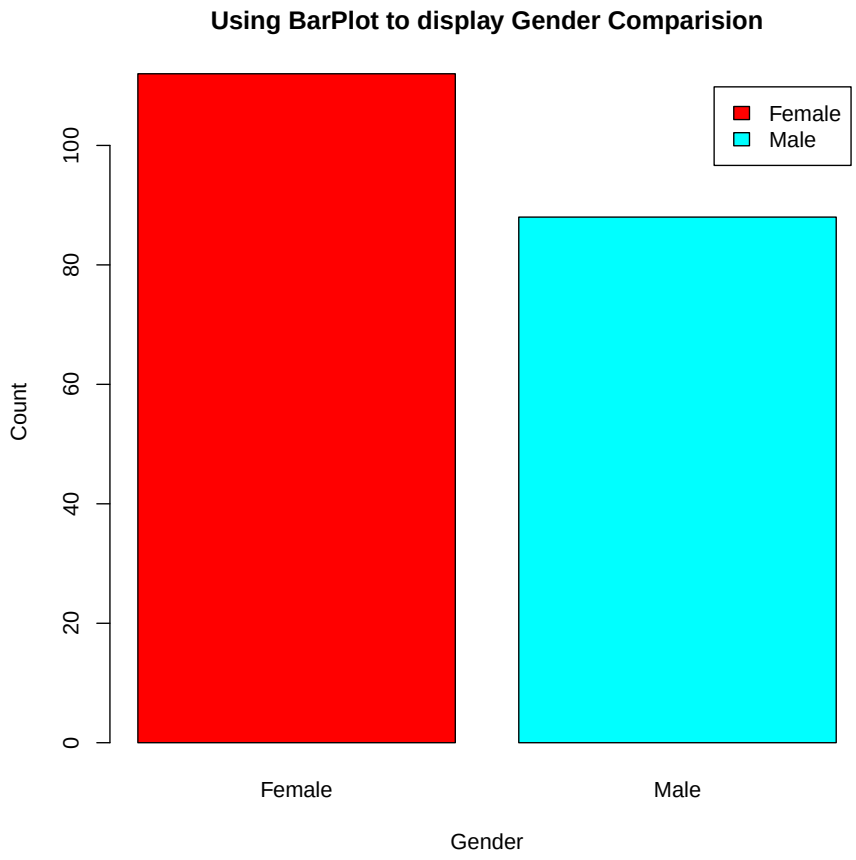
```
## [1] "CustomerID"              "Gender"                  "Age"
## [4] "Annual.Income..k.."      "Spending.Score..1.100."
```

```
## We will now display the first six rows of our dataset using the head() function and use t
head(customer_data)

##   CustomerID Gender Age Annual.Income..k.. Spending.Score..1.100.
## 1          1   Male  19                 15                     39
## 2          2   Male  21                 15                     81
## 3          3 Female  20                 16                      6
## 4          4 Female  23                 16                     77
## 5          5 Female  31                 17                     40
## 6          6 Female  22                 17                     76

summary(customer_data$Age)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   18.00   28.75   36.00   38.85   49.00   70.00
```

```
sd(customer_data$Age)

## [1] 13.96901

summary(customer_data$Annual.Income..k..)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   15.00   41.50   61.50   60.56   78.00  137.00

sd(customer_data$Annual.Income..k..)

## [1] 26.26472

summary(customer_data$Age)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   18.00   28.75   36.00   38.85   49.00   70.00

sd(customer_data$Spending.Score..1.100.)

## [1] 25.82352
```

```
## Customer Gender Visualization
## we will create a barplot and a piechart to show the gender distribution across our custo
a=table(customer_data$Gender)
barplot(a,main="Using BarPlot to display Gender Comparision",
```

```
ylab="Count",
xlab="Gender",
col=rainbow(2),
legend=rownames(a))
```

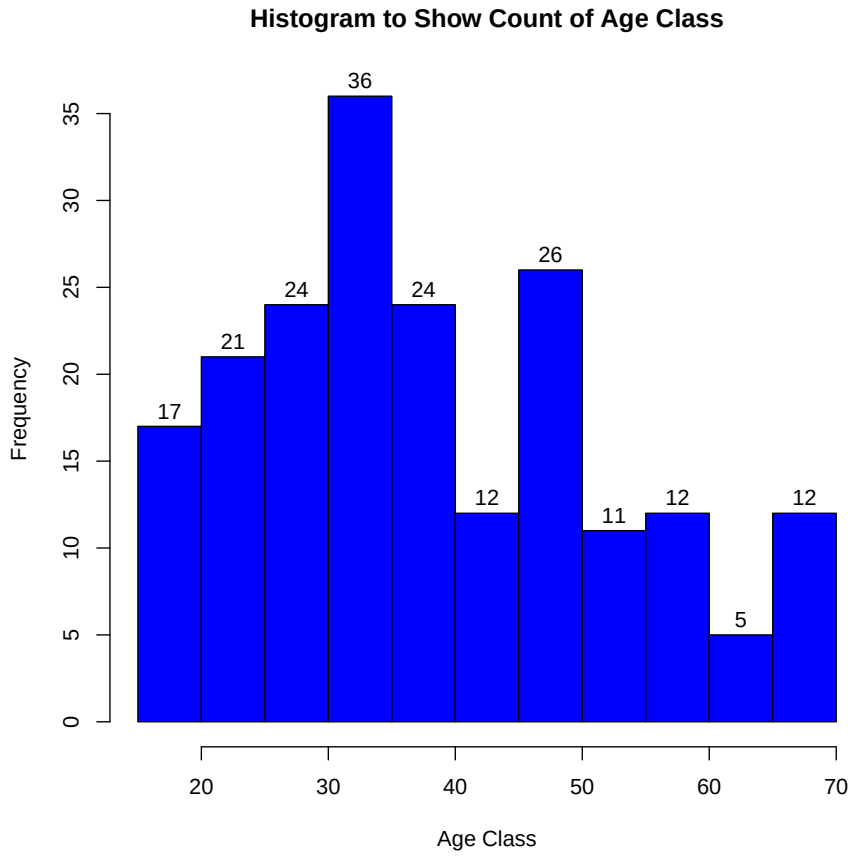



```
## From the above barplot, we observe that the number of females is higher than the males.
```

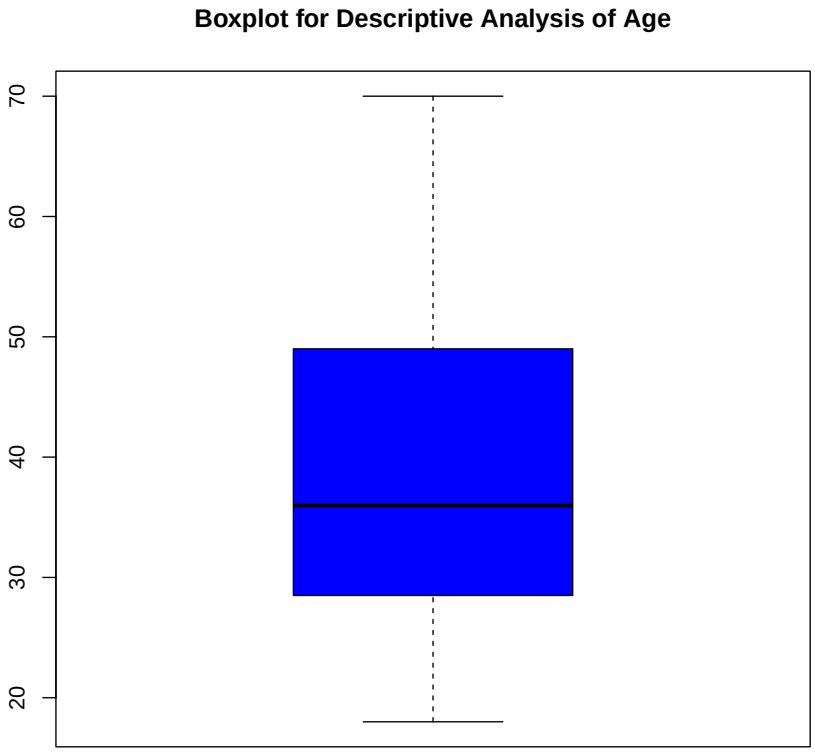
```
## let us visualize a pie chart to observe the ratio of male and female distribution.
pct=round(a/sum(a)*100)
lbs=paste(c("Female","Male")," ",pct,"%",sep=" ")
library(plotrix)

## Error in library(plotrix):  there is no package called 'plotrix'

pie3D(a,labels=lbs,main="Pie Chart Depicting Ratio of Female and Male")
```

```
## Error in pie3D(a, labels = lbs, main = "Pie Chart Depicting Ratio
of Female and Male"):  could not find function "pie3D"

## From the above graph, we conclude that the percentage of females is 56%, whereas the per
```

```
## Visualization of Age Distribution
## Let us plot a histogram to view the distribution to plot the frequency of customer ages.
summary(customer_data$Age)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   18.00   28.75   36.00   38.85   49.00   70.00

hist(customer_data$Age,
col="blue",
main="Histogram to Show Count of Age Class",
xlab="Age Class",
ylab="Frequency",
labels=TRUE)
```

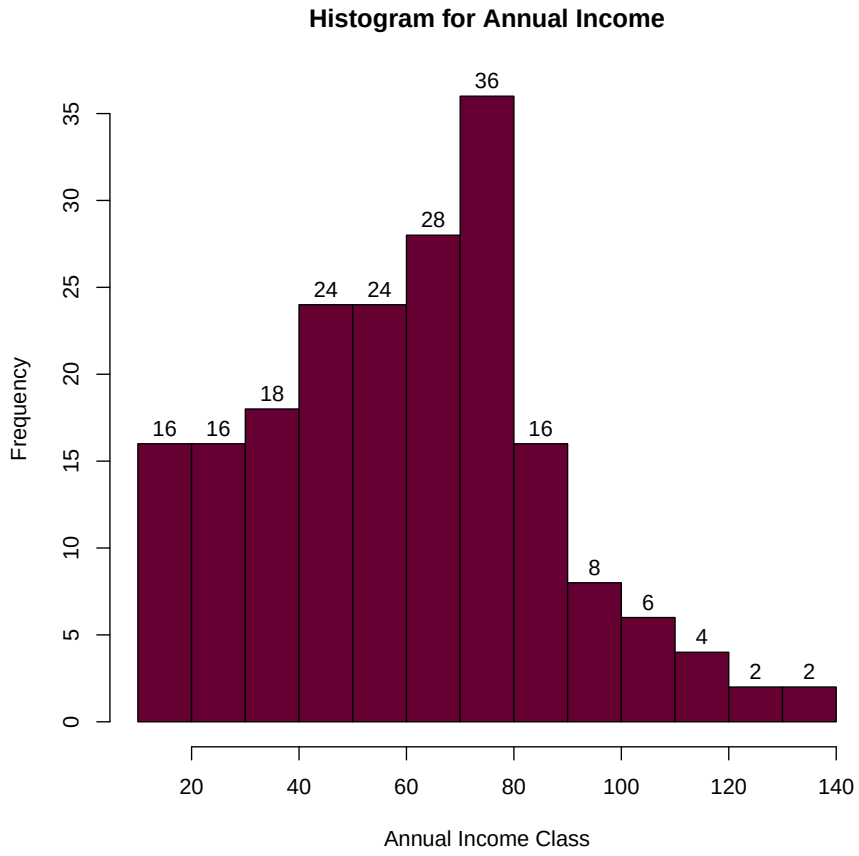



```
boxplot(customer_data$Age,
col="blue",
main="Boxplot for Descriptive Analysis of Age")
```

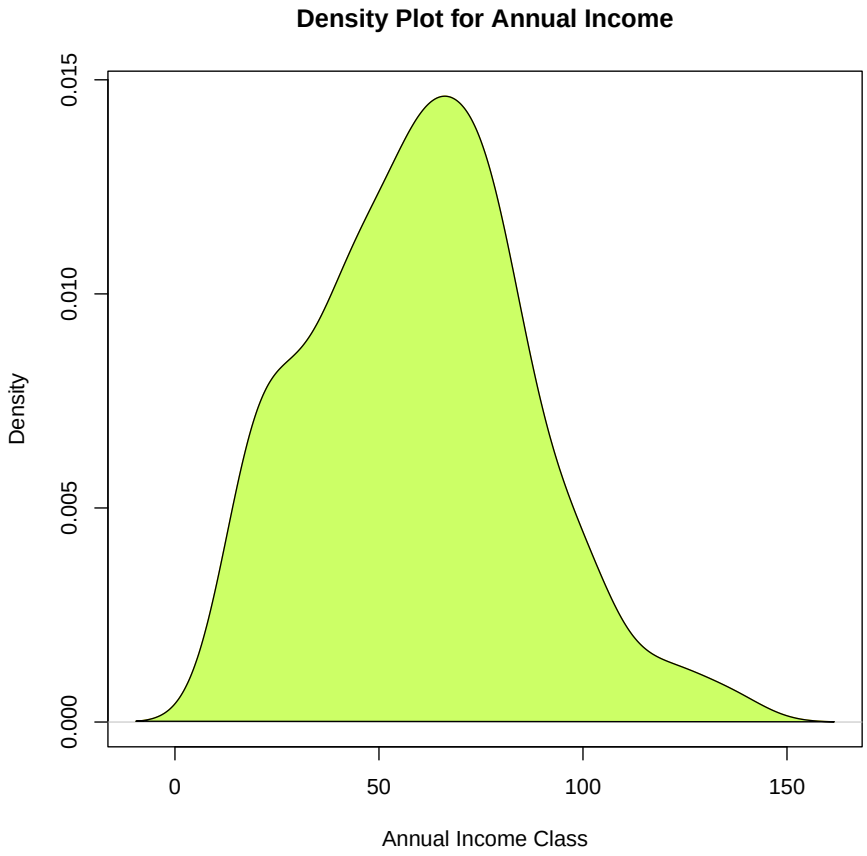



```
## From the above two visualizations, we conclude that the maximum customer ages are betwee
```

```
## Analysis of the Annual Income of the Customers
## we will create visualizations to analyze the annual income of the customers. We will plo
summary(customer_data$Annual.Income..k..)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   15.00   41.50   61.50   60.56   78.00  137.00

hist(customer_data$Annual.Income..k..,
col="#660033",
main="Histogram for Annual Income",
xlab="Annual Income Class",
ylab="Frequency",
labels=TRUE)
```

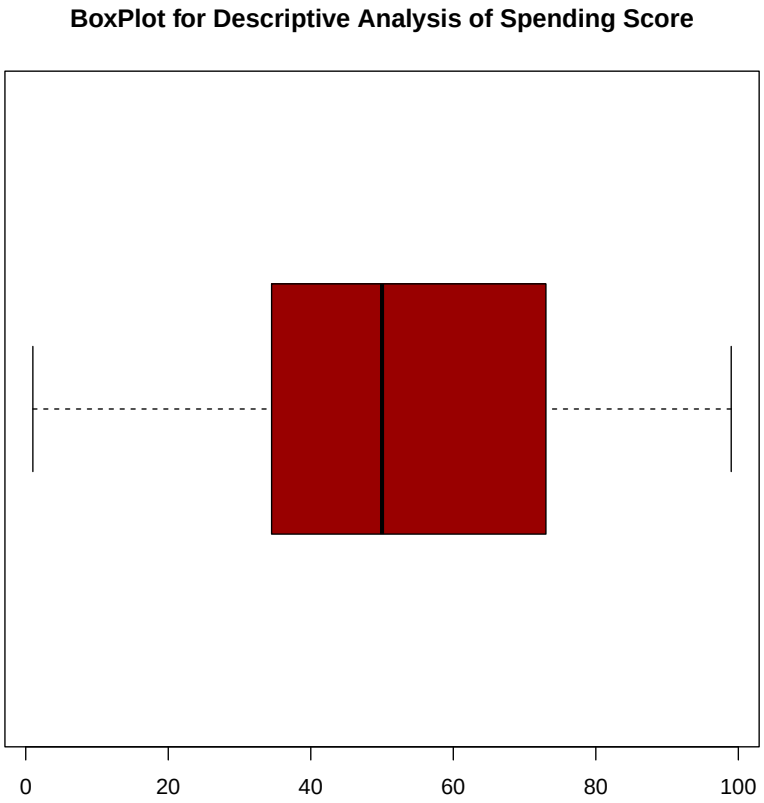



```
plot(density(customer_data$Annual.Income..k..),
col="yellow",
main="Density Plot for Annual Income",
xlab="Annual Income Class",
ylab="Density")
polygon(density(customer_data$Annual.Income..k..),
col="#ccff66")
```

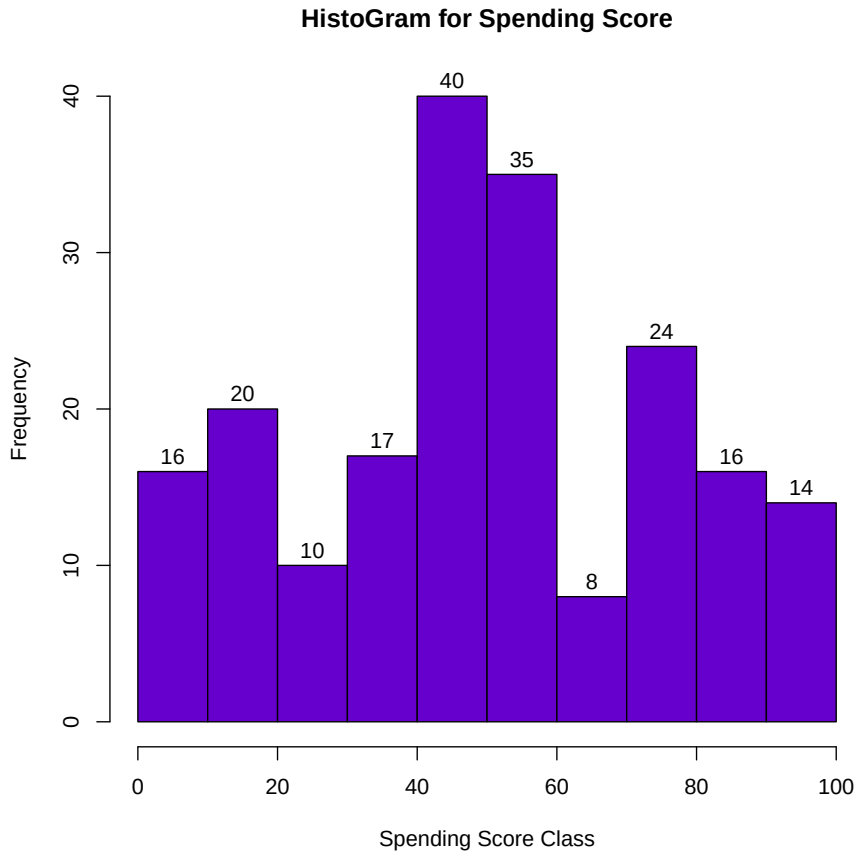



```
## From the above descriptive analysis, we conclude that the minimum annual income of the cu
```

```
## Analyzing Spending Score of the Customers
## we will create visualizations to analyze the spending score of the customers. We will plo
summary(customer_data$Spending.Score..1.100.)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1.00   34.75   50.00   50.20   73.00   99.00

## Min. 1st Qu. Median Mean 3rd Qu. Max.
## 1.00 34.75 50.00 50.20 73.00 99.00

boxplot(customer_data$Spending.Score..1.100.,
horizontal=TRUE,
col="#990000",
main="BoxPlot for Descriptive Analysis of Spending Score")
```



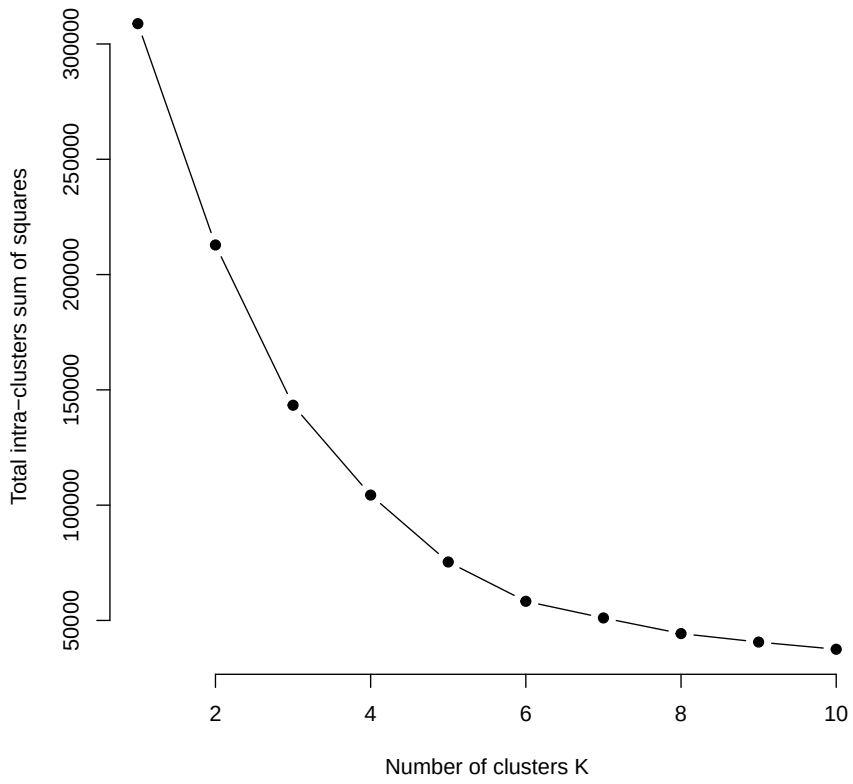

```
hist(customer_data$Spending.Score..1.100.,
main="HistoGram for Spending Score",
xlab="Spending Score Class",
ylab="Frequency",
col="#6600cc",
labels=TRUE)
```




```
## The minimum spending score is 1, maximum is 99 and the average is 50.20. We can see Desc
```

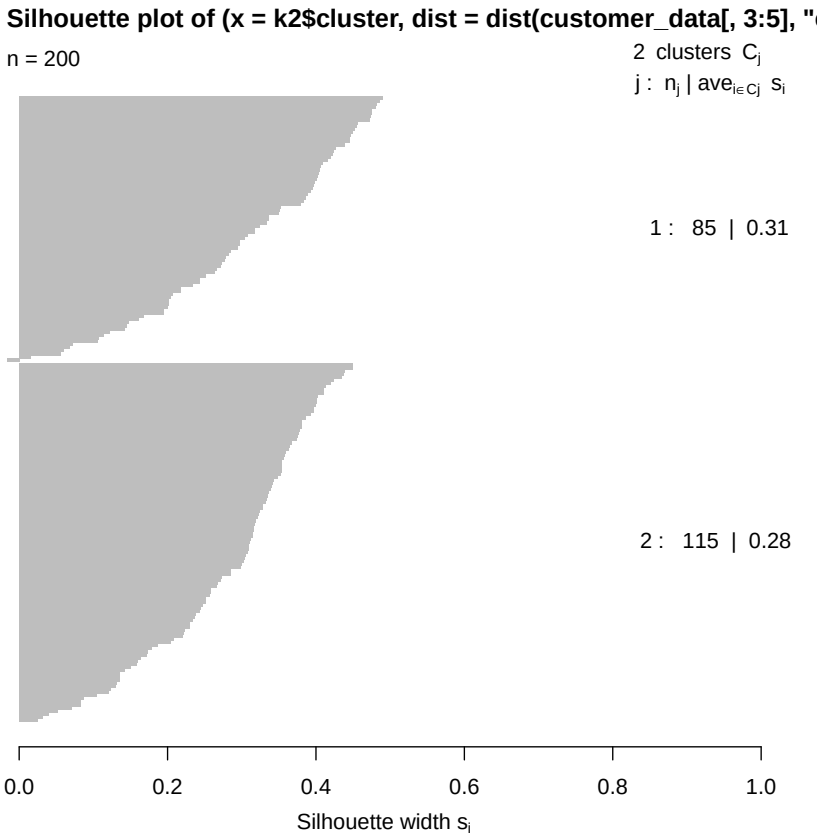
```
## K-means Algorithm
## Elbow Method
library(purrr)

## Warning:  package 'purrr' was built under R version 4.1.3

set.seed(123)
# function to calculate total intra-cluster sum of square
iss <- function(k) {
  kmeans(customer_data[,3:5],k,iter.max=100,nstart=100,algorithm="Lloyd" )$tot.withinss
}
k.values <- 1:10
iss_values <- map_dbl(k.values, iss)
```

```
plot(k.values, iss_values,
    type="b", pch = 19, frame = FALSE,
    xlab="Number of clusters K",
    ylab="Total intra-clusters sum of squares")
```

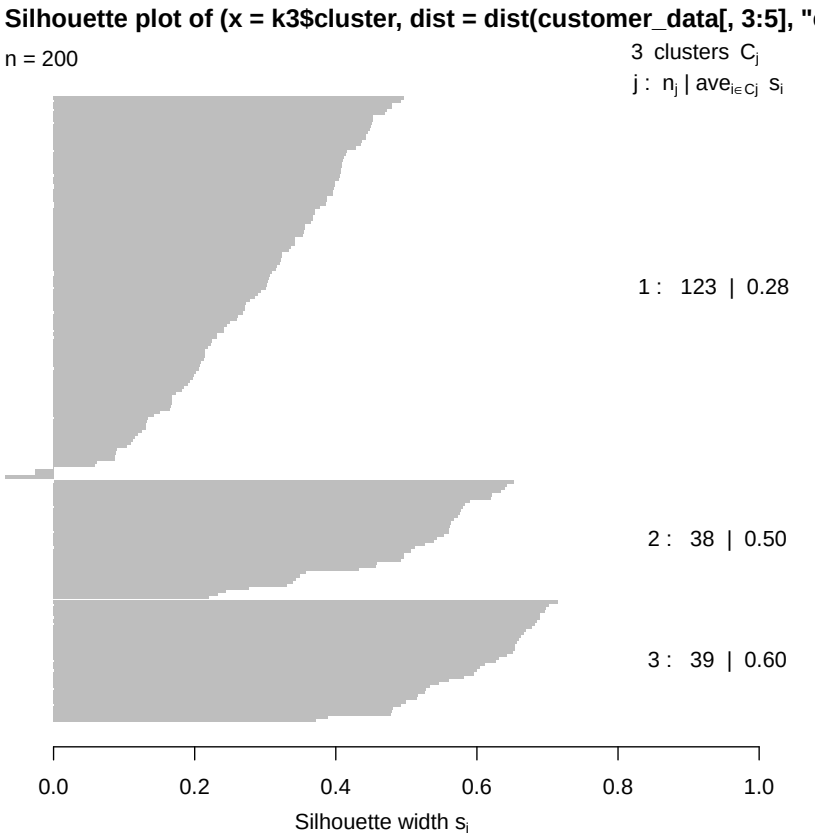



```
## From the above graph, we conclude that 4 is the appropriate number of clusters since it s
```

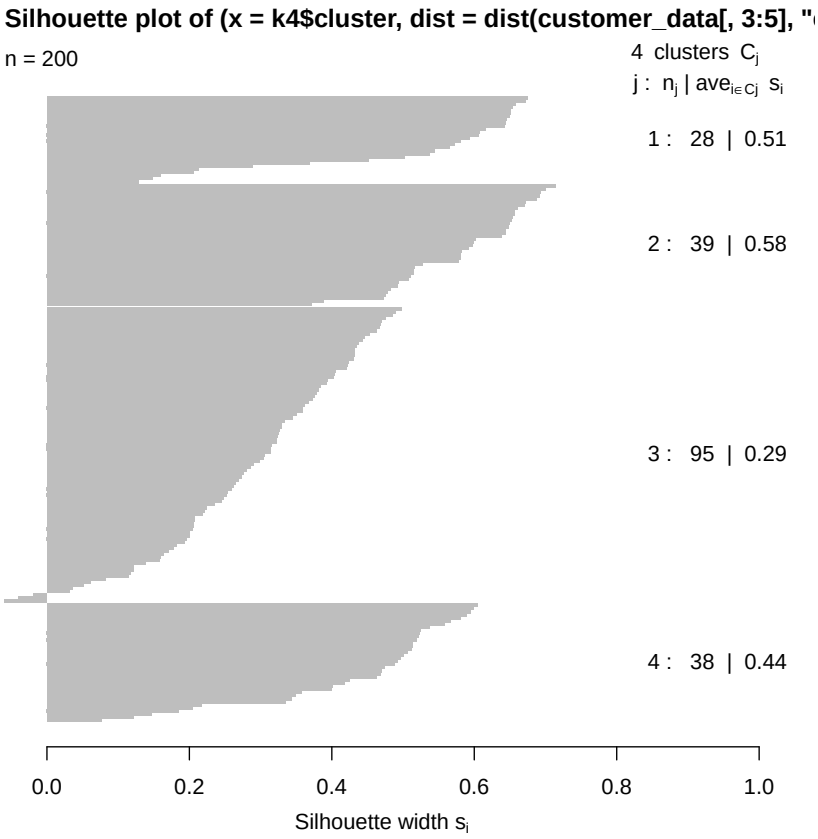
```
## Average Silhouette Method
library(cluster)
library(gridExtra)
library(grid)
k2<-kmeans(customer_data[,3:5],2,iter.max=100,nstart=50,algorithm="Lloyd")
s2<-plot(silhouette(k2$cluster,dist(customer_data[,3:5],"euclidean")))
```




```
k3<-kmeans(customer_data[,3:5],3,iter.max=100,nstart=50,algorithm="Lloyd")
s3<-plot(silhouette(k3$cluster,dist(customer_data[,3:5],"euclidean")))
```

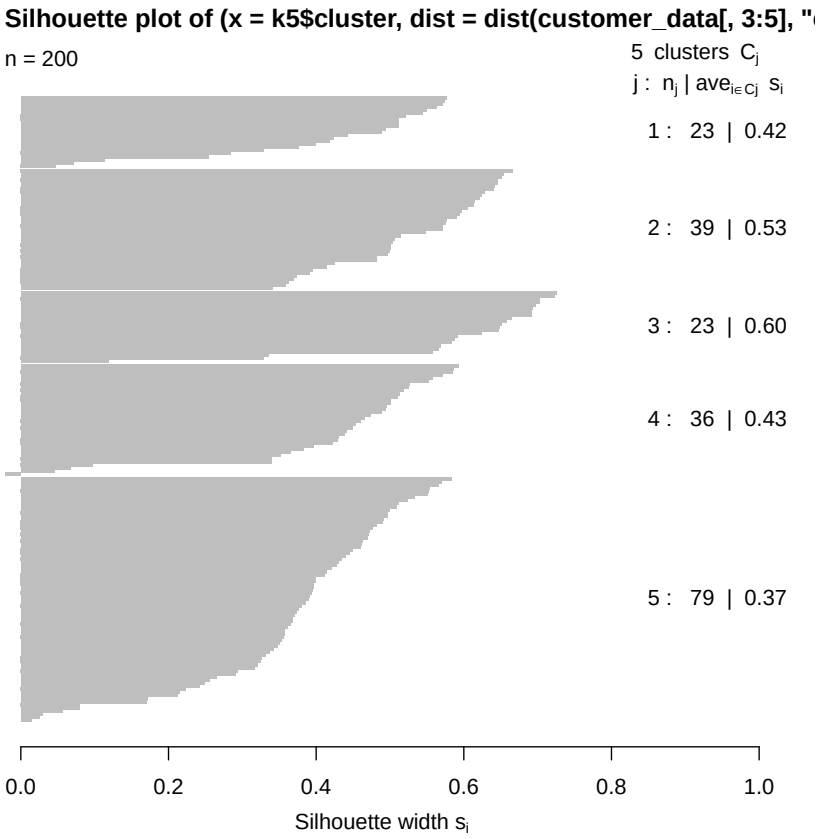



```
k4<-kmeans(customer_data[,3:5],4,iter.max=100,nstart=50,algorithm="Lloyd")
s4<-plot(silhouette(k4$cluster,dist(customer_data[,3:5],"euclidean")))
```

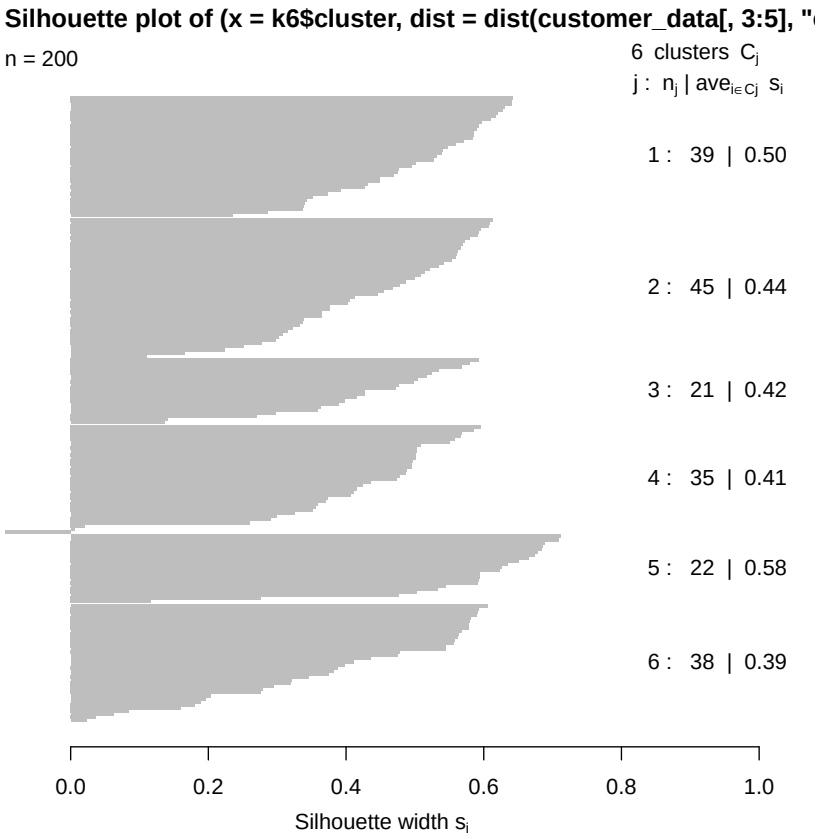


Average silhouette width : 0.41

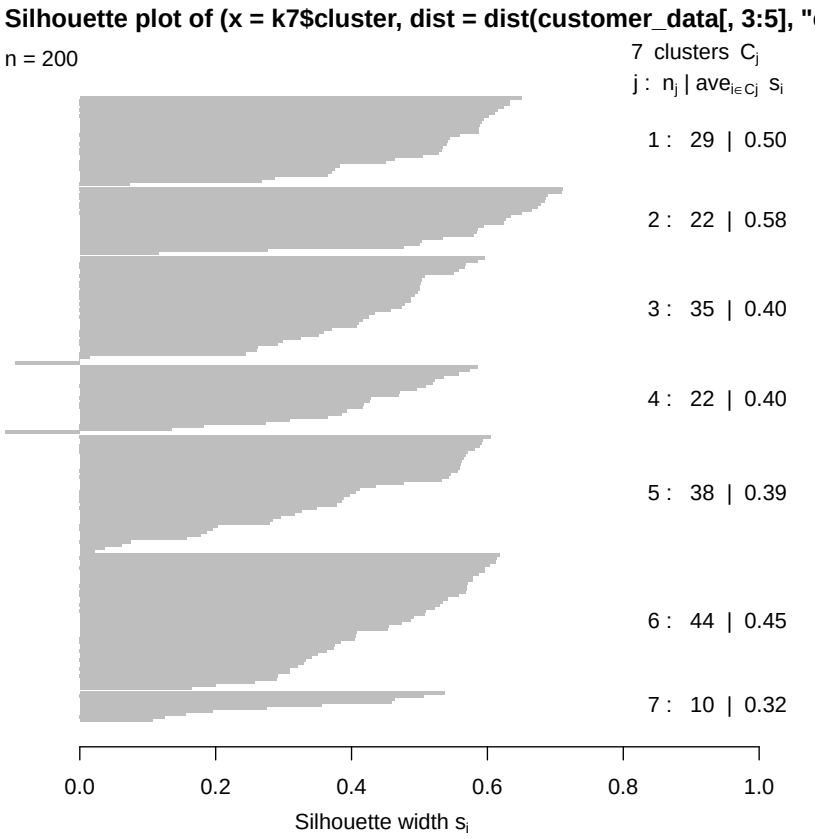
```
k5<-kmeans(customer_data[,3:5],5,iter.max=100,nstart=50,algorithm="Lloyd")
s5<-plot(silhouette(k5$cluster,dist(customer_data[,3:5],"euclidean")))
```



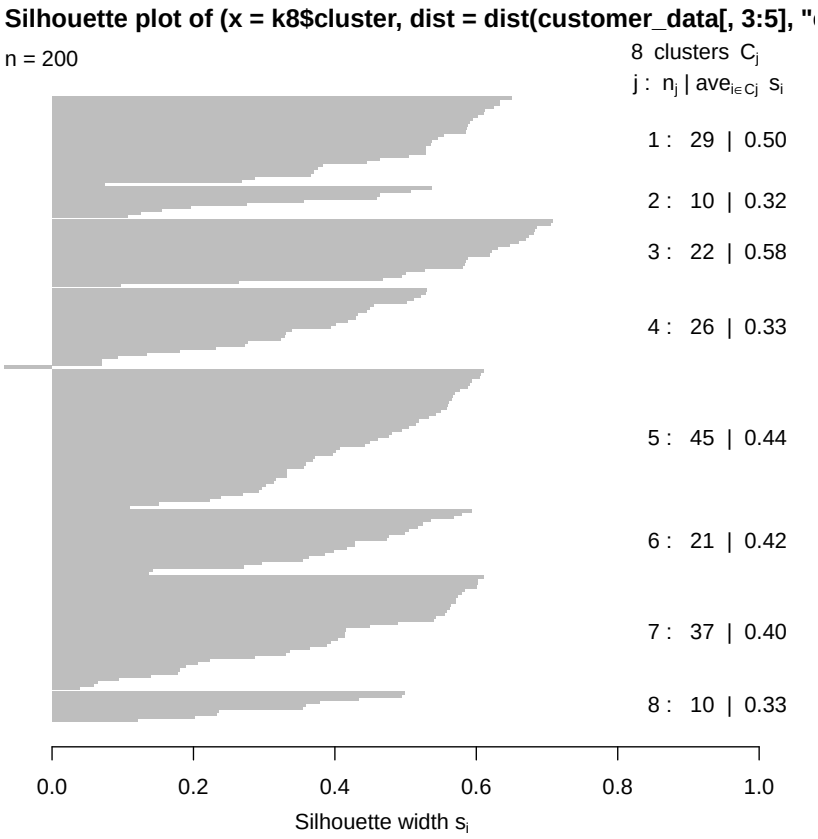

```
k6<-kmeans(customer_data[,3:5],6,iter.max=100,nstart=50,algorithm="Lloyd")
s6<-plot(silhouette(k6$cluster,dist(customer_data[,3:5],"euclidean")))
```



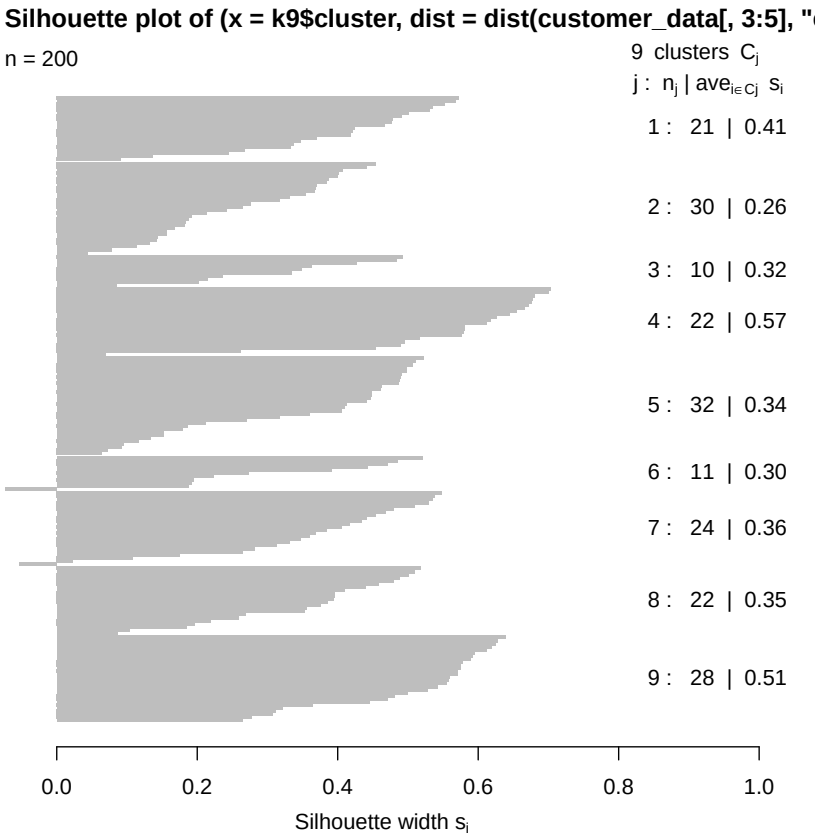

```
k7<-kmeans(customer_data[,3:5],7,iter.max=100,nstart=50,algorithm="Lloyd")
s7<-plot(silhouette(k7$cluster,dist(customer_data[,3:5],"euclidean")))
```



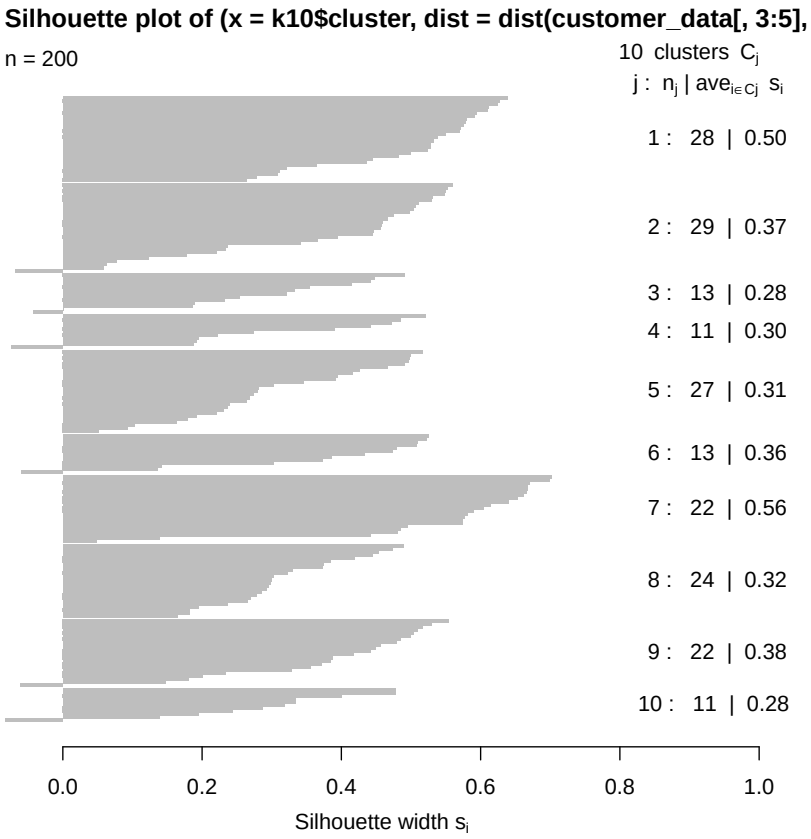

```
k8<-kmeans(customer_data[,3:5],8,iter.max=100,nstart=50,algorithm="Lloyd")
s8<-plot(silhouette(k8$cluster,dist(customer_data[,3:5],"euclidean")))
```




```
k9<-kmeans(customer_data[,3:5],9,iter.max=100,nstart=50,algorithm="Lloyd")
s9<-plot(silhouette(k9$cluster,dist(customer_data[,3:5],"euclidean")))
```




```
k10<-kmeans(customer_data[,3:5],10,iter.max=100,nstart=50,algorithm="Lloyd")
s10<-plot(silhouette(k10$cluster,dist(customer_data[,3:5],"euclidean")))
```




```
## Now, we make use of the fviz_nbclust() function to determine and visualize the optimal nu
library(NbClust)

## Error in library(NbClust):  there is no package called 'NbClust'

library(factoextra)

## Error in library(factoextra):  there is no package called 'factoextra'

fviz_nbclust(customer_data[,3:5], kmeans, method = "silhouette")

## Error in fviz_nbclust(customer_data[, 3:5], kmeans, method = "silhouette"):
could not find function "fviz_nbclust"
```

```r
## Gap Statistic Method
## For computing the gap statistics method we can utilize the clusGap function for providing
set.seed(125)
stat_gap <- clusGap(customer_data[,3:5], FUN = kmeans, nstart = 25,
            K.max = 10, B = 50)
fviz_gap_stat(stat_gap)

## Error in fviz_gap_stat(stat_gap):  could not find function "fviz_gap_stat"
```

```r
## Now, let us take k = 6 as our optimal cluster -
k6<-kmeans(customer_data[,3:5],6,iter.max=100,nstart=50,algorithm="Lloyd")
k6

## K-means clustering with 6 clusters of sizes 35, 22, 38, 44, 22, 39
##
## Cluster means:
##        Age Annual.Income..k.. Spending.Score..1.100.
## 1 41.68571           88.22857                17.28571
## 2 44.31818           25.77273                20.27273
## 3 27.00000           56.65789                49.13158
## 4 56.34091           53.70455                49.38636
## 5 25.27273           25.72727                79.36364
## 6 32.69231           86.53846                82.12821
##
## Clustering vector:
##   [1] 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2
##  [38] 5 2 5 4 5 2 3 2 5 4 3 3 3 4 3 3 4 4 4 4 4 3 4 4 3 4 4 4 3 4 4 3 3 4 4 4 4
##  [75] 4 3 4 3 3 4 4 3 4 4 3 4 4 3 3 4 4 3 4 3 3 3 4 3 4 3 3 4 4 3 4 3 4 4 4 4 4
## [112] 3 3 3 3 3 4 4 4 4 3 3 3 6 3 6 1 6 1 6 1 6 3 6 1 6 1 6 1 6 1 6 3 6 1 6 1 6
## [149] 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1
## [186] 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6
##
## Within cluster sum of squares by cluster:
## [1] 16690.857  8189.000  7742.895  7607.477  4099.818 13972.359
##  (between_SS / total_SS =  81.1 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"

## In the output of our kmeans operation, we observe a list with several key information. Fi

## cluster - This is a vector of several integers that denote the cluster which has an allo
##totss - This represents the total sum of squares.
```

```
##centers - Matrix comprising of several cluster centers
##withinss - This is a vector representing the intra-cluster sum of squares having one compo
##tot.withinss - This denotes the total intra-cluster sum of squares.
##betweenss - This is the sum of between-cluster squares.
##size - The total number of points that each cluster holds.
```

```
## Visualizing the Clustering Results using the First Two Principle Components
pcclust=prcomp(customer_data[,3:5],scale=FALSE) #principal component analysis
summary(pcclust)

## Importance of components:
##                             PC1     PC2     PC3
## Standard deviation     26.4625 26.1597 12.9317
## Proportion of Variance  0.4512  0.4410  0.1078
## Cumulative Proportion   0.4512  0.8922  1.0000

pcclust$rotation[,1:2]

##                                PC1        PC2
## Age                     0.1889742 -0.1309652
## Annual.Income..k..     -0.5886410 -0.8083757
## Spending.Score..1.100. -0.7859965  0.5739136
```

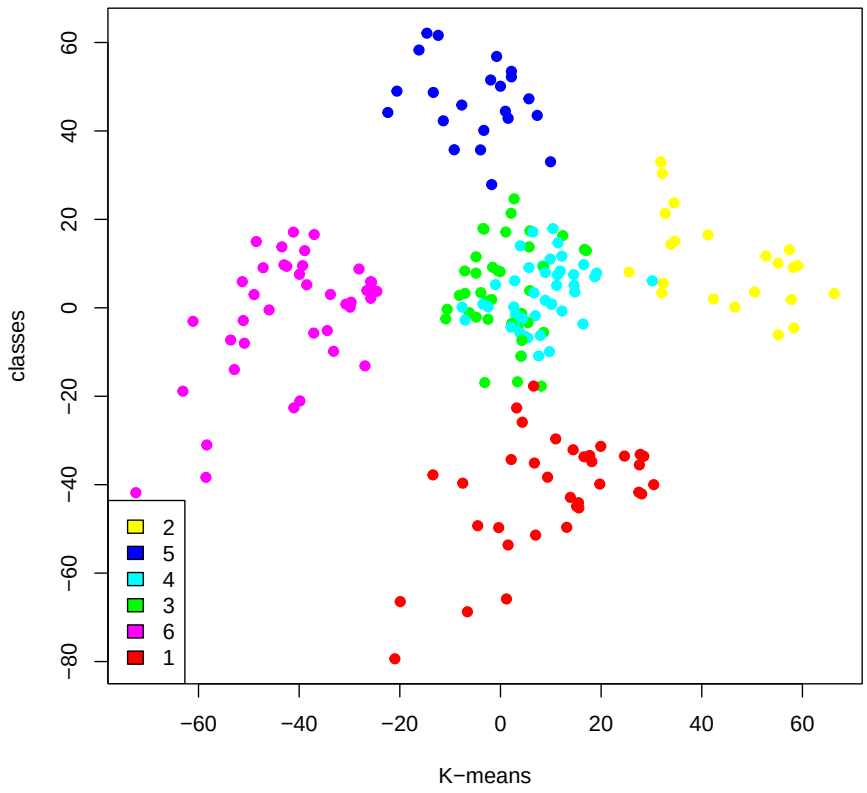
```
## Visualizing the clusters
set.seed(1)
ggplot(customer_data, aes(x =Annual.Income..k.., y = Spending.Score..1.100.)) +
  geom_point(stat = "identity", aes(color = as.factor(k6$cluster))) +
  scale_color_discrete(name=" ",
                       breaks=c("1", "2", "3", "4", "5","6"),
                       labels=c("Cluster 1", "Cluster 2", "Cluster 3", "Cluster 4", "Cluster 5","Clus
  ggtitle("Segments of Mall Customers", subtitle = "Using K-means Clustering")
```

```
## Error in ggplot(customer_data, aes(x = Annual.Income..k.., y = Spending.Score..1.100.)):
could not find function "ggplot"
```

```
## From the above visualization, we observe that there is a distribution of 6 clusters as fo

##Cluster 6 and 4 - These clusters represent the customer_data with the medium income salary

##Cluster 1 - This cluster represents the customer_data having a high annual income as well

##Cluster 3 - This cluster denotes the customer_data with low annual income as well as low y

##Cluster 2 - This cluster denotes a high annual income and low yearly spend.

##Cluster 5 - This cluster represents a low annual income but its high yearly expenditure.
```

```
ggplot(customer_data, aes(x =Spending.Score..1.100., y =Age)) +
  geom_point(stat = "identity", aes(color = as.factor(k6$cluster))) +
  scale_color_discrete(name=" ",
                       breaks=c("1", "2", "3", "4", "5","6"),
                       labels=c("Cluster 1", "Cluster 2", "Cluster 3", "Cluster 4", "Cluster
  ggtitle("Segments of Mall Customers", subtitle = "Using K-means Clustering")

## Error in ggplot(customer_data, aes(x = Spending.Score..1.100., y
= Age)):  could not find function "ggplot"
```

```
kCols=function(vec){cols=rainbow (length (unique (vec)))
return (cols[as.numeric(as.factor(vec))])}

digCluster<-k6$cluster; dignm<-as.character(digCluster); # K-means clusters

plot(pcclust$x[,1:2], col =kCols(digCluster),pch =19,xlab ="K-means",ylab="classes")
legend("bottomleft",unique(dignm),fill=unique(kCols(digCluster)))
```




```
##Cluster 4 and 1 - These two clusters consist of customers with medium PCA1 and medium PCA2

##Cluster 6 - This cluster represents customers having a high PCA2 and a low PCA1.

##Cluster 5 - In this cluster, there are customers with a medium PCA1 and a low PCA2 score.

##Cluster 3 - This cluster comprises of customers with a high PCA1 income and a high PCA2.

##Cluster 2 - This comprises of customers with a high PCA2 and a medium annual spend of inco

##With the help of clustering, we can understand the variables much better, prompting us to
```