**Day 1 – R Programming**

> #install.packages('caret')

> num = 10

> num

[1] 10

> library('caret')

> x = 10.2

> y <- 10

> z = "Hello"

> x

[1] 10.2

> y

[1] 10

> z

[1] "Hello"

> as.integer(x)

[1] 10

> a = 1 + 10i

> a

[1] 1+10i

> sqrt(144)

[1] 12

> a = 5; b = 15

> out = a > b

> out

[1] FALSE

> age <- c(21, 25, 28, 30, 20, 26)

> age

[1] 21 25 28 30 20 26

> id = c(1:10) #range values from 1-10

> id

[1] 1 2 3 4 5 6 7 8 9 10

> seq(1, 20)

[1] 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

> seq(2, 20, 2) #range values from 2 to 20 with offset 2

[1] 2 4 6 8 10 12 14 16 18 20

> loan\_default <- c(TRUE, FALSE, FALSE, TRUE, TRUE)

> loan\_default

[1] TRUE FALSE FALSE TRUE TRUE

> place\_names <- c("China", "India", "Denmark", "UK", "Finland")

> place\_names

[1] "China" "India" "Denmark" "UK" "Finland"

> class(loan\_default)

[1] "logical"

> class(age)

[1] "numeric"

> class(z)

[1] "character"

> num\_as\_str <- c("10", "30", "40", "50")

> class(num\_as\_str)

[1] "character"

> numbers <- as.integer(num\_as\_str)

> class(numbers)

[1] "integer"

> mean(numbers)

[1] 32.5

> max(age)

[1] 30

> min(numbers)

[1] 10

> median(age)

[1] 25.5

> range(numbers)

[1] 10 50

> var(age)

[1] 15.2

> sort(age)

[1] 20 21 25 26 28 30

> sort(age, decreasing = TRUE)

[1] 30 28 26 25 21 20

> random\_ele <- c(15, 2.5, TRUE, "Hello")

> random\_ele

[1] "15" "2.5" "TRUE" "Hello"

> class(random\_ele)

[1] "character"

> mat <- c(1:16)

> mat <- matrix(mat, ncol=4)

> mat

[,1] [,2] [,3] [,4]

[1,] 1 5 9 13

[2,] 2 6 10 14

[3,] 3 7 11 15

[4,] 4 8 12 16

> mat1 <- c(1:16)

> mat1 <- matrix(mat1, ncol = 4, byrow = T)

> mat1

[,1] [,2] [,3] [,4]

[1,] 1 2 3 4

[2,] 5 6 7 8

[3,] 9 10 11 12

[4,] 13 14 15 16

> matrix(c(56, 72, 25, 14, 87, 99), ncol = 3, byrow = T)

[,1] [,2] [,3]

[1,] 56 72 25

[2,] 14 87 99

> mat1[2,]

[1] 5 6 7 8

> mat1[2,2]

[1] 6

> mat1[,4]

[1] 4 8 12 16

> matr = matrix(c(5:16), nrow = 3, byrow = TRUE)

> column.names <- c("COL1", "COL2", "COL3")

> row.names <- c("ROW1", "ROW2", "ROW3")

> column.names <- c("COL1", "COL2", "COL3", "COL4")

> result <- matrix(c(5:16), nrow = 3, byrow = TRUE, dimnames = list(row.names, column.names))

> result

COL1 COL2 COL3 COL4

ROW1 5 6 7 8

ROW2 9 10 11 12

ROW3 13 14 15 16

> employee = list(1, c("John", "Rose"), c(12000, 15000))

> employee

[[1]]

[1] 1

[[2]]

[1] "John" "Rose"

[[3]]

[1] 12000 15000

> employee[[1]]

[1] 1

> employee[[2]]

[1] "John" "Rose"

> employee[[3]]

[1] 12000 15000

> employee = list(EmpID=1, EmpName=c("John", "Rose"), basic\_pay=c(12000, 15000))

> employee

$EmpID

[1] 1

$EmpName

[1] "John" "Rose"

$basic\_pay

[1] 12000 15000

> employee$EmpName

[1] "John" "Rose"

> list\_of\_expenses <- list(100, 150, 350, 50)

> class((list\_of\_expenses))

[1] "list"

> expenses <- unlist(list\_of\_expenses)

> class(expenses)

[1] "numeric"

> length(expenses)

[1] 4

> days\_from\_purchase <- c(10, 15, 20, 25)

> days\_from\_purchase

[1] 10 15 20 25

> ctf <- as.factor(days\_from\_purchase)

> typeof(ctf)

[1] "integer"

> class(ctf)

[1] "factor"

> age <- c(21, 42, 28, 31, 19)

> names <- c("John", "Sachin", "Rahul", "Ravi", "Sameer")

> salary <- c(12000, 20000, 25000, 16000, 28000)

> ownhouse <- c(TRUE, FALSE, TRUE, TRUE, FALSE)

> mydf <- data.frame(names, age, salary, ownhouse)

> mydf

names age salary ownhouse

1 John 21 12000 TRUE

2 Sachin 42 20000 FALSE

3 Rahul 28 25000 TRUE

4 Ravi 31 16000 TRUE

5 Sameer 19 28000 FALSE

> stock\_price <- c(110.55, 102.50, 145.90, 130.70, 160.45, 112.80)

> stock\_mat <- matrix(stock\_price, ncol = 2, byrow = T)

> stock\_df = data.frame(stock\_mat)

> stock\_df

X1 X2

1 110.55 102.5

2 145.90 130.7

3 160.45 112.8

> colnames(stock\_df) <- c("Open Price", "Close Price")

> letters[1:10]

[1] "a" "b" "c" "d" "e" "f" "g" "h" "i" "j"

> letters[1:26]

[1] "a" "b" "c" "d" "e" "f" "g" "h" "i" "j" "k" "l" "m" "n" "o" "p" "q" "r" "s" "t" "u" "v" "w" "x" "y" "z"

> rownames(stock\_df) <- letters[1:3]

> stock\_df

Open Price Close Price

a 110.55 102.5

b 145.90 130.7

c 160.45 112.8

> stock\_df$`Close Price`

[1] 102.5 130.7 112.8

**Day 2 – R Programming**

> X <- matrix(c(50, 70, 40, 90, 60, 80, 50, 90, 100, 50, 30, 70), nrow = 3)

> X

[,1] [,2] [,3] [,4]

[1,] 50 90 50 50

[2,] 70 60 90 30

[3,] 40 80 100 70

> rowSums(X)

[1] 240 250 290

> colSums(X)

[1] 160 230 240 150

> X <- rbind(X, apply(X, 2, mean)) #Add a row and apply mean function columnswise - 2, for rowwise its 1

> X

[,1] [,2] [,3] [,4]

[1,] 50.00000 90.00000 50 50

[2,] 70.00000 60.00000 90 30

[3,] 40.00000 80.00000 100 70

[4,] 53.33333 76.66667 80 50

> X <- cbind(X, apply(X, 1, var)) #Add a column and apply variance function rowwise - 1

> X

[,1] [,2] [,3] [,4] [,5]

[1,] 50.00000 90.00000 50 50 400.0000

[2,] 70.00000 60.00000 90 30 625.0000

[3,] 40.00000 80.00000 100 70 625.0000

[4,] 53.33333 76.66667 80 50 240.7407

> X <- matrix(c(50, 70, 40, 90, 60, 80, 50, 90, 100, 50, 30, 70), nrow = 3)

> X <- cbind(X, apply(X, 1, sd)) #Add a column and apply standard deviation function rowwise - 1

> X

[,1] [,2] [,3] [,4] [,5]

[1,] 50 90 50 50 20

[2,] 70 60 90 30 25

[3,] 40 80 100 70 25

> X <- rbind(X, apply(X, 2, max)) #Add a row and apply maximum function columnswise - 2, for rowwise its 1

> X

[,1] [,2] [,3] [,4] [,5]

[1,] 50 90 50 50 20

[2,] 70 60 90 30 25

[3,] 40 80 100 70 25

[4,] 70 90 100 70 25

> stock\_df[[1]] #1st column

[1] 110.55 145.90 160.45

> stock\_df[[2]] #2nd column

[1] 102.5 130.7 112.8

> stock\_df

Open Price Close Price BuyOrSell

a 110.55 102.5 Sell

b 145.90 130.7 Sell

c 160.45 112.8 Sell

> stock\_df[1:2, 2]

[1] 102.5 130.7

> stock\_df[1:3, 1:2]

Open Price Close Price

a 110.55 102.5

b 145.90 130.7

c 160.45 112.8

> stock\_df[, 1:2]

Open Price Close Price

a 110.55 102.5

b 145.90 130.7

c 160.45 112.8

> stock\_df[c(1, 3), 1:2]

Open Price Close Price

a 110.55 102.5

c 160.45 112.8

> stock\_df[-1, 1]

[1] 145.90 160.45

> stock\_df[-c(1, 3), 1:2]

Open Price Close Price

b 145.9 130.7

> v\_sub <- stock\_df[1:3, 2]

> v\_sub

[1] 102.5 130.7 112.8

> df\_subsetdata <- stock\_df[1:3, 2, drop=F]

> df\_subsetdata

Close Price

a 102.5

b 130.7

c 112.8

> class(v\_sub)

[1] "numeric"

> class(df\_subsetdata)

[1] "data.frame"

> setwd("C:/zubeda/PGA02\_Zubu/R Programming") #Set current working directory

> housing\_df <- read.csv("Housing.csv")

> housing\_df

price area bedrooms bathrooms stories mainroad guestroom basement

1 13300000 7420 4 2 3 yes no no

2 12250000 8960 4 4 4 yes no no

3 12250000 9960 3 2 2 yes no yes

4 12215000 7500 4 2 2 yes no yes

5 11410000 7420 4 1 2 yes yes yes

6 10850000 7500 3 3 1 yes no yes

7 10150000 8580 4 3 4 yes no no

8 10150000 16200 5 3 2 yes no no

9 9870000 8100 4 1 2 yes yes yes

10 9800000 5750 3 2 4 yes yes no

11 9800000 13200 3 1 2 yes no yes

12 9681000 6000 4 3 2 yes yes yes

13 9310000 6550 4 2 2 yes no no

14 9240000 3500 4 2 2 yes no no

15 9240000 7800 3 2 2 yes no no

16 9100000 6000 4 1 2 yes no yes

17 9100000 6600 4 2 2 yes yes yes

18 8960000 8500 3 2 4 yes no no

19 8890000 4600 3 2 2 yes yes no

20 8855000 6420 3 2 2 yes no no

21 8750000 4320 3 1 2 yes no yes

22 8680000 7155 3 2 1 yes yes yes

23 8645000 8050 3 1 1 yes yes yes

24 8645000 4560 3 2 2 yes yes yes

25 8575000 8800 3 2 2 yes no no

26 8540000 6540 4 2 2 yes yes yes

27 8463000 6000 3 2 4 yes yes yes

28 8400000 8875 3 1 1 yes no no

29 8400000 7950 5 2 2 yes no yes

30 8400000 5500 4 2 2 yes no yes

31 8400000 7475 3 2 4 yes no no

32 8400000 7000 3 1 4 yes no no

33 8295000 4880 4 2 2 yes no no

34 8190000 5960 3 3 2 yes yes yes

35 8120000 6840 5 1 2 yes yes yes

36 8080940 7000 3 2 4 yes no no

37 8043000 7482 3 2 3 yes no no

38 7980000 9000 4 2 4 yes no no

39 7962500 6000 3 1 4 yes yes no

40 7910000 6000 4 2 4 yes no no

41 7875000 6550 3 1 2 yes no yes

42 7840000 6360 3 2 4 yes no no

43 7700000 6480 3 2 4 yes no no

44 7700000 6000 4 2 4 yes no no

45 7560000 6000 4 2 4 yes no no

46 7560000 6000 3 2 3 yes no no

47 7525000 6000 3 2 4 yes no no

48 7490000 6600 3 1 4 yes no no

49 7455000 4300 3 2 2 yes no yes

50 7420000 7440 3 2 1 yes yes yes

51 7420000 7440 3 2 4 yes no no

52 7420000 6325 3 1 4 yes no no

53 7350000 6000 4 2 4 yes yes no

54 7350000 5150 3 2 4 yes no no

55 7350000 6000 3 2 2 yes yes no

56 7350000 6000 3 1 2 yes no no

57 7343000 11440 4 1 2 yes no yes

58 7245000 9000 4 2 4 yes yes no

59 7210000 7680 4 2 4 yes yes no

60 7210000 6000 3 2 4 yes yes no

61 7140000 6000 3 2 2 yes yes no

62 7070000 8880 2 1 1 yes no no

63 7070000 6240 4 2 2 yes no no

64 7035000 6360 4 2 3 yes no no

65 7000000 11175 3 1 1 yes no yes

66 6930000 8880 3 2 2 yes no yes

67 6930000 13200 2 1 1 yes no yes

68 6895000 7700 3 2 1 yes no no

69 6860000 6000 3 1 1 yes no no

70 6790000 12090 4 2 2 yes no no

71 6790000 4000 3 2 2 yes no yes

72 6755000 6000 4 2 4 yes no no

73 6720000 5020 3 1 4 yes no no

74 6685000 6600 2 2 4 yes no yes

75 6650000 4040 3 1 2 yes no yes

76 6650000 4260 4 2 2 yes no no

hotwaterheating airconditioning parking prefarea furnishingstatus

1 no yes 2 yes furnished

2 no yes 3 no furnished

3 no no 2 yes semi-furnished

4 no yes 3 yes furnished

5 no yes 2 no furnished

6 no yes 2 yes semi-furnished

7 no yes 2 yes semi-furnished

8 no no 0 no unfurnished

9 no yes 2 yes furnished

10 no yes 1 yes unfurnished

11 no yes 2 yes furnished

12 yes no 2 no semi-furnished

13 no yes 1 yes semi-furnished

14 yes no 2 no furnished

15 no no 0 yes semi-furnished

16 no no 2 no semi-furnished

17 no yes 1 yes unfurnished

18 no yes 2 no furnished

19 no yes 2 no furnished

20 no yes 1 yes semi-furnished

21 yes no 2 no semi-furnished

22 no yes 2 no unfurnished

23 no yes 1 no furnished

24 no yes 1 no furnished

25 no yes 2 no furnished

26 no yes 2 yes furnished

27 no yes 0 yes semi-furnished

28 no no 1 no semi-furnished

29 yes no 2 no unfurnished

30 no yes 1 yes semi-furnished

31 no yes 2 no unfurnished

32 no yes 2 no semi-furnished

33 no yes 1 yes furnished

34 no no 1 no unfurnished

35 no yes 1 no furnished

36 no yes 2 no furnished

37 yes no 1 yes furnished

38 no yes 2 no furnished

39 no yes 2 no unfurnished

40 no yes 1 no semi-furnished

41 no yes 0 yes furnished

42 no yes 0 yes furnished

43 no yes 2 no unfurnished

44 no no 2 no semi-furnished

45 no yes 1 no furnished

46 no yes 0 no semi-furnished

47 no yes 1 no furnished

48 no yes 3 yes furnished

49 no no 1 no unfurnished

50 no yes 0 yes semi-furnished

51 no no 1 yes unfurnished

52 no yes 1 no unfurnished

53 no yes 1 no furnished

54 no yes 2 no semi-furnished

55 no yes 1 no semi-furnished

56 no yes 1 no unfurnished

57 no no 1 yes semi-furnished

58 no yes 1 yes furnished

59 no yes 1 no semi-furnished

60 no yes 1 no furnished

61 no no 1 no semi-furnished

62 no yes 1 no semi-furnished

63 no yes 1 no furnished

64 no yes 2 yes furnished

65 no yes 1 yes furnished

66 no yes 1 no furnished

67 yes no 1 no furnished

68 no no 2 no unfurnished

69 no yes 1 no furnished

70 no no 2 yes furnished

71 no yes 0 yes semi-furnished

72 no yes 0 no unfurnished

73 no yes 0 yes unfurnished

74 no no 0 yes furnished

75 yes no 1 no furnished

76 yes no 0 no semi-furnished

[ reached 'max' / getOption("max.print") -- omitted 469 rows ]

> dim(housing\_df) #no. of rows, no. of columns

[1] 545 13

> filter\_df <- housing\_df[housing\_df$price > 10000000, ]

> filter\_df

price area bedrooms bathrooms stories mainroad guestroom basement

1 13300000 7420 4 2 3 yes no no

2 12250000 8960 4 4 4 yes no no

3 12250000 9960 3 2 2 yes no yes

4 12215000 7500 4 2 2 yes no yes

5 11410000 7420 4 1 2 yes yes yes

6 10850000 7500 3 3 1 yes no yes

7 10150000 8580 4 3 4 yes no no

8 10150000 16200 5 3 2 yes no no

hotwaterheating airconditioning parking prefarea furnishingstatus

1 no yes 2 yes furnished

2 no yes 3 no furnished

3 no no 2 yes semi-furnished

4 no yes 3 yes furnished

5 no yes 2 no furnished

6 no yes 2 yes semi-furnished

7 no yes 2 yes semi-furnished

8 no no 0 no unfurnished

> filt\_df <- housing\_df[housing\_df$area > 6000, ]

> filt\_df

price area bedrooms bathrooms stories mainroad guestroom basement

1 13300000 7420 4 2 3 yes no no

2 12250000 8960 4 4 4 yes no no

3 12250000 9960 3 2 2 yes no yes

4 12215000 7500 4 2 2 yes no yes

5 11410000 7420 4 1 2 yes yes yes

6 10850000 7500 3 3 1 yes no yes

7 10150000 8580 4 3 4 yes no no

8 10150000 16200 5 3 2 yes no no

9 9870000 8100 4 1 2 yes yes yes

11 9800000 13200 3 1 2 yes no yes

13 9310000 6550 4 2 2 yes no no

15 9240000 7800 3 2 2 yes no no

17 9100000 6600 4 2 2 yes yes yes

18 8960000 8500 3 2 4 yes no no

20 8855000 6420 3 2 2 yes no no

22 8680000 7155 3 2 1 yes yes yes

23 8645000 8050 3 1 1 yes yes yes

25 8575000 8800 3 2 2 yes no no

26 8540000 6540 4 2 2 yes yes yes

28 8400000 8875 3 1 1 yes no no

29 8400000 7950 5 2 2 yes no yes

31 8400000 7475 3 2 4 yes no no

32 8400000 7000 3 1 4 yes no no

35 8120000 6840 5 1 2 yes yes yes

36 8080940 7000 3 2 4 yes no no

37 8043000 7482 3 2 3 yes no no

38 7980000 9000 4 2 4 yes no no

41 7875000 6550 3 1 2 yes no yes

42 7840000 6360 3 2 4 yes no no

43 7700000 6480 3 2 4 yes no no

48 7490000 6600 3 1 4 yes no no

50 7420000 7440 3 2 1 yes yes yes

51 7420000 7440 3 2 4 yes no no

52 7420000 6325 3 1 4 yes no no

57 7343000 11440 4 1 2 yes no yes

58 7245000 9000 4 2 4 yes yes no

59 7210000 7680 4 2 4 yes yes no

62 7070000 8880 2 1 1 yes no no

63 7070000 6240 4 2 2 yes no no

64 7035000 6360 4 2 3 yes no no

65 7000000 11175 3 1 1 yes no yes

66 6930000 8880 3 2 2 yes no yes

67 6930000 13200 2 1 1 yes no yes

68 6895000 7700 3 2 1 yes no no

70 6790000 12090 4 2 2 yes no no

74 6685000 6600 2 2 4 yes no yes

77 6650000 6420 3 2 3 yes no no

78 6650000 6500 3 2 3 yes no no

83 6615000 10500 3 2 1 yes no yes

86 6510000 8250 3 2 3 yes no no

87 6510000 6670 3 1 3 yes no yes

89 6475000 7410 3 1 1 yes yes yes

90 6440000 8580 5 3 2 yes no no

92 6419000 6750 2 1 1 yes yes yes

94 6300000 7200 3 2 1 yes no yes

97 6300000 9000 3 1 1 yes no yes

98 6300000 6400 3 1 1 yes yes yes

99 6293000 6600 3 2 3 yes no no

101 6230000 6600 3 2 1 yes no yes

104 6195000 6350 3 2 3 yes yes no

108 6125000 6420 3 1 3 yes no yes

110 6090000 6615 4 2 2 yes yes no

111 6090000 6600 3 1 1 yes yes yes

112 6090000 8372 3 1 3 yes no no

114 6083000 9620 3 1 1 yes no yes

115 6020000 6800 2 1 1 yes yes yes

116 6020000 8000 3 1 1 yes yes yes

117 6020000 6900 3 2 1 yes yes yes

119 5950000 6420 3 1 1 yes no yes

120 5950000 7020 3 1 1 yes no yes

121 5950000 6540 3 1 1 yes yes yes

122 5950000 7231 3 1 2 yes yes yes

123 5950000 6254 4 2 1 yes no yes

124 5950000 7320 4 2 2 yes no no

125 5950000 6525 3 2 4 yes no no

126 5943000 15600 3 1 1 yes no no

hotwaterheating airconditioning parking prefarea furnishingstatus

1 no yes 2 yes furnished

2 no yes 3 no furnished

3 no no 2 yes semi-furnished

4 no yes 3 yes furnished

5 no yes 2 no furnished

6 no yes 2 yes semi-furnished

7 no yes 2 yes semi-furnished

8 no no 0 no unfurnished

9 no yes 2 yes furnished

11 no yes 2 yes furnished

13 no yes 1 yes semi-furnished

15 no no 0 yes semi-furnished

17 no yes 1 yes unfurnished

18 no yes 2 no furnished

20 no yes 1 yes semi-furnished

22 no yes 2 no unfurnished

23 no yes 1 no furnished

25 no yes 2 no furnished

26 no yes 2 yes furnished

28 no no 1 no semi-furnished

29 yes no 2 no unfurnished

31 no yes 2 no unfurnished

32 no yes 2 no semi-furnished

35 no yes 1 no furnished

36 no yes 2 no furnished

37 yes no 1 yes furnished

38 no yes 2 no furnished

41 no yes 0 yes furnished

42 no yes 0 yes furnished

43 no yes 2 no unfurnished

48 no yes 3 yes furnished

50 no yes 0 yes semi-furnished

51 no no 1 yes unfurnished

52 no yes 1 no unfurnished

57 no no 1 yes semi-furnished

58 no yes 1 yes furnished

59 no yes 1 no semi-furnished

62 no yes 1 no semi-furnished

63 no yes 1 no furnished

64 no yes 2 yes furnished

65 no yes 1 yes furnished

66 no yes 1 no furnished

67 yes no 1 no furnished

68 no no 2 no unfurnished

70 no no 2 yes furnished

74 no no 0 yes furnished

77 no yes 0 yes furnished

78 no yes 0 yes furnished

83 no yes 1 yes furnished

86 no yes 0 no furnished

87 no no 0 yes unfurnished

89 no yes 2 yes unfurnished

90 no no 2 no furnished

92 no no 2 yes furnished

94 no yes 3 no semi-furnished

97 no no 1 yes furnished

98 no yes 1 yes semi-furnished

99 no yes 0 yes unfurnished

101 no yes 0 yes unfurnished

104 no yes 0 no furnished

108 no no 0 yes unfurnished

110 yes no 1 no semi-furnished

111 no no 2 yes semi-furnished

112 no yes 2 no unfurnished

114 no no 2 yes furnished

115 no no 2 no furnished

116 no yes 2 yes semi-furnished

117 no no 0 yes unfurnished

119 no yes 0 yes furnished

120 no yes 2 yes semi-furnished

121 no no 2 yes furnished

122 no yes 0 yes semi-furnished

123 no no 1 yes semi-furnished

124 no no 0 no furnished

125 no no 1 no furnished

126 no yes 2 no semi-furnished

[ reached 'max' / getOption("max.print") -- omitted 81 rows ]

> price <- 5

> if(price > 5) {

+ print("Sell the stock")

+ } else {

+ print("Buy the stock")

+ }

[1] "Buy the stock"

> source("Conditional.R")

[1] "Buy the stock"

> stock\_df

Open Price Close Price BuyOrSell

a 110.55 102.5 Sell

b 145.90 130.7 Sell

c 160.45 112.8 Sell

> stock\_df$BuyOrSell <- ifelse(stock\_df$`Close Price` < 80, "Buy", "Sell")

> stock\_df

Open Price Close Price BuyOrSell

a 110.55 102.5 Sell

b 145.90 130.7 Sell

c 160.45 112.8 Sell

> for (x in 1:10) { print(x ^ 2) } #i raised to 2

[1] 1

[1] 4

[1] 9

[1] 16

[1] 25

[1] 36

[1] 49

[1] 64

[1] 81

[1] 100

> mtcars #inbuilt dataset

mpg cyl disp hp drat wt qsec vs am gear carb

Mazda RX4 21.0 6 160.0 110 3.90 2.620 16.46 0 1 4 4

Mazda RX4 Wag 21.0 6 160.0 110 3.90 2.875 17.02 0 1 4 4

Datsun 710 22.8 4 108.0 93 3.85 2.320 18.61 1 1 4 1

Hornet 4 Drive 21.4 6 258.0 110 3.08 3.215 19.44 1 0 3 1

Hornet Sportabout 18.7 8 360.0 175 3.15 3.440 17.02 0 0 3 2

Valiant 18.1 6 225.0 105 2.76 3.460 20.22 1 0 3 1

Duster 360 14.3 8 360.0 245 3.21 3.570 15.84 0 0 3 4

Merc 240D 24.4 4 146.7 62 3.69 3.190 20.00 1 0 4 2

Merc 230 22.8 4 140.8 95 3.92 3.150 22.90 1 0 4 2

Merc 280 19.2 6 167.6 123 3.92 3.440 18.30 1 0 4 4

Merc 280C 17.8 6 167.6 123 3.92 3.440 18.90 1 0 4 4

Merc 450SE 16.4 8 275.8 180 3.07 4.070 17.40 0 0 3 3

Merc 450SL 17.3 8 275.8 180 3.07 3.730 17.60 0 0 3 3

Merc 450SLC 15.2 8 275.8 180 3.07 3.780 18.00 0 0 3 3

Cadillac Fleetwood 10.4 8 472.0 205 2.93 5.250 17.98 0 0 3 4

Lincoln Continental 10.4 8 460.0 215 3.00 5.424 17.82 0 0 3 4

Chrysler Imperial 14.7 8 440.0 230 3.23 5.345 17.42 0 0 3 4

Fiat 128 32.4 4 78.7 66 4.08 2.200 19.47 1 1 4 1

Honda Civic 30.4 4 75.7 52 4.93 1.615 18.52 1 1 4 2

Toyota Corolla 33.9 4 71.1 65 4.22 1.835 19.90 1 1 4 1

Toyota Corona 21.5 4 120.1 97 3.70 2.465 20.01 1 0 3 1

Dodge Challenger 15.5 8 318.0 150 2.76 3.520 16.87 0 0 3 2

AMC Javelin 15.2 8 304.0 150 3.15 3.435 17.30 0 0 3 2

Camaro Z28 13.3 8 350.0 245 3.73 3.840 15.41 0 0 3 4

Pontiac Firebird 19.2 8 400.0 175 3.08 3.845 17.05 0 0 3 2

Fiat X1-9 27.3 4 79.0 66 4.08 1.935 18.90 1 1 4 1

Porsche 914-2 26.0 4 120.3 91 4.43 2.140 16.70 0 1 5 2

Lotus Europa 30.4 4 95.1 113 3.77 1.513 16.90 1 1 5 2

Ford Pantera L 15.8 8 351.0 264 4.22 3.170 14.50 0 1 5 4

Ferrari Dino 19.7 6 145.0 175 3.62 2.770 15.50 0 1 5 6

Maserati Bora 15.0 8 301.0 335 3.54 3.570 14.60 0 1 5 8

Volvo 142E 21.4 4 121.0 109 4.11 2.780 18.60 1 1 4 2

> iris #inbuilt dataset

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

7 4.6 3.4 1.4 0.3 setosa

8 5.0 3.4 1.5 0.2 setosa

9 4.4 2.9 1.4 0.2 setosa

10 4.9 3.1 1.5 0.1 setosa

11 5.4 3.7 1.5 0.2 setosa

12 4.8 3.4 1.6 0.2 setosa

13 4.8 3.0 1.4 0.1 setosa

14 4.3 3.0 1.1 0.1 setosa

15 5.8 4.0 1.2 0.2 setosa

16 5.7 4.4 1.5 0.4 setosa

17 5.4 3.9 1.3 0.4 setosa

18 5.1 3.5 1.4 0.3 setosa

19 5.7 3.8 1.7 0.3 setosa

20 5.1 3.8 1.5 0.3 setosa

21 5.4 3.4 1.7 0.2 setosa

22 5.1 3.7 1.5 0.4 setosa

23 4.6 3.6 1.0 0.2 setosa

24 5.1 3.3 1.7 0.5 setosa

25 4.8 3.4 1.9 0.2 setosa

26 5.0 3.0 1.6 0.2 setosa

27 5.0 3.4 1.6 0.4 setosa

28 5.2 3.5 1.5 0.2 setosa

29 5.2 3.4 1.4 0.2 setosa

30 4.7 3.2 1.6 0.2 setosa

31 4.8 3.1 1.6 0.2 setosa

32 5.4 3.4 1.5 0.4 setosa

33 5.2 4.1 1.5 0.1 setosa

34 5.5 4.2 1.4 0.2 setosa

35 4.9 3.1 1.5 0.2 setosa

36 5.0 3.2 1.2 0.2 setosa

37 5.5 3.5 1.3 0.2 setosa

38 4.9 3.6 1.4 0.1 setosa

39 4.4 3.0 1.3 0.2 setosa

40 5.1 3.4 1.5 0.2 setosa

41 5.0 3.5 1.3 0.3 setosa

42 4.5 2.3 1.3 0.3 setosa

43 4.4 3.2 1.3 0.2 setosa

44 5.0 3.5 1.6 0.6 setosa

45 5.1 3.8 1.9 0.4 setosa

46 4.8 3.0 1.4 0.3 setosa

47 5.1 3.8 1.6 0.2 setosa

48 4.6 3.2 1.4 0.2 setosa

49 5.3 3.7 1.5 0.2 setosa

50 5.0 3.3 1.4 0.2 setosa

51 7.0 3.2 4.7 1.4 versicolor

52 6.4 3.2 4.5 1.5 versicolor

53 6.9 3.1 4.9 1.5 versicolor

54 5.5 2.3 4.0 1.3 versicolor

55 6.5 2.8 4.6 1.5 versicolor

56 5.7 2.8 4.5 1.3 versicolor

57 6.3 3.3 4.7 1.6 versicolor

58 4.9 2.4 3.3 1.0 versicolor

59 6.6 2.9 4.6 1.3 versicolor

60 5.2 2.7 3.9 1.4 versicolor

61 5.0 2.0 3.5 1.0 versicolor

62 5.9 3.0 4.2 1.5 versicolor

63 6.0 2.2 4.0 1.0 versicolor

64 6.1 2.9 4.7 1.4 versicolor

65 5.6 2.9 3.6 1.3 versicolor

66 6.7 3.1 4.4 1.4 versicolor

67 5.6 3.0 4.5 1.5 versicolor

68 5.8 2.7 4.1 1.0 versicolor

69 6.2 2.2 4.5 1.5 versicolor

70 5.6 2.5 3.9 1.1 versicolor

71 5.9 3.2 4.8 1.8 versicolor

72 6.1 2.8 4.0 1.3 versicolor

73 6.3 2.5 4.9 1.5 versicolor

74 6.1 2.8 4.7 1.2 versicolor

75 6.4 2.9 4.3 1.3 versicolor

76 6.6 3.0 4.4 1.4 versicolor

77 6.8 2.8 4.8 1.4 versicolor

78 6.7 3.0 5.0 1.7 versicolor

79 6.0 2.9 4.5 1.5 versicolor

80 5.7 2.6 3.5 1.0 versicolor

81 5.5 2.4 3.8 1.1 versicolor

82 5.5 2.4 3.7 1.0 versicolor

83 5.8 2.7 3.9 1.2 versicolor

84 6.0 2.7 5.1 1.6 versicolor

85 5.4 3.0 4.5 1.5 versicolor

86 6.0 3.4 4.5 1.6 versicolor

87 6.7 3.1 4.7 1.5 versicolor

88 6.3 2.3 4.4 1.3 versicolor

89 5.6 3.0 4.1 1.3 versicolor

90 5.5 2.5 4.0 1.3 versicolor

91 5.5 2.6 4.4 1.2 versicolor

92 6.1 3.0 4.6 1.4 versicolor

93 5.8 2.6 4.0 1.2 versicolor

94 5.0 2.3 3.3 1.0 versicolor

95 5.6 2.7 4.2 1.3 versicolor

96 5.7 3.0 4.2 1.2 versicolor

97 5.7 2.9 4.2 1.3 versicolor

98 6.2 2.9 4.3 1.3 versicolor

99 5.1 2.5 3.0 1.1 versicolor

100 5.7 2.8 4.1 1.3 versicolor

101 6.3 3.3 6.0 2.5 virginica

102 5.8 2.7 5.1 1.9 virginica

103 7.1 3.0 5.9 2.1 virginica

104 6.3 2.9 5.6 1.8 virginica

105 6.5 3.0 5.8 2.2 virginica

106 7.6 3.0 6.6 2.1 virginica

107 4.9 2.5 4.5 1.7 virginica

108 7.3 2.9 6.3 1.8 virginica

109 6.7 2.5 5.8 1.8 virginica

110 7.2 3.6 6.1 2.5 virginica

111 6.5 3.2 5.1 2.0 virginica

112 6.4 2.7 5.3 1.9 virginica

113 6.8 3.0 5.5 2.1 virginica

114 5.7 2.5 5.0 2.0 virginica

115 5.8 2.8 5.1 2.4 virginica

116 6.4 3.2 5.3 2.3 virginica

117 6.5 3.0 5.5 1.8 virginica

118 7.7 3.8 6.7 2.2 virginica

119 7.7 2.6 6.9 2.3 virginica

120 6.0 2.2 5.0 1.5 virginica

121 6.9 3.2 5.7 2.3 virginica

122 5.6 2.8 4.9 2.0 virginica

123 7.7 2.8 6.7 2.0 virginica

124 6.3 2.7 4.9 1.8 virginica

125 6.7 3.3 5.7 2.1 virginica

126 7.2 3.2 6.0 1.8 virginica

127 6.2 2.8 4.8 1.8 virginica

128 6.1 3.0 4.9 1.8 virginica

129 6.4 2.8 5.6 2.1 virginica

130 7.2 3.0 5.8 1.6 virginica

131 7.4 2.8 6.1 1.9 virginica

132 7.9 3.8 6.4 2.0 virginica

133 6.4 2.8 5.6 2.2 virginica

134 6.3 2.8 5.1 1.5 virginica

135 6.1 2.6 5.6 1.4 virginica

136 7.7 3.0 6.1 2.3 virginica

137 6.3 3.4 5.6 2.4 virginica

138 6.4 3.1 5.5 1.8 virginica

139 6.0 3.0 4.8 1.8 virginica

140 6.9 3.1 5.4 2.1 virginica

141 6.7 3.1 5.6 2.4 virginica

142 6.9 3.1 5.1 2.3 virginica

143 5.8 2.7 5.1 1.9 virginica

144 6.8 3.2 5.9 2.3 virginica

145 6.7 3.3 5.7 2.5 virginica

146 6.7 3.0 5.2 2.3 virginica

147 6.3 2.5 5.0 1.9 virginica

148 6.5 3.0 5.2 2.0 virginica

149 6.2 3.4 5.4 2.3 virginica

150 5.9 3.0 5.1 1.8 virginica

> names(mtcars) #variable/column names

[1] "mpg" "cyl" "disp" "hp" "drat" "wt" "qsec" "vs" "am" "gear" "carb"

> for (c in names(mtcars)) { print(c) }

[1] "mpg"

[1] "cyl"

[1] "disp"

[1] "hp"

[1] "drat"

[1] "wt"

[1] "qsec"

[1] "vs"

[1] "am"

[1] "gear"

[1] "carb"

> price <- 12.99

> while (price < 15) {

+ price <- price + 1

+ print(price)

+ }

[1] 13.99

[1] 14.99

[1] 15.99

> check\_price <- function(x) {

+ if(x > 110) {

+ print("Price beyond threshold")

+ } else {

+ print("Price within threshold")

+ }

+ }

> check\_price(200)

[1] "Price beyond threshold"

> myvect <- c(10, 20, 30, NA, 60, 80)

> mean(myvect)

[1] NA

> sd(myvect)

[1] NA

> min(myvect)

[1] NA

> mean(myvect, na.rm = TRUE)

[1] 40

> stock\_price <- c(10, 5, 20, 15, 12, 22)

> matrix\_form <- matrix(stock\_price, ncol = 2, byrow = TRUE)

> matrix\_form

[,1] [,2]

[1,] 10 5

[2,] 20 15

[3,] 12 22

> apply(matrix\_form, 1, sum)

[1] 15 35 34

> apply(matrix\_form, 2, sum)

[1] 42 42

> lapply(1:3, function(x) x ^ 2) #Returns list

[[1]]

[1] 1

[[2]]

[1] 4

[[3]]

[1] 9

> sapply(1:3, function(x) x ^ 2) #Returns vector

[1] 1 4 9

> l <- lapply(1:3, function(x) x ^ 2)

> class(l)

[1] "list"

> s <- sapply(1:3, function(x) x ^ 2)

> class(s)

[1] "numeric"

> #Initial Date: 1/1/1970

> purchase\_on <- 365

> class(purchase\_on) <- "Date" #Convert to Date & Adds 365 days to the default date

> purchase\_on

[1] "1971-01-01"

> purchase\_on <- -10

> class(purchase\_on) <- "Date" #Convert to Date & Subtracts 10 days from the default date

> purchase\_on

[1] "1969-12-22"

> purchase\_date <- as.Date(365, origin=as.Date("2015-03-31")) #365 days added to origin date

> purchase\_date

[1] "2016-03-30"

> sale\_date <- as.Date(-10, origin=as.Date("2015-02-10")) #10 days subtracted from origin date

> sale\_date

[1] "2015-01-31"

> format(sale\_date, "%Y")

[1] "2015"

> format(sale\_date, "%m")

[1] "01"

> format(sale\_date, "%b")

[1] "Jan"

> format(sale\_date, "%B")

[1] "January"

> Sys.Date()

[1] "2022-02-15"

> format(Sys.Date(), "%d/%m/%Y")

[1] "15/02/2022"

> as.Date("2021/02/04", format="%Y/%m/%d") #convert a format of date to date type

[1] "2021-02-04"

> as.Date(purchase\_date) > as.Date(sale\_date)

[1] TRUE

> as.Date(purchase\_date) < as.Date(sale\_date)

[1] FALSE

> first\_date <- "2020-05-16"

> second\_date <- "2020-12-24"

> as.Date(first\_date) > as.Date(second\_date)

[1] FALSE

> as.Date(first\_date) < as.Date(second\_date)

[1] TRUE

> dim(housing\_df)

[1] 545 13

> str(housing\_df)

'data.frame': 545 obs. of 13 variables:

$ price : int 13300000 12250000 12250000 12215000 11410000 10850000 10150000 10150000 9870000 9800000 ...

$ area : int 7420 8960 9960 7500 7420 7500 8580 16200 8100 5750 ...

$ bedrooms : int 4 4 3 4 4 3 4 5 4 3 ...

$ bathrooms : int 2 4 2 2 1 3 3 3 1 2 ...

$ stories : int 3 4 2 2 2 1 4 2 2 4 ...

$ mainroad : chr "yes" "yes" "yes" "yes" ...

$ guestroom : chr "no" "no" "no" "no" ...

$ basement : chr "no" "no" "yes" "yes" ...

$ hotwaterheating : chr "no" "no" "no" "no" ...

$ airconditioning : chr "yes" "yes" "no" "yes" ...

$ parking : int 2 3 2 3 2 2 2 0 2 1 ...

$ prefarea : chr "yes" "no" "yes" "yes" ...

$ furnishingstatus: chr "furnished" "furnished" "semi-furnished" "furnished" ...

> summary(housing\_df)

price area bedrooms bathrooms

Min. : 1750000 Min. : 1650 Min. :1.000 Min. :1.000

1st Qu.: 3430000 1st Qu.: 3600 1st Qu.:2.000 1st Qu.:1.000

Median : 4340000 Median : 4600 Median :3.000 Median :1.000

Mean : 4766729 Mean : 5151 Mean :2.965 Mean :1.286

3rd Qu.: 5740000 3rd Qu.: 6360 3rd Qu.:3.000 3rd Qu.:2.000

Max. :13300000 Max. :16200 Max. :6.000 Max. :4.000

stories mainroad guestroom basement

Min. :1.000 Length:545 Length:545 Length:545

1st Qu.:1.000 Class :character Class :character Class :character

Median :2.000 Mode :character Mode :character Mode :character

Mean :1.806

3rd Qu.:2.000

Max. :4.000

hotwaterheating airconditioning parking prefarea

Length:545 Length:545 Min. :0.0000 Length:545

Class :character Class :character 1st Qu.:0.0000 Class :character

Mode :character Mode :character Median :0.0000 Mode :character

Mean :0.6936

3rd Qu.:1.0000

Max. :3.0000

furnishingstatus

Length:545

Class :character

Mode :character

**Day 3 – R Programming**

> ages <- c(34, 45, 26, 32, 21)

> location <- c("Urban", "Rural", "Urban", "Rural", "Urban")

> tapply(ages, location, mean) #location wise age mean

Rural Urban

38.5 27.0

> #history() #get previous command

> setwd("C:/zubeda/PGA02\_Zubu/R Programming") #Set current working directory

> housing\_df = read.csv("Housing.csv")

> housing\_df

price area bedrooms bathrooms stories mainroad guestroom basement hotwaterheating airconditioning parking

1 13300000 7420 4 2 3 yes no no no yes 2

2 12250000 8960 4 4 4 yes no no no yes 3

3 12250000 9960 3 2 2 yes no yes no no 2

4 12215000 7500 4 2 2 yes no yes no yes 3

5 11410000 7420 4 1 2 yes yes yes no yes 2

6 10850000 7500 3 3 1 yes no yes no yes 2

7 10150000 8580 4 3 4 yes no no no yes 2

8 10150000 16200 5 3 2 yes no no no no 0

9 9870000 8100 4 1 2 yes yes yes no yes 2

10 9800000 5750 3 2 4 yes yes no no yes 1

11 9800000 13200 3 1 2 yes no yes no yes 2

12 9681000 6000 4 3 2 yes yes yes yes no 2

13 9310000 6550 4 2 2 yes no no no yes 1

14 9240000 3500 4 2 2 yes no no yes no 2

15 9240000 7800 3 2 2 yes no no no no 0

16 9100000 6000 4 1 2 yes no yes no no 2

17 9100000 6600 4 2 2 yes yes yes no yes 1

18 8960000 8500 3 2 4 yes no no no yes 2

19 8890000 4600 3 2 2 yes yes no no yes 2

20 8855000 6420 3 2 2 yes no no no yes 1

21 8750000 4320 3 1 2 yes no yes yes no 2

22 8680000 7155 3 2 1 yes yes yes no yes 2

23 8645000 8050 3 1 1 yes yes yes no yes 1

24 8645000 4560 3 2 2 yes yes yes no yes 1

25 8575000 8800 3 2 2 yes no no no yes 2

26 8540000 6540 4 2 2 yes yes yes no yes 2

27 8463000 6000 3 2 4 yes yes yes no yes 0

28 8400000 8875 3 1 1 yes no no no no 1

29 8400000 7950 5 2 2 yes no yes yes no 2

30 8400000 5500 4 2 2 yes no yes no yes 1

31 8400000 7475 3 2 4 yes no no no yes 2

32 8400000 7000 3 1 4 yes no no no yes 2

33 8295000 4880 4 2 2 yes no no no yes 1

34 8190000 5960 3 3 2 yes yes yes no no 1

35 8120000 6840 5 1 2 yes yes yes no yes 1

36 8080940 7000 3 2 4 yes no no no yes 2

37 8043000 7482 3 2 3 yes no no yes no 1

38 7980000 9000 4 2 4 yes no no no yes 2

39 7962500 6000 3 1 4 yes yes no no yes 2

40 7910000 6000 4 2 4 yes no no no yes 1

41 7875000 6550 3 1 2 yes no yes no yes 0

42 7840000 6360 3 2 4 yes no no no yes 0

43 7700000 6480 3 2 4 yes no no no yes 2

44 7700000 6000 4 2 4 yes no no no no 2

45 7560000 6000 4 2 4 yes no no no yes 1

46 7560000 6000 3 2 3 yes no no no yes 0

47 7525000 6000 3 2 4 yes no no no yes 1

48 7490000 6600 3 1 4 yes no no no yes 3

49 7455000 4300 3 2 2 yes no yes no no 1

50 7420000 7440 3 2 1 yes yes yes no yes 0

51 7420000 7440 3 2 4 yes no no no no 1

52 7420000 6325 3 1 4 yes no no no yes 1

53 7350000 6000 4 2 4 yes yes no no yes 1

54 7350000 5150 3 2 4 yes no no no yes 2

55 7350000 6000 3 2 2 yes yes no no yes 1

56 7350000 6000 3 1 2 yes no no no yes 1

57 7343000 11440 4 1 2 yes no yes no no 1

58 7245000 9000 4 2 4 yes yes no no yes 1

59 7210000 7680 4 2 4 yes yes no no yes 1

60 7210000 6000 3 2 4 yes yes no no yes 1

61 7140000 6000 3 2 2 yes yes no no no 1

62 7070000 8880 2 1 1 yes no no no yes 1

63 7070000 6240 4 2 2 yes no no no yes 1

64 7035000 6360 4 2 3 yes no no no yes 2

65 7000000 11175 3 1 1 yes no yes no yes 1

66 6930000 8880 3 2 2 yes no yes no yes 1

67 6930000 13200 2 1 1 yes no yes yes no 1

68 6895000 7700 3 2 1 yes no no no no 2

69 6860000 6000 3 1 1 yes no no no yes 1

70 6790000 12090 4 2 2 yes no no no no 2

71 6790000 4000 3 2 2 yes no yes no yes 0

72 6755000 6000 4 2 4 yes no no no yes 0

73 6720000 5020 3 1 4 yes no no no yes 0

74 6685000 6600 2 2 4 yes no yes no no 0

75 6650000 4040 3 1 2 yes no yes yes no 1

76 6650000 4260 4 2 2 yes no no yes no 0

prefarea furnishingstatus

1 yes furnished

2 no furnished

3 yes semi-furnished

4 yes furnished

5 no furnished

6 yes semi-furnished

7 yes semi-furnished

8 no unfurnished

9 yes furnished

10 yes unfurnished

11 yes furnished

12 no semi-furnished

13 yes semi-furnished

14 no furnished

15 yes semi-furnished

16 no semi-furnished

17 yes unfurnished

18 no furnished

19 no furnished

20 yes semi-furnished

21 no semi-furnished

22 no unfurnished

23 no furnished

24 no furnished

25 no furnished

26 yes furnished

27 yes semi-furnished

28 no semi-furnished

29 no unfurnished

30 yes semi-furnished

31 no unfurnished

32 no semi-furnished

33 yes furnished

34 no unfurnished

35 no furnished

36 no furnished

37 yes furnished

38 no furnished

39 no unfurnished

40 no semi-furnished

41 yes furnished

42 yes furnished

43 no unfurnished

44 no semi-furnished

45 no furnished

46 no semi-furnished

47 no furnished

48 yes furnished

49 no unfurnished

50 yes semi-furnished

51 yes unfurnished

52 no unfurnished

53 no furnished

54 no semi-furnished

55 no semi-furnished

56 no unfurnished

57 yes semi-furnished

58 yes furnished

59 no semi-furnished

60 no furnished

61 no semi-furnished

62 no semi-furnished

63 no furnished

64 yes furnished

65 yes furnished

66 no furnished

67 no furnished

68 no unfurnished

69 no furnished

70 yes furnished

71 yes semi-furnished

72 no unfurnished

73 yes unfurnished

74 yes furnished

75 no furnished

76 no semi-furnished

[ reached 'max' / getOption("max.print") -- omitted 469 rows ]

> dev.off() #clear plot window

null device

1

> par(mfrow=c(2,1)) #subplots/partions of 2 rows, 1 col

> #Univariate Analysis

> hist(housing\_df$area, col = "orange")

> boxplot(housing\_df$area, col = "light blue")

> dev.off()

null device

1

> boxplot(housing\_df$area, horizontal = T, col = "light blue")

> dev.off()

null device

1

> summary(mtcars)

mpg cyl disp hp drat wt qsec

Min. :10.40 Min. :4.000 Min. : 71.1 Min. : 52.0 Min. :2.760 Min. :1.513 Min. :14.50

1st Qu.:15.43 1st Qu.:4.000 1st Qu.:120.8 1st Qu.: 96.5 1st Qu.:3.080 1st Qu.:2.581 1st Qu.:16.89

Median :19.20 Median :6.000 Median :196.3 Median :123.0 Median :3.695 Median :3.325 Median :17.71

Mean :20.09 Mean :6.188 Mean :230.7 Mean :146.7 Mean :3.597 Mean :3.217 Mean :17.85

3rd Qu.:22.80 3rd Qu.:8.000 3rd Qu.:326.0 3rd Qu.:180.0 3rd Qu.:3.920 3rd Qu.:3.610 3rd Qu.:18.90

Max. :33.90 Max. :8.000 Max. :472.0 Max. :335.0 Max. :4.930 Max. :5.424 Max. :22.90

vs am gear carb

Min. :0.0000 Min. :0.0000 Min. :3.000 Min. :1.000

1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:3.000 1st Qu.:2.000

Median :0.0000 Median :0.0000 Median :4.000 Median :2.000

Mean :0.4375 Mean :0.4062 Mean :3.688 Mean :2.812

3rd Qu.:1.0000 3rd Qu.:1.0000 3rd Qu.:4.000 3rd Qu.:4.000

Max. :1.0000 Max. :1.0000 Max. :5.000 Max. :8.000

> #Bivariate Analysis

> table(mtcars$vs, mtcars$gear) #Frequency table/Cross table

3 4 5

0 12 2 4

1 3 10 1

> #row index - vs, col index - gear

> df\_numeric\_vars <- Filter(is.numeric, housing\_df) #Filter(condition, df)

> names(df\_numeric\_vars)

[1] "price" "area" "bedrooms" "bathrooms" "stories" "parking"

> df\_categorical\_vars <- Filter(is.factor, housing\_df)

> names(df\_categorical\_vars)

character(0)

> rownames(mtcars)

[1] "Mazda RX4" "Mazda RX4 Wag" "Datsun 710" "Hornet 4 Drive"

[5] "Hornet Sportabout" "Valiant" "Duster 360" "Merc 240D"

[9] "Merc 230" "Merc 280" "Merc 280C" "Merc 450SE"

[13] "Merc 450SL" "Merc 450SLC" "Cadillac Fleetwood" "Lincoln Continental"

[17] "Chrysler Imperial" "Fiat 128" "Honda Civic" "Toyota Corolla"

[21] "Toyota Corona" "Dodge Challenger" "AMC Javelin" "Camaro Z28"

[25] "Pontiac Firebird" "Fiat X1-9" "Porsche 914-2" "Lotus Europa"

[29] "Ford Pantera L" "Ferrari Dino" "Maserati Bora" "Volvo 142E"

> #?data/fn/keyword - get help documentation internally

> #??data/fn/keyword - get help documentation online

> ?mtcars

> ?iris

> counts <- table(mtcars$vs, mtcars$gear)

> #Side by Side barplot

> barplot(counts, main="Car Distribution by Gears and VS", xlab="Number of Gears", ylab="Frequency", col=c("darkblue", "red"), legend=rownames(counts), beside=TRUE)

> dev.off()

null device

1

> #Stacked barplot

> barplot(counts, main="Car Distribution by Gears and VS", xlab="Number of Gears", ylab="Frequency", col=c("darkblue", "red"), legend=rownames(counts), names.arg=c("3", "4", "5"))

> #names.arg - label appear at the bottom of each bar

> nas <- sapply(housing\_df, function(X) sum(is.na(x))) #Missing value checking

> nas

price area bedrooms bathrooms stories mainroad

0 0 0 0 0 0

guestroom basement hotwaterheating airconditioning parking prefarea

0 0 0 0 0 0

furnishingstatus

0

> missing\_percent <- (nas \* 100) / (nrow(housing\_df))

> missing\_percent

price area bedrooms bathrooms stories mainroad

0 0 0 0 0 0

guestroom basement hotwaterheating airconditioning parking prefarea

0 0 0 0 0 0

furnishingstatus

0

> colnames(mtcars)

[1] "mpg" "cyl" "disp" "hp" "drat" "wt" "qsec" "vs" "am" "gear" "carb"

> names(mtcars)

[1] "mpg" "cyl" "disp" "hp" "drat" "wt" "qsec" "vs" "am" "gear" "carb"

> dev.off()

null device

1

> library(dplyr)

> library(ggplot2)

> data.frame(missing\_percent, variable=colnames(housing\_df))%>% #redirection operator/pipe operator for chaining commands with dependency, passing output of one to another

+ ggplot(aes(variable, missing\_percent)) +

+ geom\_bar(stat="identity") + #height of bars to represent values in the data

+ labs(x="Features", y="Percent of Missing values") +

+ theme(axis.text.x=element\_text(angle=90, hjust=1))

> #aes(reorder(variable col, - or + the variable to be sorted)) sorts output in asc or desc order

> paste("Hello", "Everybody") #Concats elements seperated by spaces

[1] "Hello Everybody"

> paste("A", "1", sep="") #Concats elements with no spaces

[1] "A1"

> x <- c(32, 12, 30, 45)

> labels <- c("Mumbai", "Chennai", "Pune", "Banglore")

> pct <- round(x / sum(x) \* 100)

> lbls <- paste(labels, pct)

> lbls <- paste(lbls, "%", sep="")

> pct

[1] 27 10 25 38

> lbls

[1] "Mumbai 27%" "Chennai 10%" "Pune 25%" "Banglore 38%"

> pie(x, labels=lbls, col=rainbow(length(lbls)), main="City Pie Chart") #rainbow(length) will generate 4 hexdecimal values

> legend("topright", c("Mumbai", "Chennai", "Pune", "Banglore"), cex=0.5, fill=rainbow(length(x))) #cex=Controls zoom of the font

> legend("topright", c("Mumbai", "Chennai", "Pune", "Banglore"), cex=1, fill=rainbow(length(x)))

> #install.packages("Quandl")

> library("Quandl")

**Day 4 – R Programming**

> dev.off()

null device

1

> setwd("C:/zubeda/PGA02\_Zubu/R Programming")

> library("plyr")

> library("ggplot2")

> df\_AP <- read.csv("ADANIPORTS.csv")

> edit(df\_AP)

Date Symbol Series Prev.Close Open High Low Last Close VWAP Volume Turnover

1 2007-11-27 MUNDRAPORT EQ 440.00 770.00 1050.00 770.00 959.00 962.90 984.72 27294366 2687719053785000

2 2007-11-28 MUNDRAPORT EQ 962.90 984.00 990.00 874.00 885.00 893.90 941.38 4581338 431276530165000

3 2007-11-29 MUNDRAPORT EQ 893.90 909.00 914.75 841.00 887.00 884.20 888.09 5124121 455065846265000

4 2007-11-30 MUNDRAPORT EQ 884.20 890.00 958.00 890.00 929.00 921.55 929.17 4609762 428325662830000

5 2007-12-03 MUNDRAPORT EQ 921.55 939.75 995.00 922.00 980.00 969.30 965.65 2977470 287519974300000

6 2007-12-04 MUNDRAPORT EQ 969.30 985.00 1056.00 976.00 1049.00 1041.45 1015.39 4849250 492386736075000

7 2007-12-05 MUNDRAPORT EQ 1041.45 1061.00 1099.50 1050.00 1084.00 1082.45 1082.79 2848209 308400973015000

8 2007-12-06 MUNDRAPORT EQ 1082.45 1089.00 1109.70 1051.00 1090.10 1081.30 1087.03 1749516 190177114020000

9 2007-12-07 MUNDRAPORT EQ 1081.30 1100.00 1134.00 1078.00 1100.00 1102.40 1106.57 2247904 248746530710000

10 2007-12-10 MUNDRAPORT EQ 1102.40 1110.00 1110.00 1061.10 1073.55 1075.40 1080.38 1012350 109372679360000

11 2007-12-11 MUNDRAPORT EQ 1075.40 1081.00 1089.00 1041.00 1046.00 1047.65 1067.80 810464 86541556460000

12 2007-12-12 MUNDRAPORT EQ 1047.65 1032.00 1065.00 1016.00 1036.90 1036.80 1043.92 744799 77751369165000

13 2007-12-13 MUNDRAPORT EQ 1036.80 1040.00 1150.00 1030.25 1131.15 1129.95 1109.09 3067687 340233907520000

14 2007-12-14 MUNDRAPORT EQ 1129.95 1139.90 1140.00 1101.10 1107.00 1110.50 1119.55 1070737 119874627765000

15 2007-12-17 MUNDRAPORT EQ 1110.50 1140.00 1168.00 1021.50 1052.00 1044.25 1102.42 1404955 154884767715000

16 2007-12-18 MUNDRAPORT EQ 1044.25 1045.00 1109.90 1031.55 1085.00 1074.95 1077.84 1226984 132249513310000

17 2007-12-19 MUNDRAPORT EQ 1074.95 1091.00 1116.00 1046.30 1078.00 1066.90 1082.93 845666 91579757645000

18 2007-12-20 MUNDRAPORT EQ 1066.90 1083.50 1083.50 1051.00 1067.00 1060.20 1065.52 623288 66412706110000

19 2007-12-24 MUNDRAPORT EQ 1060.20 1095.00 1192.00 1085.25 1160.00 1156.80 1160.77 2060892 239221361310000

20 2007-12-26 MUNDRAPORT EQ 1156.80 1175.00 1214.00 1148.00 1212.00 1199.90 1183.30 1467031 173593856540000

21 2007-12-27 MUNDRAPORT EQ 1199.90 1215.00 1240.00 1204.00 1209.00 1211.65 1222.58 977495 119506465945000

22 2007-12-28 MUNDRAPORT EQ 1211.65 1189.40 1274.00 1175.00 1270.00 1249.10 1221.31 1164138 142177280540000

23 2007-12-31 MUNDRAPORT EQ 1249.10 1263.35 1295.00 1261.00 1268.00 1268.80 1277.64 737249 94194213815000

24 2008-01-01 MUNDRAPORT EQ 1268.80 1279.00 1319.00 1263.70 1308.00 1296.85 1285.72 491348 63173462100000

25 2008-01-02 MUNDRAPORT EQ 1296.85 1310.25 1324.00 1270.00 1300.15 1307.45 1302.15 703815 91647340425000

26 2008-01-03 MUNDRAPORT EQ 1307.45 1305.00 1314.70 1261.15 1267.15 1275.80 1289.24 505058 65114250075000

27 2008-01-04 MUNDRAPORT EQ 1275.80 1278.80 1294.80 1233.00 1239.90 1240.35 1256.03 550795 69181674340000

28 2008-01-07 MUNDRAPORT EQ 1240.35 1240.00 1278.90 1215.00 1233.00 1227.25 1244.76 630963 78539769975000

29 2008-01-08 MUNDRAPORT EQ 1227.25 1240.00 1255.00 1185.00 1202.00 1204.80 1217.08 530499 64565951270000

30 2008-01-09 MUNDRAPORT EQ 1204.80 1200.00 1210.00 1151.00 1181.00 1180.25 1176.37 627507 73818313330000

31 2008-01-10 MUNDRAPORT EQ 1180.25 1185.00 1199.80 1110.00 1118.00 1121.55 1156.44 438806 50745246590000

32 2008-01-11 MUNDRAPORT EQ 1121.55 1128.00 1130.00 1063.00 1096.00 1085.85 1087.78 616938 67109272025000

33 2008-01-14 MUNDRAPORT EQ 1085.85 1082.40 1082.40 1031.10 1035.00 1035.15 1042.40 835916 87135710755000

34 2008-01-15 MUNDRAPORT EQ 1035.15 1045.60 1078.70 1036.05 1057.00 1049.55 1050.69 830493 87259337110000

35 2008-01-16 MUNDRAPORT EQ 1049.55 1046.00 1064.00 1000.00 1038.30 1030.40 1032.86 816188 84300609685000

36 2008-01-17 MUNDRAPORT EQ 1030.40 1050.00 1053.50 1011.00 1014.95 1020.90 1033.73 336003 34733490900000

37 2008-01-18 MUNDRAPORT EQ 1020.90 1010.00 1072.00 974.90 995.00 994.60 1022.57 676854 69213280915000

38 2008-01-21 MUNDRAPORT EQ 994.60 995.00 1005.00 795.70 853.00 825.05 880.77 788623 69459899855000

39 2008-01-22 MUNDRAPORT EQ 825.05 700.00 810.00 660.05 739.00 735.55 703.20 546161 38406113705000

40 2008-01-23 MUNDRAPORT EQ 735.55 760.00 881.90 760.00 862.20 857.00 818.67 535462 43836526980000

41 2008-01-24 MUNDRAPORT EQ 857.00 875.00 935.00 812.00 814.70 814.15 854.83 511017 43683319425000

42 2008-01-25 MUNDRAPORT EQ 814.15 820.00 883.00 820.00 866.00 865.70 858.33 404045 34680333860000

43 2008-01-28 MUNDRAPORT EQ 865.70 835.00 835.00 783.20 822.00 820.80 804.38 467052 37568552380000

44 2008-01-29 MUNDRAPORT EQ 820.80 840.00 860.00 820.05 840.00 840.75 841.27 220070 18513823345000

45 2008-01-30 MUNDRAPORT EQ 840.75 849.80 864.00 822.25 834.00 830.45 833.82 286190 23863110660000

46 2008-01-31 MUNDRAPORT EQ 830.45 831.00 849.90 812.55 836.60 837.65 833.58 194300 16196555895000

47 2008-02-01 MUNDRAPORT EQ 837.65 831.65 852.30 820.00 826.00 825.35 828.09 204391 16925451805000

48 2008-02-04 MUNDRAPORT EQ 825.35 847.90 872.40 840.00 859.00 856.10 858.77 280230 24065208695000

49 2008-02-05 MUNDRAPORT EQ 856.10 856.00 857.00 830.00 834.65 834.30 842.06 162093 13649192020000

50 2008-02-06 MUNDRAPORT EQ 834.30 803.00 824.90 780.00 809.00 807.50 810.50 193260 15663794125000

51 2008-02-07 MUNDRAPORT EQ 807.50 825.00 830.00 792.00 795.90 796.25 809.53 212932 17237575975000

52 2008-02-08 MUNDRAPORT EQ 796.25 810.00 830.00 765.15 786.00 784.05 781.48 285025 22274252000000

53 2008-02-11 MUNDRAPORT EQ 784.05 785.00 785.00 695.00 699.00 711.20 736.23 223955 16488264325000

54 2008-02-12 MUNDRAPORT EQ 711.20 725.00 734.95 655.60 689.00 681.30 681.38 303409 20673577510000

55 2008-02-13 MUNDRAPORT EQ 681.30 815.90 815.90 664.00 678.00 670.95 681.68 214900 14649214640000

56 2008-02-14 MUNDRAPORT EQ 670.95 680.00 714.00 680.00 710.00 709.80 704.71 269032 18959036175000

57 2008-02-15 MUNDRAPORT EQ 709.80 700.00 763.70 681.25 729.00 728.75 734.23 353049 25921872820000

58 2008-02-18 MUNDRAPORT EQ 728.75 735.00 775.00 735.00 772.00 771.60 762.33 342580 26115882900000

59 2008-02-19 MUNDRAPORT EQ 771.60 779.00 786.90 760.20 767.00 763.90 772.24 137412 10611555840000

60 2008-02-20 MUNDRAPORT EQ 763.90 750.00 760.00 720.00 740.00 732.10 730.61 197489 14428706935000

61 2008-02-21 MUNDRAPORT EQ 732.10 762.00 762.00 730.10 738.90 737.60 741.53 125558 9310465240000

62 2008-02-22 MUNDRAPORT EQ 737.60 723.00 737.00 715.00 724.50 724.00 726.52 81070 5889922195000

63 2008-02-25 MUNDRAPORT EQ 724.00 725.05 758.90 702.30 707.00 707.65 711.70 152803 10875065635000

64 2008-02-26 MUNDRAPORT EQ 707.65 725.00 744.00 713.00 735.00 735.80 733.73 251269 18436350425000

65 2008-02-27 MUNDRAPORT EQ 735.80 749.70 783.40 741.00 744.00 746.40 762.47 305320 23279802440000

66 2008-02-28 MUNDRAPORT EQ 746.40 740.00 754.90 725.05 740.00 737.75 738.91 112491 8312092510000

Trades Deliverable.Volume X.Deliverble

1 NA 9859619 0.3612

2 NA 1453278 0.3172

3 NA 1069678 0.2088

4 NA 1260913 0.2735

5 NA 816123 0.2741

6 NA 1537667 0.3171

7 NA 904260 0.3175

8 NA 825691 0.4720

9 NA 697763 0.3104

10 NA 417514 0.4124

11 NA 415191 0.5123

12 NA 363848 0.4885

13 NA 1040076 0.3390

14 NA 525239 0.4905

15 NA 670298 0.4771

16 NA 449420 0.3663

17 NA 344171 0.4070

18 NA 276356 0.4434

19 NA 807879 0.3920

20 NA 469389 0.3200

21 NA 355431 0.3636

22 NA 503564 0.4326

23 NA 316377 0.4291

24 NA 172911 0.3519

25 NA 221397 0.3146

26 NA 217437 0.4305

27 NA 230237 0.4180

28 NA 239404 0.3794

29 NA 228866 0.4314

30 NA 259280 0.4132

31 NA 200150 0.4561

32 NA 312121 0.5059

33 NA 570824 0.6829

34 NA 504259 0.6072

35 NA 478517 0.5863

36 NA 145194 0.4321

37 NA 278615 0.4116

38 NA 474223 0.6013

39 NA 376194 0.6888

40 NA 283881 0.5302

41 NA 258346 0.5056

42 NA 178177 0.4410

43 NA 241365 0.5168

44 NA 74141 0.3369

45 NA 165926 0.5798

46 NA 103890 0.5347

47 NA 115715 0.5661

48 NA 128195 0.4575

49 NA 96153 0.5932

50 NA 110565 0.5721

51 NA 106275 0.4991

52 NA 154857 0.5433

53 NA 118002 0.5269

54 NA 187180 0.6169

55 NA 108761 0.5061

56 NA 148611 0.5524

57 NA 110621 0.3133

58 NA 154099 0.4498

59 NA 47543 0.3460

60 NA 89397 0.4527

61 NA 37956 0.3023

62 NA 31808 0.3924

63 NA 71403 0.4673

64 NA 53136 0.2115

65 NA 84490 0.2767

66 NA 36730 0.3265

[ reached 'max' / getOption("max.print") -- omitted 3256 rows ]

> names(df\_AP)

[1] "Date" "Symbol" "Series" "Prev.Close" "Open"

[6] "High" "Low" "Last" "Close" "VWAP"

[11] "Volume" "Turnover" "Trades" "Deliverable.Volume" "X.Deliverble"

> head(df\_AP) #get first 6 rows

Date Symbol Series Prev.Close Open High Low Last Close VWAP Volume Turnover Trades

1 2007-11-27 MUNDRAPORT EQ 440.00 770.00 1050.00 770 959 962.90 984.72 27294366 2687719053785000 NA

2 2007-11-28 MUNDRAPORT EQ 962.90 984.00 990.00 874 885 893.90 941.38 4581338 431276530165000 NA

3 2007-11-29 MUNDRAPORT EQ 893.90 909.00 914.75 841 887 884.20 888.09 5124121 455065846265000 NA

4 2007-11-30 MUNDRAPORT EQ 884.20 890.00 958.00 890 929 921.55 929.17 4609762 428325662830000 NA

5 2007-12-03 MUNDRAPORT EQ 921.55 939.75 995.00 922 980 969.30 965.65 2977470 287519974300000 NA

6 2007-12-04 MUNDRAPORT EQ 969.30 985.00 1056.00 976 1049 1041.45 1015.39 4849250 492386736075000 NA

Deliverable.Volume X.Deliverble

1 9859619 0.3612

2 1453278 0.3172

3 1069678 0.2088

4 1260913 0.2735

5 816123 0.2741

6 1537667 0.3171

> v <- c(8, 14, 26, 5, 43)

> plot(v, type="o") #Line plot with points

> plot(v, type="p") #Points plot

> plot(v, type="l") #Line plot without points

> plot(v, type="o", col="red", xlab="Month", ylab="Rainfall", main="Rainfall Chart")

> v <- c(12, 14, 28, 5, 44)

> t <- c(15, 8, 8, 10, 13)

> plot(v, type="o", col="blue", xlab="Month", ylab="Rainfall", main="Rainfall Chart")

> lines(t, type="o", col="red")

> df\_aapl <- read.csv("AAPL.csv")

> head(df\_aapl)

Date Open High Low Close Adj.Close Volume

1 2021-02-17 131.25 132.22 129.47 130.84 130.0669 97918500

2 2021-02-18 129.20 130.00 127.41 129.71 128.9436 96856700

3 2021-02-19 130.24 130.71 128.80 129.87 129.1027 87668800

4 2021-02-22 128.01 129.72 125.60 126.00 125.2555 103916400

5 2021-02-23 123.76 126.71 118.39 125.86 125.1164 158273000

6 2021-02-24 124.94 125.56 122.23 125.35 124.6094 111039900

> df\_waltdisney <- read.csv("DIS.csv")

> head(df\_waltdisney)

Date Open High Low Close Adj.Close Volume

1 2021-02-17 185.36 187.63 182.16 186.44 186.44 11391800

2 2021-02-18 184.79 186.40 182.84 183.00 183.00 12380900

3 2021-02-19 184.27 184.78 182.79 183.65 183.65 8834500

4 2021-02-22 181.74 194.02 181.53 191.76 191.76 18799600

5 2021-02-23 193.59 198.94 188.66 197.09 197.09 23191400

6 2021-02-24 197.58 200.60 195.33 197.51 197.51 16205900

> df\_nike <- read.csv("NKE.csv")

> head(df\_nike)

Date Open High Low Close Adj.Close Volume

1 2021-02-17 141.30 144.56 140.21 143.99 142.9153 6437100

2 2021-02-18 142.98 145.39 141.21 145.09 144.0071 4486800

3 2021-02-19 145.43 145.50 141.50 142.02 140.9601 7486000

4 2021-02-22 141.54 142.46 136.26 136.67 135.6500 8985900

5 2021-02-23 136.03 136.83 131.58 136.13 135.1140 10364100

6 2021-02-24 135.06 135.96 133.95 135.65 134.6376 6360900

> df\_aapl <- cbind(df\_aapl, Stock="")

> df\_waltdisney <- cbind(df\_waltdisney, Stock="")

> df\_nike <- cbind(df\_nike, Stock="")

> head(df\_aapl)

Date Open High Low Close Adj.Close Volume Stock

1 2021-02-17 131.25 132.22 129.47 130.84 130.0669 97918500

2 2021-02-18 129.20 130.00 127.41 129.71 128.9436 96856700

3 2021-02-19 130.24 130.71 128.80 129.87 129.1027 87668800

4 2021-02-22 128.01 129.72 125.60 126.00 125.2555 103916400

5 2021-02-23 123.76 126.71 118.39 125.86 125.1164 158273000

6 2021-02-24 124.94 125.56 122.23 125.35 124.6094 111039900

> head(df\_waltdisney)

Date Open High Low Close Adj.Close Volume Stock

1 2021-02-17 185.36 187.63 182.16 186.44 186.44 11391800

2 2021-02-18 184.79 186.40 182.84 183.00 183.00 12380900

3 2021-02-19 184.27 184.78 182.79 183.65 183.65 8834500

4 2021-02-22 181.74 194.02 181.53 191.76 191.76 18799600

5 2021-02-23 193.59 198.94 188.66 197.09 197.09 23191400

6 2021-02-24 197.58 200.60 195.33 197.51 197.51 16205900

> head(df\_nike)

Date Open High Low Close Adj.Close Volume Stock

1 2021-02-17 141.30 144.56 140.21 143.99 142.9153 6437100

2 2021-02-18 142.98 145.39 141.21 145.09 144.0071 4486800

3 2021-02-19 145.43 145.50 141.50 142.02 140.9601 7486000

4 2021-02-22 141.54 142.46 136.26 136.67 135.6500 8985900

5 2021-02-23 136.03 136.83 131.58 136.13 135.1140 10364100

6 2021-02-24 135.06 135.96 133.95 135.65 134.6376 6360900

> df\_aapl$Stock <- paste(df\_aapl$Stock, "Bertrandt", sep="")

> df\_waltdisney$Stock <- paste(df\_waltdisney$Stock, "Deutsche Bank", sep="")

> df\_nike$Stock <- paste(df\_nike$Stock, "Siemens", sep="")

> head(df\_aapl)

Date Open High Low Close Adj.Close Volume Stock

1 2021-02-17 131.25 132.22 129.47 130.84 130.0669 97918500 Bertrandt

2 2021-02-18 129.20 130.00 127.41 129.71 128.9436 96856700 Bertrandt

3 2021-02-19 130.24 130.71 128.80 129.87 129.1027 87668800 Bertrandt

4 2021-02-22 128.01 129.72 125.60 126.00 125.2555 103916400 Bertrandt

5 2021-02-23 123.76 126.71 118.39 125.86 125.1164 158273000 Bertrandt

6 2021-02-24 124.94 125.56 122.23 125.35 124.6094 111039900 Bertrandt

> head(df\_waltdisney)

Date Open High Low Close Adj.Close Volume Stock

1 2021-02-17 185.36 187.63 182.16 186.44 186.44 11391800 Deutsche Bank

2 2021-02-18 184.79 186.40 182.84 183.00 183.00 12380900 Deutsche Bank

3 2021-02-19 184.27 184.78 182.79 183.65 183.65 8834500 Deutsche Bank

4 2021-02-22 181.74 194.02 181.53 191.76 191.76 18799600 Deutsche Bank

5 2021-02-23 193.59 198.94 188.66 197.09 197.09 23191400 Deutsche Bank

6 2021-02-24 197.58 200.60 195.33 197.51 197.51 16205900 Deutsche Bank

> head(df\_nike)

Date Open High Low Close Adj.Close Volume Stock

1 2021-02-17 141.30 144.56 140.21 143.99 142.9153 6437100 Siemens

2 2021-02-18 142.98 145.39 141.21 145.09 144.0071 4486800 Siemens

3 2021-02-19 145.43 145.50 141.50 142.02 140.9601 7486000 Siemens

4 2021-02-22 141.54 142.46 136.26 136.67 135.6500 8985900 Siemens

5 2021-02-23 136.03 136.83 131.58 136.13 135.1140 10364100 Siemens

6 2021-02-24 135.06 135.96 133.95 135.65 134.6376 6360900 Siemens

> df\_allStocks <- rbind(df\_aapl, df\_waltdisney, df\_nike)

> df\_allStocks

Date Open High Low Close Adj.Close Volume Stock

1 2021-02-17 131.25 132.22 129.47 130.84 130.0669 97918500 Bertrandt

2 2021-02-18 129.20 130.00 127.41 129.71 128.9436 96856700 Bertrandt

3 2021-02-19 130.24 130.71 128.80 129.87 129.1027 87668800 Bertrandt

4 2021-02-22 128.01 129.72 125.60 126.00 125.2555 103916400 Bertrandt

5 2021-02-23 123.76 126.71 118.39 125.86 125.1164 158273000 Bertrandt

6 2021-02-24 124.94 125.56 122.23 125.35 124.6094 111039900 Bertrandt

7 2021-02-25 124.68 126.46 120.54 120.99 120.2751 148199500 Bertrandt

8 2021-02-26 122.59 124.85 121.20 121.26 120.5436 164560400 Bertrandt

9 2021-03-01 123.75 127.93 122.79 127.79 127.0350 116307900 Bertrandt

10 2021-03-02 128.41 128.72 125.01 125.12 124.3807 102260900 Bertrandt

11 2021-03-03 124.81 125.71 121.84 122.06 121.3388 112966300 Bertrandt

12 2021-03-04 121.75 123.60 118.62 120.13 119.4202 178155000 Bertrandt

13 2021-03-05 120.98 121.94 117.57 121.42 120.7026 153766600 Bertrandt

14 2021-03-08 120.93 121.00 116.21 116.36 115.6725 154376600 Bertrandt

15 2021-03-09 119.03 122.06 118.79 121.09 120.3745 129525800 Bertrandt

16 2021-03-10 121.69 122.17 119.45 119.98 119.2711 111943300 Bertrandt

17 2021-03-11 122.54 123.21 121.26 121.96 121.2394 103026500 Bertrandt

18 2021-03-12 120.40 121.17 119.16 121.03 120.3149 88105100 Bertrandt

19 2021-03-15 121.41 124.00 120.42 123.99 123.2574 92403800 Bertrandt

20 2021-03-16 125.70 127.22 124.72 125.57 124.8281 115227900 Bertrandt

21 2021-03-17 124.05 125.86 122.34 124.76 124.0229 111932600 Bertrandt

22 2021-03-18 122.88 123.18 120.32 120.53 119.8179 121229700 Bertrandt

23 2021-03-19 119.90 121.43 119.68 119.99 119.2811 185549500 Bertrandt

24 2021-03-22 120.33 123.87 120.26 123.39 122.6610 111912300 Bertrandt

25 2021-03-23 123.33 124.24 122.14 122.54 121.8160 95467100 Bertrandt

26 2021-03-24 122.82 122.90 120.07 120.09 119.3805 88530500 Bertrandt

27 2021-03-25 119.54 121.66 119.00 120.59 119.8775 98844700 Bertrandt

28 2021-03-26 120.35 121.48 118.92 121.21 120.4938 94071200 Bertrandt

29 2021-03-29 121.65 122.58 120.73 121.39 120.6728 80819200 Bertrandt

30 2021-03-30 120.11 120.40 118.86 119.90 119.1916 85671900 Bertrandt

31 2021-03-31 121.65 123.52 121.15 122.15 121.4283 118323800 Bertrandt

32 2021-04-01 123.66 124.18 122.49 123.00 122.2733 75089100 Bertrandt

33 2021-04-05 123.87 126.16 123.07 125.90 125.1561 88651200 Bertrandt

34 2021-04-06 126.50 127.13 125.65 126.21 125.4643 80171300 Bertrandt

35 2021-04-07 125.83 127.92 125.14 127.90 127.1443 83466700 Bertrandt

36 2021-04-08 128.95 130.39 128.52 130.36 129.5898 88844600 Bertrandt

37 2021-04-09 129.80 133.04 129.47 133.00 132.2142 106686700 Bertrandt

38 2021-04-12 132.52 132.85 130.63 131.24 130.4646 91420000 Bertrandt

39 2021-04-13 132.44 134.66 131.93 134.43 133.6357 91266500 Bertrandt

40 2021-04-14 134.94 135.00 131.66 132.03 131.2499 87222800 Bertrandt

41 2021-04-15 133.82 135.00 133.64 134.50 133.7053 89347100 Bertrandt

42 2021-04-16 134.30 134.67 133.28 134.16 133.3673 84922400 Bertrandt

43 2021-04-19 133.51 135.47 133.34 134.84 134.0433 94264200 Bertrandt

44 2021-04-20 135.02 135.53 131.81 133.11 132.3235 94812300 Bertrandt

45 2021-04-21 132.36 133.75 131.30 133.50 132.7112 68847100 Bertrandt

46 2021-04-22 133.04 134.15 131.41 131.94 131.1605 84566500 Bertrandt

47 2021-04-23 132.16 135.12 132.16 134.32 133.5264 78657500 Bertrandt

48 2021-04-26 134.83 135.06 133.56 134.72 133.9240 66905100 Bertrandt

49 2021-04-27 135.01 135.41 134.11 134.39 133.5960 66015800 Bertrandt

50 2021-04-28 134.31 135.02 133.08 133.58 132.7907 107760100 Bertrandt

51 2021-04-29 136.47 137.07 132.45 133.48 132.6913 151101000 Bertrandt

52 2021-04-30 131.78 133.56 131.07 131.46 130.6833 109839500 Bertrandt

53 2021-05-03 132.04 134.07 131.83 132.54 131.7569 75135100 Bertrandt

54 2021-05-04 131.19 131.49 126.70 127.85 127.0946 137564700 Bertrandt

55 2021-05-05 129.20 130.45 127.97 128.10 127.3431 84000900 Bertrandt

56 2021-05-06 127.89 129.75 127.13 129.74 128.9735 78128300 Bertrandt

57 2021-05-07 130.85 131.26 129.48 130.21 129.6606 78973300 Bertrandt

58 2021-05-10 129.41 129.54 126.81 126.85 126.3147 88071200 Bertrandt

59 2021-05-11 123.50 126.27 122.77 125.91 125.3787 126142800 Bertrandt

60 2021-05-12 123.40 124.64 122.25 122.77 122.2519 112172300 Bertrandt

61 2021-05-13 124.58 126.15 124.26 124.97 124.4426 105861300 Bertrandt

62 2021-05-14 126.25 127.89 125.85 127.45 126.9122 81918000 Bertrandt

63 2021-05-17 126.82 126.93 125.17 126.27 125.7372 74244600 Bertrandt

64 2021-05-18 126.56 126.99 124.78 124.85 124.3232 63342900 Bertrandt

65 2021-05-19 123.16 124.92 122.86 124.69 124.1638 92612000 Bertrandt

66 2021-05-20 125.23 127.72 125.10 127.31 126.7728 76857100 Bertrandt

67 2021-05-21 127.82 128.00 125.21 125.43 124.9007 79295400 Bertrandt

68 2021-05-24 126.01 127.94 125.94 127.10 126.5637 63092900 Bertrandt

69 2021-05-25 127.82 128.32 126.32 126.90 126.3645 72009500 Bertrandt

70 2021-05-26 126.96 127.39 126.42 126.85 126.3147 56575900 Bertrandt

71 2021-05-27 126.44 127.64 125.08 125.28 124.7513 94625600 Bertrandt

72 2021-05-28 125.57 125.80 124.55 124.61 124.0842 71311100 Bertrandt

73 2021-06-01 125.08 125.35 123.94 124.28 123.7556 67637100 Bertrandt

74 2021-06-02 124.28 125.24 124.05 125.06 124.5323 59278900 Bertrandt

75 2021-06-03 124.68 124.85 123.13 123.54 123.0187 76229200 Bertrandt

76 2021-06-04 124.07 126.16 123.85 125.89 125.3588 75169300 Bertrandt

77 2021-06-07 126.17 126.32 124.83 125.90 125.3687 71057600 Bertrandt

78 2021-06-08 126.60 128.46 126.21 126.74 126.2052 74403800 Bertrandt

79 2021-06-09 127.21 127.75 126.52 127.13 126.5935 56877900 Bertrandt

80 2021-06-10 127.02 128.19 125.94 126.11 125.5778 71186400 Bertrandt

81 2021-06-11 126.53 127.44 126.10 127.35 126.8126 53522400 Bertrandt

82 2021-06-14 127.82 130.54 127.07 130.48 129.9294 96906500 Bertrandt

83 2021-06-15 129.94 130.60 129.39 129.64 129.0929 62746300 Bertrandt

84 2021-06-16 130.37 130.89 128.46 130.15 129.6008 91815000 Bertrandt

85 2021-06-17 129.80 132.55 129.65 131.79 131.2339 96721700 Bertrandt

86 2021-06-18 130.71 131.51 130.24 130.46 129.9095 108953300 Bertrandt

87 2021-06-21 130.30 132.41 129.21 132.30 131.7417 79663300 Bertrandt

88 2021-06-22 132.13 134.08 131.62 133.98 133.4146 74783600 Bertrandt

89 2021-06-23 133.77 134.32 133.23 133.70 133.1358 60214200 Bertrandt

90 2021-06-24 134.45 134.64 132.93 133.41 132.8470 68711000 Bertrandt

91 2021-06-25 133.46 133.89 132.81 133.11 132.5483 70783700 Bertrandt

92 2021-06-28 133.41 135.25 133.35 134.78 134.2113 62111300 Bertrandt

93 2021-06-29 134.80 136.49 134.35 136.33 135.7547 64556100 Bertrandt

94 2021-06-30 136.17 137.41 135.87 136.96 136.3821 63261400 Bertrandt

95 2021-07-01 136.60 137.33 135.76 137.27 136.6908 52485800 Bertrandt

96 2021-07-02 137.90 140.00 137.75 139.96 139.3694 78852600 Bertrandt

97 2021-07-06 140.07 143.15 140.07 142.02 141.4207 108181800 Bertrandt

98 2021-07-07 143.54 144.89 142.66 144.57 143.9599 104911600 Bertrandt

99 2021-07-08 141.58 144.06 140.67 143.24 142.6355 105575500 Bertrandt

100 2021-07-09 142.75 145.65 142.65 145.11 144.4977 99890800 Bertrandt

101 2021-07-12 146.21 146.32 144.00 144.50 143.8902 76299700 Bertrandt

102 2021-07-13 144.03 147.46 143.63 145.64 145.0254 100827100 Bertrandt

103 2021-07-14 148.10 149.57 147.68 149.15 148.5206 127050800 Bertrandt

104 2021-07-15 149.24 150.00 147.09 148.48 147.8534 106820300 Bertrandt

105 2021-07-16 148.46 149.76 145.88 146.39 145.7722 93251400 Bertrandt

106 2021-07-19 143.75 144.07 141.67 142.45 141.8489 121434600 Bertrandt

107 2021-07-20 143.46 147.10 142.96 146.15 145.5332 96350000 Bertrandt

108 2021-07-21 145.53 146.13 144.63 145.40 144.7864 74993500 Bertrandt

109 2021-07-22 145.94 148.20 145.81 146.80 146.1805 77338200 Bertrandt

110 2021-07-23 147.55 148.72 146.92 148.56 147.9331 71447400 Bertrandt

111 2021-07-26 148.27 149.83 147.70 148.99 148.3613 72434100 Bertrandt

112 2021-07-27 149.12 149.21 145.55 146.77 146.1507 104818600 Bertrandt

113 2021-07-28 144.81 146.97 142.54 144.98 144.3682 118931200 Bertrandt

114 2021-07-29 144.69 146.55 144.58 145.64 145.0254 56699500 Bertrandt

115 2021-07-30 144.38 146.33 144.11 145.86 145.2445 70382000 Bertrandt

116 2021-08-02 146.36 146.95 145.25 145.52 144.9059 62880000 Bertrandt

117 2021-08-03 145.81 148.04 145.18 147.36 146.7382 64786600 Bertrandt

118 2021-08-04 147.27 147.79 146.28 146.95 146.3299 56368300 Bertrandt

119 2021-08-05 146.98 147.84 146.17 147.06 146.4394 46397700 Bertrandt

120 2021-08-06 146.35 147.11 145.63 146.14 145.7413 54067400 Bertrandt

121 2021-08-09 146.20 146.70 145.52 146.09 145.6915 48908700 Bertrandt

122 2021-08-10 146.44 147.71 145.30 145.60 145.2028 69023100 Bertrandt

123 2021-08-11 146.05 146.72 145.53 145.86 145.4621 48493500 Bertrandt

124 2021-08-12 146.19 149.05 145.84 148.89 148.4838 72282600 Bertrandt

125 2021-08-13 148.97 149.44 148.27 149.10 148.6933 59318800 Bertrandt

[ reached 'max' / getOption("max.print") -- omitted 637 rows ]

> df\_allStocks$Date <- as.character(df\_allStocks$Date)

> datesplit\_list <- strsplit(df\_allStocks$Date, "-")

> df\_dates <- ldply(datesplit\_list)

> colnames(df\_dates) <- c("Year", "Month", "Day")

> df\_allStocks <- cbind(df\_allStocks, df\_dates)

> names(df\_allStocks)

[1] "Date" "Open" "High" "Low" "Close" "Adj.Close" "Volume" "Stock" "Year"

[10] "Month" "Day"

> head(df\_allStocks)

Date Open High Low Close Adj.Close Volume Stock Year Month Day

1 2021-02-17 131.25 132.22 129.47 130.84 130.0669 97918500 Bertrandt 2021 02 17

2 2021-02-18 129.20 130.00 127.41 129.71 128.9436 96856700 Bertrandt 2021 02 18

3 2021-02-19 130.24 130.71 128.80 129.87 129.1027 87668800 Bertrandt 2021 02 19

4 2021-02-22 128.01 129.72 125.60 126.00 125.2555 103916400 Bertrandt 2021 02 22

5 2021-02-23 123.76 126.71 118.39 125.86 125.1164 158273000 Bertrandt 2021 02 23

6 2021-02-24 124.94 125.56 122.23 125.35 124.6094 111039900 Bertrandt 2021 02 24

> g <- ggplot(data=df\_aapl, aes(x=Date, y=Open, group=1)) # group 1st param

> g <- g + geom\_line(linetype="dashed")

> g

> g <- ggplot(data=df\_aapl, aes(x=Date, y=Open, group=1)) # group 1st param

> g <- g + geom\_line(linetype="dashed", col="red")

> g

> g <- ggplot(data=df\_aapl, aes(x=Date, y=Open, group=1)) # group 1st param

> g <- g + geom\_line(linetype="solid", col="red", size=1.5)

> g <- g + labs(title="Apple Inc", subtitle="Open Prices", y="Open", x="Year", caption="Yearwise Apple Stock")

> g

> options(scipen = 999)

> ggplot(data=df\_allStocks, aes(x=Stock, y=Volume)) +

+ geom\_bar(stat="identity") #if we want heights of the bars to represent values in the data, map a value to y aes

> #scipen - avoid scientific notations by giving largest limit eg. 999

> ggplot(data=df\_allStocks, aes(x=Stock, y=Volume)) +

+ geom\_bar(stat="identity") + coord\_flip() #coord\_flip to create horizontal plot

> ggplot(data=df\_allStocks, aes(x=Stock, y=Volume)) +

+ geom\_bar(stat="identity", width=0.5) #change width of bars

> ggplot(data=df\_allStocks, aes(x=Stock, y=Volume)) +

+ geom\_bar(stat="identity", width=0.5, col="blue")

> ggplot(data=df\_allStocks, aes(x=Stock, y=Volume, fill=Stock)) +

+ geom\_bar(stat="identity", width=0.5)

> #fill=Stock - fill colors automatically as per the levels of the bar

> ggplot(df\_nike, aes(x=Open)) + geom\_histogram()

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> ggplot(df\_waltdisney, aes(x=Open)) + geom\_histogram()

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> ggplot(df\_nike, aes(x=Volume)) + geom\_histogram(fill="lightblue", color="darkblue")

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> ggplot(df\_nike, aes(x=Close)) + geom\_histogram(fill="lightblue", color="darkblue")

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> ggplot(df\_nike, aes(x=Close)) + geom\_histogram(fill="lightblue", color="darkblue", binwidth=3)

> ggplot(df\_nike, aes(x=Open)) +

+ geom\_histogram(aes(y=..density..),fill="white", colour="black") +

+ geom\_density(alpha=.2, fill="Turquoise") #alpha controls the transparency

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> ggplot(df\_nike, aes(x=Open, col=Stock)) + geom\_histogram(fill="light blue", binwidth=3)

> ggplot(df\_allStocks, aes(x=Open, col=Stock)) + geom\_histogram(fill="light blue", binwidth=3) #Different outline color for different stock category

> ggplot(df\_waltdisney, aes(x=Open, y=Close)) + geom\_point()

> ggplot(df\_nike, aes(x=Open, y=Close)) + geom\_point(size=2, shape=23) + geom\_smooth(method="lm")

`geom\_smooth()` using formula 'y ~ x'

> #size - size of point, shape - shape of point (0-25), method="lm" - draw linear model (linear regression) line

> ggplot(df\_nike, aes(x=Open, y=Close)) +

+ geom\_point(shape=18, color="dark grey") +

+ geom\_smooth(method="lm", linetype="dashed", color="red")

> df\_midwest = read.csv("http://goo.gl/G1K41K")

> dim(df\_midwest)

[1] 437 28

> summary(df\_midwest)

PID county state area poptotal popdensity

Min. : 561 Length:437 Length:437 Min. :0.00500 Min. : 1701 Min. : 85.05

1st Qu.: 670 Class :character Class :character 1st Qu.:0.02400 1st Qu.: 18840 1st Qu.: 622.41

Median :1221 Mode :character Mode :character Median :0.03000 Median : 35324 Median : 1156.21

Mean :1437 Mean :0.03317 Mean : 96130 Mean : 3097.74

3rd Qu.:2059 3rd Qu.:0.03800 3rd Qu.: 75651 3rd Qu.: 2330.00

Max. :3052 Max. :0.11000 Max. :5105067 Max. :88018.40

popwhite popblack popamerindian popasian popother percwhite

Min. : 416 Min. : 0 Min. : 4.0 Min. : 0 Min. : 0 Min. :10.69

1st Qu.: 18630 1st Qu.: 29 1st Qu.: 44.0 1st Qu.: 35 1st Qu.: 20 1st Qu.:94.89

Median : 34471 Median : 201 Median : 94.0 Median : 102 Median : 66 Median :98.03

Mean : 81840 Mean : 11024 Mean : 343.1 Mean : 1310 Mean : 1613 Mean :95.56

3rd Qu.: 72968 3rd Qu.: 1291 3rd Qu.: 288.0 3rd Qu.: 401 3rd Qu.: 345 3rd Qu.:99.07

Max. :3204947 Max. :1317147 Max. :10289.0 Max. :188565 Max. :384119 Max. :99.82

percblack percamerindan percasian percother popadults perchsd

Min. : 0.0000 Min. : 0.05623 Min. :0.0000 Min. :0.00000 Min. : 1287 Min. :46.91

1st Qu.: 0.1157 1st Qu.: 0.15793 1st Qu.:0.1737 1st Qu.:0.09102 1st Qu.: 12271 1st Qu.:71.33

Median : 0.5390 Median : 0.21502 Median :0.2972 Median :0.17844 Median : 22188 Median :74.25

Mean : 2.6763 Mean : 0.79894 Mean :0.4872 Mean :0.47906 Mean : 60973 Mean :73.97

3rd Qu.: 2.6014 3rd Qu.: 0.38362 3rd Qu.:0.5212 3rd Qu.:0.48050 3rd Qu.: 47541 3rd Qu.:77.20

Max. :40.2100 Max. :89.17738 Max. :5.0705 Max. :7.52427 Max. :3291995 Max. :88.90

percollege percprof poppovertyknown percpovertyknown percbelowpoverty percchildbelowpovert

Min. : 7.336 Min. : 0.5203 Min. : 1696 Min. :80.90 Min. : 2.180 Min. : 1.919

1st Qu.:14.114 1st Qu.: 2.9980 1st Qu.: 18364 1st Qu.:96.89 1st Qu.: 9.199 1st Qu.:11.624

Median :16.798 Median : 3.8142 Median : 33788 Median :98.17 Median :11.822 Median :15.270

Mean :18.273 Mean : 4.4473 Mean : 93642 Mean :97.11 Mean :12.511 Mean :16.447

3rd Qu.:20.550 3rd Qu.: 4.9493 3rd Qu.: 72840 3rd Qu.:98.60 3rd Qu.:15.133 3rd Qu.:20.352

Max. :48.079 Max. :20.7913 Max. :5023523 Max. :99.86 Max. :48.691 Max. :64.308

percadultpoverty percelderlypoverty inmetro category

Min. : 1.938 Min. : 3.547 Min. :0.0000 Length:437

1st Qu.: 7.668 1st Qu.: 8.912 1st Qu.:0.0000 Class :character

Median :10.008 Median :10.869 Median :0.0000 Mode :character

Mean :10.919 Mean :11.389 Mean :0.3432

3rd Qu.:13.182 3rd Qu.:13.412 3rd Qu.:1.0000

Max. :43.312 Max. :31.162 Max. :1.0000

> ggplot(df\_midwest, aes(x=area, y=poptotal)) +

+ geom\_point(shape=18, color="dark grey") +

+ geom\_smooth(method="lm", linetype="dashed", color="red")

`geom\_smooth()` using formula 'y ~ x'

> ggplot(df\_midwest, aes(x=area, y=poptotal)) + geom\_point(shape=18, color="dark grey")+geom\_smooth(method="lm", linetype="dashed", color="red") + coord\_cartesian(xlim=c(0,0.1), ylim=c(0,600000))

`geom\_smooth()` using formula 'y ~ x'

> seq(1, 20, 3)

[1] 1 4 7 10 13 16 19

> g <- ggplot(df\_midwest, aes(x=area, y=poptotal)) +

+ geom\_point(size=2) +

+ geom\_smooth(method="lm",col="black") +

+ coord\_cartesian(xlim=c(0,0.1), ylim=c(0,1000000)) +

+ labs(title="Area Vs Population", subtitle = "Using midwest dataset", y="Population", x="area", caption = "Midwest Demographics")

> g + scale\_x\_continuous(breaks=seq(0, 0.10, 0.01))

`geom\_smooth()` using formula 'y ~ x'

> g + scale\_y\_continuous(breaks=seq(0, 1000000, 50000))

`geom\_smooth()` using formula 'y ~ x'

> g <- ggplot(df\_midwest, aes(x=area, y=poptotal)) +

+ geom\_point(aes(color=state), size=2) +

+ geom\_smooth(method="lm",col="black") +

+ coord\_cartesian(xlim=c(0,0.1), ylim=c(0,1000000)) +

+ labs(title="Area Vs Population", subtitle = "Using midwest dataset", y="Population", x="area", caption = "Midwest Demographics")

> g + scale\_x\_continuous(breaks=seq(0, 0.10, 0.01))

`geom\_smooth()` using formula 'y ~ x'

> g + scale\_y\_continuous(breaks=seq(0, 1000000, 50000))

> ggplot(df\_allStocks, aes(x=Month, y=Close)) + geom\_boxplot()

> ggplot(df\_allStocks, aes(x=Month, y=Close)) + geom\_boxplot() + coord\_flip()

> ggplot(df\_allStocks, aes(x=Month, y=Close, color=Month)) + geom\_boxplot() + coord\_flip()

> ggplot(df\_midwest, aes(x=state, y=poptotal)) + geom\_boxplot(outlier.color = "red", outlier.shape = 1, outlier.size = 2)

> ggplot(df\_allStocks, aes(x=Year, y=Close)) + geom\_boxplot() + facet\_grid(~ Stock)

> ggplot(df\_allStocks, aes(x=Month, y=Close)) + geom\_boxplot() + facet\_grid(Stock ~ Year)

> ggplot(df\_allStocks, aes(x=Open)) +

+ geom\_histogram(color="black", fill="white") +

+ facet\_grid(Stock ~ .)

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> ggplot(df\_allStocks, aes(x=Open, color=Stock)) +

+ geom\_histogram(fill="white") +

+ facet\_grid(Stock ~ .)

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> ggplot(df\_allStocks, aes(x=Close, color=Stock)) +

+ geom\_histogram(fill="white") +

+ facet\_grid(Stock ~ ., scales="free\_y")

**Day 5 – R Programming**

> dev.off()

null device

1

> setwd("C:/zubeda/PGA02\_Zubu/R Programming")

> library("plyr")

> library("ggplot2")

> g <- ggplot(df\_midwest, aes(x=area, y=poptotal)) +

+ geom\_point(shape=18, color="dark grey") +

+ geom\_smooth(method="lm", linetype="dashed", col="red") +

+ coord\_cartesian(xlim=c(0, 0.1), ylim=c(0, 600000))

> g <- g + theme\_light()

> g

`geom\_smooth()` using formula 'y ~ x'

> ggplot(df\_waltdisney, aes(x=Open, y=Close)) +

+ geom\_point() + theme(panel.grid.major = element\_line(size=0.5, linetype="dashed", colour="red"), panel.background=element\_rect(fill="lightblue"))

> ggplot(df\_allStocks, aes(x=Stock, y=Volume)) +

+ geom\_bar(stat="identity") + theme(panel.grid.major = element\_line(size=0.5, linetype="solid", colour="blue"), panel.background=element\_rect(fill="lightblue"))

> library(RColorBrewer)

> head(brewer.pal.info, 12)

maxcolors category

BrBG 11 div

PiYG 11 div

PRGn 11 div

PuOr 11 div

RdBu 11 div

RdGy 11 div

RdYlBu 11 div

RdYlGn 11 div

Spectral 11 div

Accent 8 qual

Dark2 8 qual

Paired 12 qual

colorblind

BrBG TRUE

PiYG TRUE

PRGn TRUE

PuOr TRUE

RdBu TRUE

RdGy FALSE

RdYlBu TRUE

RdYlGn FALSE

Spectral FALSE

Accent FALSE

Dark2 TRUE

Paired TRUE

> display.brewer.all()

> g <- ggplot(df\_midwest, aes(x=area, y=poptotal)) +

+ geom\_point(aes(color=state), size=2) +

+ geom\_smooth(method="lm",col="black") +

+ coord\_cartesian(xlim=c(0, 0.1), ylim=c(0, 1000000)) +

+ labs(title="Area Vs Population", subtitle = "Using midwest dataset", y="Population", x="area", caption = "Midwest Demographics")

> g <- g + scale\_colour\_brewer(palette="Dark2")

> g

`geom\_smooth()` using formula 'y ~ x'

> g <- ggplot(df\_midwest, aes(x=area, y=poptotal)) +

+ geom\_point(aes(color=state), size=2) +

+ geom\_smooth(method="lm",col="black") +

+ coord\_cartesian(xlim=c(0, 0.1), ylim=c(0, 1000000)) +

+ labs(title="Area Vs Population", subtitle = "Using midwest dataset", y="Population", x="area", caption = "Midwest Demographics")

> library(grid)

> annotate\_text <- "Showing population by area with best fit regression line"

> g

`geom\_smooth()` using formula 'y ~ x'

> annotatechart <- grid.text(annotate\_text, x=0.5, y=0.9, gp=gpar(col="darkred", fontsize=9, fontface="plain"))

**Class Assessment**

> setwd("C:/zubeda/PGA02\_Zubu/R Programming")

> #Q1)

> #II. Create a vector of length 4 using seq() function and showcase how to access the elements using numeric indexes, logical indexes and character indexes.

> v <- seq(11, 15, length.out=4) #returns 4 numbers, including 1st, last and middle numbers averaged if numbers are more then limit

> v

[1] 11.00000 12.33333 13.66667 15.00000

> v[1]

[1] 11

> v[3]

[1] 13.66667

> v[c(2, 4)]

[1] 12.33333 15.00000

> v[c(TRUE, FALSE, TRUE, FALSE)]

[1] 11.00000 13.66667

> names(v) <- c("el1", "el2", "el3", "el4")

> v

el1 el2 el3 el4

11.00000 12.33333 13.66667 15.00000

> v["el1"]

el1

11

> y <- c("Mumbai"=400, "Delhi"=100, "Chennai"=300, "Kolkata"=200)

> y

Mumbai Delhi Chennai Kolkata

400 100 300 200

> y["Chennai"]

Chennai

300

> y["Mumbai"]

Mumbai

400

>

> #I. Load the in-built dataset called trees, that consists of measurements of the girth, height, and volume of 31 black cherry trees and display rows where height is greater than 82

> ?trees

> trees

Girth Height Volume

1 8.3 70 10.3

2 8.6 65 10.3

3 8.8 63 10.2

4 10.5 72 16.4

5 10.7 81 18.8

6 10.8 83 19.7

7 11.0 66 15.6

8 11.0 75 18.2

9 11.1 80 22.6

10 11.2 75 19.9

11 11.3 79 24.2

12 11.4 76 21.0

13 11.4 76 21.4

14 11.7 69 21.3

15 12.0 75 19.1

16 12.9 74 22.2

17 12.9 85 33.8

18 13.3 86 27.4

19 13.7 71 25.7

20 13.8 64 24.9

21 14.0 78 34.5

22 14.2 80 31.7

23 14.5 74 36.3

24 16.0 72 38.3

25 16.3 77 42.6

26 17.3 81 55.4

27 17.5 82 55.7

28 17.9 80 58.3

29 18.0 80 51.5

30 18.0 80 51.0

31 20.6 87 77.0

> dim(trees)

[1] 31 3

> nrow(trees)

[1] 31

> ncol(trees)

[1] 3

> summary(trees)

Girth Height Volume

Min. : 8.30 Min. :63 Min. :10.20

1st Qu.:11.05 1st Qu.:72 1st Qu.:19.40

Median :12.90 Median :76 Median :24.20

Mean :13.25 Mean :76 Mean :30.17

3rd Qu.:15.25 3rd Qu.:80 3rd Qu.:37.30

Max. :20.60 Max. :87 Max. :77.00

> names(trees)

[1] "Girth" "Height" "Volume"

> str(trees)

'data.frame': 31 obs. of 3 variables:

$ Girth : num 8.3 8.6 8.8 10.5 10.7 10.8 11 11 11.1 11.2 ...

$ Height: num 70 65 63 72 81 83 66 75 80 75 ...

$ Volume: num 10.3 10.3 10.2 16.4 18.8 19.7 15.6 18.2 22.6 19.9 ...

> trees[trees$Height > 82,]

Girth Height Volume

6 10.8 83 19.7

17 12.9 85 33.8

18 13.3 86 27.4

31 20.6 87 77.0

>

> #Q2) For the 'StudentsPerformance' dataset, perform the following tasks:

> #I. Analyze the student's performance in exams and write your own observations about the students and plot the results

> #II. Create a function to remove outliers using the IQR method

>

> #Function definition such that outliers of passed columns are removed

> students <- read.csv("StudentsPerformance.csv")

> #Get Dimensions

> nrow(students)

[1] 1000

> ncol(students)

[1] 8

> #Get data types

> str(students)

'data.frame': 1000 obs. of 8 variables:

$ gender : chr "female" "female" "female" "male" ...

$ race.ethnicity : chr "group B" "group C" "group B" "group A" ...

$ parental.level.of.education: chr "bachelor's degree" "some college" "master's degree" "associate's degree" ...

$ lunch : chr "standard" "standard" "standard" "free/reduced" ...

$ test.preparation.course : chr "none" "completed" "none" "none" ...

$ math.score : int 72 69 90 47 76 71 88 40 64 38 ...

$ reading.score : int 72 90 95 57 78 83 95 43 64 60 ...

$ writing.score : int 74 88 93 44 75 78 92 39 67 50 ...

> #rename column names with new column names

> namesOfColumns <- c("Gender", "Race", "Parent\_Education", "Lunch", "Test\_Prep", "Math\_Score", "Reading\_Score", "Writing\_Score")

> colnames(students) <- namesOfColumns

> colnames(students)

[1] "Gender" "Race" "Parent\_Education" "Lunch" "Test\_Prep" "Math\_Score" "Reading\_Score"

[8] "Writing\_Score"

> summary(students) #Summary statistics of numeric variable

Gender Race Parent\_Education Lunch Test\_Prep Math\_Score Reading\_Score

Length:1000 Length:1000 Length:1000 Length:1000 Length:1000 Min. : 0.00 Min. : 17.00

Class :character Class :character Class :character Class :character Class :character 1st Qu.: 57.00 1st Qu.: 59.00

Mode :character Mode :character Mode :character Mode :character Mode :character Median : 66.00 Median : 70.00

Mean : 66.09 Mean : 69.17

3rd Qu.: 77.00 3rd Qu.: 79.00

Max. :100.00 Max. :100.00

Writing\_Score

Min. : 10.00

1st Qu.: 57.75

Median : 69.00

Mean : 68.05

3rd Qu.: 79.00

Max. :100.00

>

> #Obervations

> #1. There are more females than males

> #2. Group C has the largest number of members

> #3. some college and associates degree are the most frequently occuring #parental levels of education

> #4. most students have a standard lunch

> #5. most students have not completed the test prep course

> #6. the scores for math, reading and writing are on the same scale 0-100

>

> remove\_outliers <- function(x, na.rm=TRUE, ...) {

+ qnt <- quantile(x, probs=c(.25, .75), na.rm=na.rm, ...)

+ H <- 1.5 \* IQR(x, na.rm = na.rm)

+ y <- x

+ y[x < (qnt[1] - H)] <- NA

+ y[x > (qnt[2] + H)] <- NA

+ y

+ }

> #Combine columns categorical cols as it is, and last 3 cols with outliers removed

> performance\_data <- cbind(students[1:5], apply(students[6], 2, remove\_outliers), apply(students[7], 2, remove\_outliers), apply(students[8], 2, remove\_outliers))

> performance\_data

Gender Race Parent\_Education Lunch Test\_Prep Math\_Score Reading\_Score Writing\_Score

1 female group B bachelor's degree standard none 72 72 74

2 female group C some college standard completed 69 90 88

3 female group B master's degree standard none 90 95 93

4 male group A associate's degree free/reduced none 47 57 44

5 male group C some college standard none 76 78 75

6 female group B associate's degree standard none 71 83 78

7 female group B some college standard completed 88 95 92

8 male group B some college free/reduced none 40 43 39

9 male group D high school free/reduced completed 64 64 67

10 female group B high school free/reduced none 38 60 50

11 male group C associate's degree standard none 58 54 52

12 male group D associate's degree standard none 40 52 43

13 female group B high school standard none 65 81 73

14 male group A some college standard completed 78 72 70

15 female group A master's degree standard none 50 53 58

16 female group C some high school standard none 69 75 78

17 male group C high school standard none 88 89 86

18 female group B some high school free/reduced none NA 32 28

19 male group C master's degree free/reduced completed 46 42 46

20 female group C associate's degree free/reduced none 54 58 61

21 male group D high school standard none 66 69 63

22 female group B some college free/reduced completed 65 75 70

23 male group D some college standard none 44 54 53

24 female group C some high school standard none 69 73 73

25 male group D bachelor's degree free/reduced completed 74 71 80

26 male group A master's degree free/reduced none 73 74 72

27 male group B some college standard none 69 54 55

28 female group C bachelor's degree standard none 67 69 75

29 male group C high school standard none 70 70 65

30 female group D master's degree standard none 62 70 75

31 female group D some college standard none 69 74 74

32 female group B some college standard none 63 65 61

33 female group E master's degree free/reduced none 56 72 65

34 male group D some college standard none 40 42 38

35 male group E some college standard none 97 87 82

36 male group E associate's degree standard completed 81 81 79

37 female group D associate's degree standard none 74 81 83

38 female group D some high school free/reduced none 50 64 59

39 female group D associate's degree free/reduced completed 75 90 88

40 male group B associate's degree free/reduced none 57 56 57

41 male group C associate's degree free/reduced none 55 61 54

42 female group C associate's degree standard none 58 73 68

43 female group B associate's degree standard none 53 58 65

44 male group B some college free/reduced completed 59 65 66

45 female group E associate's degree free/reduced none 50 56 54

46 male group B associate's degree standard none 65 54 57

47 female group A associate's degree standard completed 55 65 62

48 female group C high school standard none 66 71 76

49 female group D associate's degree free/reduced completed 57 74 76

50 male group C high school standard completed 82 84 82

51 male group E some college standard none 53 55 48

52 male group E associate's degree free/reduced completed 77 69 68

53 male group C some college standard none 53 44 42

54 male group D high school standard none 88 78 75

55 female group C some high school free/reduced completed 71 84 87

56 female group C high school free/reduced none 33 41 43

57 female group E associate's degree standard completed 82 85 86

58 male group D associate's degree standard none 52 55 49

59 male group D some college standard completed 58 59 58

60 female group C some high school free/reduced none NA NA NA

61 male group E bachelor's degree free/reduced completed 79 74 72

62 male group A some high school free/reduced none 39 39 34

63 male group A associate's degree free/reduced none 62 61 55

64 female group C associate's degree standard none 69 80 71

65 female group D some high school standard none 59 58 59

66 male group B some high school standard none 67 64 61

67 male group D some high school free/reduced none 45 37 37

68 female group C some college standard none 60 72 74

69 male group B associate's degree free/reduced none 61 58 56

70 female group C associate's degree standard none 39 64 57

71 female group D some college free/reduced completed 58 63 73

72 male group D some college standard completed 63 55 63

73 female group A associate's degree free/reduced none 41 51 48

74 male group C some high school free/reduced none 61 57 56

75 male group C some high school standard none 49 49 41

76 male group B associate's degree free/reduced none 44 41 38

77 male group E some high school standard none 30 NA NA

78 male group A bachelor's degree standard completed 80 78 81

79 female group D some high school standard completed 61 74 72

80 female group E master's degree standard none 62 68 68

81 female group B associate's degree standard none 47 49 50

82 male group B high school free/reduced none 49 45 45

83 male group A some college free/reduced completed 50 47 54

84 male group E associate's degree standard none 72 64 63

85 male group D high school free/reduced none 42 39 34

86 female group C some college standard none 73 80 82

87 female group C some college free/reduced none 76 83 88

88 female group D associate's degree standard none 71 71 74

89 female group A some college standard none 58 70 67

90 female group D some high school standard none 73 86 82

91 female group C bachelor's degree standard none 65 72 74

92 male group C high school free/reduced none 27 34 36

93 male group C high school standard none 71 79 71

94 male group C associate's degree free/reduced completed 43 45 50

95 female group B some college standard none 79 86 92

96 male group C associate's degree free/reduced completed 78 81 82

97 male group B some high school standard completed 65 66 62

98 female group E some college standard completed 63 72 70

99 female group D some college free/reduced none 58 67 62

100 female group D bachelor's degree standard none 65 67 62

101 male group B some college standard none 79 67 67

102 male group D bachelor's degree standard completed 68 74 74

103 female group D associate's degree standard none 85 91 89

104 male group B high school standard completed 60 44 47

105 male group C some college standard completed 98 86 90

106 female group C some college standard none 58 67 72

107 female group D master's degree standard none 87 100 100

108 male group E associate's degree standard completed 66 63 64

109 female group B associate's degree free/reduced none 52 76 70

110 female group B some high school standard none 70 64 72

111 female group D associate's degree free/reduced completed 77 89 98

112 male group C high school standard none 62 55 49

113 male group A associate's degree standard none 54 53 47

114 female group D some college standard none 51 58 54

115 female group E bachelor's degree standard completed 99 100 100

116 male group C high school standard none 84 77 74

117 female group B bachelor's degree free/reduced none 75 85 82

118 female group D bachelor's degree standard none 78 82 79

119 female group D some high school standard none 51 63 61

120 female group C some college standard none 55 69 65

121 female group C bachelor's degree standard completed 79 92 89

122 male group B associate's degree standard completed 91 89 92

123 female group C some college standard completed 88 93 93

124 male group D high school free/reduced none 63 57 56

125 male group E some college standard none 83 80 73

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> dim(performance\_data)

[1] 1000 8

> sum(is.na(performance\_data)) # Sum of null values

[1] 19

> performance\_1 <- na.omit(performance\_data)

> performance\_1

Gender Race Parent\_Education Lunch Test\_Prep Math\_Score Reading\_Score Writing\_Score

1 female group B bachelor's degree standard none 72 72 74

2 female group C some college standard completed 69 90 88

3 female group B master's degree standard none 90 95 93

4 male group A associate's degree free/reduced none 47 57 44

5 male group C some college standard none 76 78 75

6 female group B associate's degree standard none 71 83 78

7 female group B some college standard completed 88 95 92

8 male group B some college free/reduced none 40 43 39

9 male group D high school free/reduced completed 64 64 67

10 female group B high school free/reduced none 38 60 50

11 male group C associate's degree standard none 58 54 52

12 male group D associate's degree standard none 40 52 43

13 female group B high school standard none 65 81 73

14 male group A some college standard completed 78 72 70

15 female group A master's degree standard none 50 53 58

16 female group C some high school standard none 69 75 78

17 male group C high school standard none 88 89 86

19 male group C master's degree free/reduced completed 46 42 46

20 female group C associate's degree free/reduced none 54 58 61

21 male group D high school standard none 66 69 63

22 female group B some college free/reduced completed 65 75 70

23 male group D some college standard none 44 54 53

24 female group C some high school standard none 69 73 73

25 male group D bachelor's degree free/reduced completed 74 71 80

26 male group A master's degree free/reduced none 73 74 72

27 male group B some college standard none 69 54 55

28 female group C bachelor's degree standard none 67 69 75

29 male group C high school standard none 70 70 65

30 female group D master's degree standard none 62 70 75

31 female group D some college standard none 69 74 74

32 female group B some college standard none 63 65 61

33 female group E master's degree free/reduced none 56 72 65

34 male group D some college standard none 40 42 38

35 male group E some college standard none 97 87 82

36 male group E associate's degree standard completed 81 81 79

37 female group D associate's degree standard none 74 81 83

38 female group D some high school free/reduced none 50 64 59

39 female group D associate's degree free/reduced completed 75 90 88

40 male group B associate's degree free/reduced none 57 56 57

41 male group C associate's degree free/reduced none 55 61 54

42 female group C associate's degree standard none 58 73 68

43 female group B associate's degree standard none 53 58 65

44 male group B some college free/reduced completed 59 65 66

45 female group E associate's degree free/reduced none 50 56 54

46 male group B associate's degree standard none 65 54 57

47 female group A associate's degree standard completed 55 65 62

48 female group C high school standard none 66 71 76

49 female group D associate's degree free/reduced completed 57 74 76

50 male group C high school standard completed 82 84 82

51 male group E some college standard none 53 55 48

52 male group E associate's degree free/reduced completed 77 69 68

53 male group C some college standard none 53 44 42

54 male group D high school standard none 88 78 75

55 female group C some high school free/reduced completed 71 84 87

56 female group C high school free/reduced none 33 41 43

57 female group E associate's degree standard completed 82 85 86

58 male group D associate's degree standard none 52 55 49

59 male group D some college standard completed 58 59 58

61 male group E bachelor's degree free/reduced completed 79 74 72

62 male group A some high school free/reduced none 39 39 34

63 male group A associate's degree free/reduced none 62 61 55

64 female group C associate's degree standard none 69 80 71

65 female group D some high school standard none 59 58 59

66 male group B some high school standard none 67 64 61

67 male group D some high school free/reduced none 45 37 37

68 female group C some college standard none 60 72 74

69 male group B associate's degree free/reduced none 61 58 56

70 female group C associate's degree standard none 39 64 57

71 female group D some college free/reduced completed 58 63 73

72 male group D some college standard completed 63 55 63

73 female group A associate's degree free/reduced none 41 51 48

74 male group C some high school free/reduced none 61 57 56

75 male group C some high school standard none 49 49 41

76 male group B associate's degree free/reduced none 44 41 38

78 male group A bachelor's degree standard completed 80 78 81

79 female group D some high school standard completed 61 74 72

80 female group E master's degree standard none 62 68 68

81 female group B associate's degree standard none 47 49 50

82 male group B high school free/reduced none 49 45 45

83 male group A some college free/reduced completed 50 47 54

84 male group E associate's degree standard none 72 64 63

85 male group D high school free/reduced none 42 39 34

86 female group C some college standard none 73 80 82

87 female group C some college free/reduced none 76 83 88

88 female group D associate's degree standard none 71 71 74

89 female group A some college standard none 58 70 67

90 female group D some high school standard none 73 86 82

91 female group C bachelor's degree standard none 65 72 74

92 male group C high school free/reduced none 27 34 36

93 male group C high school standard none 71 79 71

94 male group C associate's degree free/reduced completed 43 45 50

95 female group B some college standard none 79 86 92

96 male group C associate's degree free/reduced completed 78 81 82

97 male group B some high school standard completed 65 66 62

98 female group E some college standard completed 63 72 70

99 female group D some college free/reduced none 58 67 62

100 female group D bachelor's degree standard none 65 67 62

101 male group B some college standard none 79 67 67

102 male group D bachelor's degree standard completed 68 74 74

103 female group D associate's degree standard none 85 91 89

104 male group B high school standard completed 60 44 47

105 male group C some college standard completed 98 86 90

106 female group C some college standard none 58 67 72

107 female group D master's degree standard none 87 100 100

108 male group E associate's degree standard completed 66 63 64

109 female group B associate's degree free/reduced none 52 76 70

110 female group B some high school standard none 70 64 72

111 female group D associate's degree free/reduced completed 77 89 98

112 male group C high school standard none 62 55 49

113 male group A associate's degree standard none 54 53 47

114 female group D some college standard none 51 58 54

115 female group E bachelor's degree standard completed 99 100 100

116 male group C high school standard none 84 77 74

117 female group B bachelor's degree free/reduced none 75 85 82

118 female group D bachelor's degree standard none 78 82 79

119 female group D some high school standard none 51 63 61

120 female group C some college standard none 55 69 65

121 female group C bachelor's degree standard completed 79 92 89

122 male group B associate's degree standard completed 91 89 92

123 female group C some college standard completed 88 93 93

124 male group D high school free/reduced none 63 57 56

125 male group E some college standard none 83 80 73

126 female group B high school standard none 87 95 86

127 male group B some high school standard none 72 68 67

128 male group D some college standard completed 65 77 74

[ reached 'max' / getOption("max.print") -- omitted 863 rows ]

> nrow(performance\_1)

[1] 988

> library(ggplot2)

> Data <- performance\_1

>

> plot1 <-

+ ggplot() +

+ geom\_bar(data = Data, aes(x = Gender), width = 0.2, fill = "green") +

+ geom\_text(stat='count', data = Data, aes(x = Gender, label=..count..), vjust=-0.2) +

+ theme\_bw() +

+ xlab("Gender") +

+ ylab("Number of Students") +

+ theme\_classic() +

+ ggtitle("Number of Students by Gender") +

+ scale\_fill\_brewer(type = "qual", palette = 1, direction = 1,

+ aesthetics = "fill") +

+ ylim(0, 600)

>

> plot1

>

> #There are more 510 female students and 478 male students.

>

> #Students By race:

> plot2 <- ggplot() +

+ geom\_bar(data = Data, aes(x = Race), width = 0.6, fill = "green") +

+ geom\_text(data = Data, aes(x = Race, label = ..count..), stat = "count", vjust = -0.2) +

+ theme\_bw() +

+ xlab("Race/Ethnicity") +

+ ylab("Number of Students") +

+ theme(

+ text = element\_text(family = "Tahoma")

+ ) +

+ theme\_classic()+

+ scale\_fill\_brewer(type = "qual", palette = 1, direction = 1,

+ aesthetics = "fill") +

+ ggtitle("Number of Students by Race/Ethnicity")

> plot2

> #There are 316 students in group C, 261 students in group D while there are only 88 students in group A.

>

> #Plot scores by Gender to determine if there is a different score tendency for each gender

> # Math scores by Gender plot

> p <- ggplot(students, aes(Math\_Score)) + geom\_histogram(binwidth=5, color="gray", aes(fill=Gender))

> p <- p + xlab("Math Scores") + ylab("Gender") + ggtitle("Math Scores by Gender")

> p

>

> # Boxplot of scores and Test Prep by Gender

> b <- ggplot(students, aes(Gender, Writing\_Score, color = Test\_Prep))

> b <- b + geom\_boxplot()

> b <- b + ggtitle("Writing scores by Gender Boxplot")

> b <- b + xlab("Gender") + ylab("Writing Scores")

> b

>

> # Reading scores by Gender plot

> p1 <- ggplot(students, aes(Reading\_Score)) + geom\_histogram(binwidth=5, color="gray", aes(fill=Gender))

> p1 <- p1 + xlab("Reading Scores") + ylab("Gender") + ggtitle("Reading Scores by Gender")

> p1

>

> b1 <- ggplot(students, aes(Gender, Math\_Score, color = Test\_Prep))

> b1 <- b1 + geom\_boxplot()

> b1 <- b1 + ggtitle("Math scores by Gender Boxplot")

> b1 <- b1 + xlab("Gender") + ylab("Math Scores")

> b1

>

> # Writing scores by Gender plot

> p2 <- ggplot(students, aes(Writing\_Score)) + geom\_histogram(binwidth=5, color="gray", aes(fill=Gender))

> p2 <- p2 + xlab("Writing Scores") + ylab("Gender") + ggtitle("Writing Scores by Gender")

> p2

>

> b2 <- ggplot(students, aes(Gender, Reading\_Score, color = Test\_Prep))

> b2 <- b2 + geom\_boxplot()

> b2 <- b2 + ggtitle("Reading scores by Gender Boxplot")

> b2 <- b2 + xlab("Gender") + ylab("Reading Scores")

> b2

>

> #Conclusion :

>

> #1. students who completed the prep class had better scores in all three tests.

> #2. male students have received better scores in Math while female students in reading and writing.

>

> #Which gender does better in tests

> # To find out the result, we need to create a columns that stores average of score

> performance\_2 <- performance\_1

> performance\_2$Total\_score = performance\_2$Math\_Score + performance\_2$Reading\_Score +performance\_2$Writing\_Score

> performance\_2$Avg\_score = round((performance\_2$Total\_score)/3,0)

> performance\_2

Gender Race Parent\_Education Lunch Test\_Prep Math\_Score Reading\_Score Writing\_Score Total\_score Avg\_score

1 female group B bachelor's degree standard none 72 72 74 218 73

2 female group C some college standard completed 69 90 88 247 82

3 female group B master's degree standard none 90 95 93 278 93

4 male group A associate's degree free/reduced none 47 57 44 148 49

5 male group C some college standard none 76 78 75 229 76

6 female group B associate's degree standard none 71 83 78 232 77

7 female group B some college standard completed 88 95 92 275 92

8 male group B some college free/reduced none 40 43 39 122 41

9 male group D high school free/reduced completed 64 64 67 195 65

10 female group B high school free/reduced none 38 60 50 148 49

11 male group C associate's degree standard none 58 54 52 164 55

12 male group D associate's degree standard none 40 52 43 135 45

13 female group B high school standard none 65 81 73 219 73

14 male group A some college standard completed 78 72 70 220 73

15 female group A master's degree standard none 50 53 58 161 54

16 female group C some high school standard none 69 75 78 222 74

17 male group C high school standard none 88 89 86 263 88

19 male group C master's degree free/reduced completed 46 42 46 134 45

20 female group C associate's degree free/reduced none 54 58 61 173 58

21 male group D high school standard none 66 69 63 198 66

22 female group B some college free/reduced completed 65 75 70 210 70

23 male group D some college standard none 44 54 53 151 50

24 female group C some high school standard none 69 73 73 215 72

25 male group D bachelor's degree free/reduced completed 74 71 80 225 75

26 male group A master's degree free/reduced none 73 74 72 219 73

27 male group B some college standard none 69 54 55 178 59

28 female group C bachelor's degree standard none 67 69 75 211 70

29 male group C high school standard none 70 70 65 205 68

30 female group D master's degree standard none 62 70 75 207 69

31 female group D some college standard none 69 74 74 217 72

32 female group B some college standard none 63 65 61 189 63

33 female group E master's degree free/reduced none 56 72 65 193 64

34 male group D some college standard none 40 42 38 120 40

35 male group E some college standard none 97 87 82 266 89

36 male group E associate's degree standard completed 81 81 79 241 80

37 female group D associate's degree standard none 74 81 83 238 79

38 female group D some high school free/reduced none 50 64 59 173 58

39 female group D associate's degree free/reduced completed 75 90 88 253 84

40 male group B associate's degree free/reduced none 57 56 57 170 57

41 male group C associate's degree free/reduced none 55 61 54 170 57

42 female group C associate's degree standard none 58 73 68 199 66

43 female group B associate's degree standard none 53 58 65 176 59

44 male group B some college free/reduced completed 59 65 66 190 63

45 female group E associate's degree free/reduced none 50 56 54 160 53

46 male group B associate's degree standard none 65 54 57 176 59

47 female group A associate's degree standard completed 55 65 62 182 61

48 female group C high school standard none 66 71 76 213 71

49 female group D associate's degree free/reduced completed 57 74 76 207 69

50 male group C high school standard completed 82 84 82 248 83

51 male group E some college standard none 53 55 48 156 52

52 male group E associate's degree free/reduced completed 77 69 68 214 71

53 male group C some college standard none 53 44 42 139 46

54 male group D high school standard none 88 78 75 241 80

55 female group C some high school free/reduced completed 71 84 87 242 81

56 female group C high school free/reduced none 33 41 43 117 39

57 female group E associate's degree standard completed 82 85 86 253 84

58 male group D associate's degree standard none 52 55 49 156 52

59 male group D some college standard completed 58 59 58 175 58

61 male group E bachelor's degree free/reduced completed 79 74 72 225 75

62 male group A some high school free/reduced none 39 39 34 112 37

63 male group A associate's degree free/reduced none 62 61 55 178 59

64 female group C associate's degree standard none 69 80 71 220 73

65 female group D some high school standard none 59 58 59 176 59

66 male group B some high school standard none 67 64 61 192 64

67 male group D some high school free/reduced none 45 37 37 119 40

68 female group C some college standard none 60 72 74 206 69

69 male group B associate's degree free/reduced none 61 58 56 175 58

70 female group C associate's degree standard none 39 64 57 160 53

71 female group D some college free/reduced completed 58 63 73 194 65

72 male group D some college standard completed 63 55 63 181 60

73 female group A associate's degree free/reduced none 41 51 48 140 47

74 male group C some high school free/reduced none 61 57 56 174 58

75 male group C some high school standard none 49 49 41 139 46

76 male group B associate's degree free/reduced none 44 41 38 123 41

78 male group A bachelor's degree standard completed 80 78 81 239 80

79 female group D some high school standard completed 61 74 72 207 69

80 female group E master's degree standard none 62 68 68 198 66

81 female group B associate's degree standard none 47 49 50 146 49

82 male group B high school free/reduced none 49 45 45 139 46

83 male group A some college free/reduced completed 50 47 54 151 50

84 male group E associate's degree standard none 72 64 63 199 66

85 male group D high school free/reduced none 42 39 34 115 38

86 female group C some college standard none 73 80 82 235 78

87 female group C some college free/reduced none 76 83 88 247 82

88 female group D associate's degree standard none 71 71 74 216 72

89 female group A some college standard none 58 70 67 195 65

90 female group D some high school standard none 73 86 82 241 80

91 female group C bachelor's degree standard none 65 72 74 211 70

92 male group C high school free/reduced none 27 34 36 97 32

93 male group C high school standard none 71 79 71 221 74

94 male group C associate's degree free/reduced completed 43 45 50 138 46

95 female group B some college standard none 79 86 92 257 86

96 male group C associate's degree free/reduced completed 78 81 82 241 80

97 male group B some high school standard completed 65 66 62 193 64

98 female group E some college standard completed 63 72 70 205 68

99 female group D some college free/reduced none 58 67 62 187 62

100 female group D bachelor's degree standard none 65 67 62 194 65

101 male group B some college standard none 79 67 67 213 71

102 male group D bachelor's degree standard completed 68 74 74 216 72

103 female group D associate's degree standard none 85 91 89 265 88

[ reached 'max' / getOption("max.print") -- omitted 888 rows ]

>

> #comparison of avg scores - male vs female

> ggplot(performance\_2, aes( x= Avg\_score, color = Gender))+

+ geom\_density() +

+ geom\_vline( color = "red",linetype = "dashed", lwd =0.5 ,xintercept = mean(performance\_2[performance\_2$Gender == "female",]$Avg\_score))+

+ geom\_vline( color = "cyan",linetype = "dashed", lwd=0.5 , xintercept = mean(performance\_2[performance\_2$Gender == "male",]$Avg\_score)) +

+ labs(title ="Distribution of scores by Gender", x ="Score", y = " Density")

>

> #From the above density plot, we see that scores of female students have a higher mean than male students.

>

> #Q3) For the given ‘chinook’ database, perform the following tasks:

> #install.packages("DBI")

> library(DBI)

> #install.packages("readr")

> library(readr)

> #install.packages("RSQLite")

> library(RSQLite)

>

> #I. Connect to the above database and convert all the tables into data frame

> con <- dbConnect(RSQLite::SQLite(),"chinook.db")

> db <- dbConnect(dbDriver("SQLite"), dbname="chinook.db")

> dbListTables(db)

[1] "albums" "artists" "customers" "employees" "genres" "invoice\_items" "invoices"

[8] "media\_types" "playlist\_track" "playlists" "sqlite\_sequence" "sqlite\_stat1" "tracks"

>

> albums <- dbReadTable(db, "albums")

> head(albums)

AlbumId Title ArtistId

1 1 For Those About To Rock We Salute You 1

2 2 Balls to the Wall 2

3 3 Restless and Wild 2

4 4 Let There Be Rock 1

5 5 Big Ones 3

6 6 Jagged Little Pill 4

> artists <- dbReadTable(db, "artists")

> head(artists)

ArtistId Name

1 1 AC/DC

2 2 Accept

3 3 Aerosmith

4 4 Alanis Morissette

5 5 Alice In Chains

6 6 Antônio Carlos Jobim

> customers <- dbReadTable(db, "customers")

> head(customers)

CustomerId FirstName LastName Company Address City

1 1 Luís Gonçalves Embraer - Empresa Brasileira de Aeronáutica S.A. Av. Brigadeiro Faria Lima, 2170 São José dos Campos

2 2 Leonie Köhler <NA> Theodor-Heuss-Straße 34 Stuttgart

3 3 François Tremblay <NA> 1498 rue Bélanger Montréal

4 4 Bjørn Hansen <NA> Ullevålsveien 14 Oslo

5 5 František Wichterlová JetBrains s.r.o. Klanova 9/506 Prague

6 6 Helena Holý <NA> Rilská 3174/6 Prague

State Country PostalCode Phone Fax Email SupportRepId

1 SP Brazil 12227-000 +55 (12) 3923-5555 +55 (12) 3923-5566 luisg@embraer.com.br 3

2 <NA> Germany 70174 +49 0711 2842222 <NA> leonekohler@surfeu.de 5

3 QC Canada H2G 1A7 +1 (514) 721-4711 <NA> ftremblay@gmail.com 3

4 <NA> Norway 0171 +47 22 44 22 22 <NA> bjorn.hansen@yahoo.no 4

5 <NA> Czech Republic 14700 +420 2 4172 5555 +420 2 4172 5555 frantisekw@jetbrains.com 4

6 <NA> Czech Republic 14300 +420 2 4177 0449 <NA> hholy@gmail.com 5

> employees <- dbReadTable(db, "employees")

> head(employees)

EmployeeId LastName FirstName Title ReportsTo BirthDate HireDate Address City

1 1 Adams Andrew General Manager NA 1962-02-18 00:00:00 2002-08-14 00:00:00 11120 Jasper Ave NW Edmonton

2 2 Edwards Nancy Sales Manager 1 1958-12-08 00:00:00 2002-05-01 00:00:00 825 8 Ave SW Calgary

3 3 Peacock Jane Sales Support Agent 2 1973-08-29 00:00:00 2002-04-01 00:00:00 1111 6 Ave SW Calgary

4 4 Park Margaret Sales Support Agent 2 1947-09-19 00:00:00 2003-05-03 00:00:00 683 10 Street SW Calgary

5 5 Johnson Steve Sales Support Agent 2 1965-03-03 00:00:00 2003-10-17 00:00:00 7727B 41 Ave Calgary

6 6 Mitchell Michael IT Manager 1 1973-07-01 00:00:00 2003-10-17 00:00:00 5827 Bowness Road NW Calgary

State Country PostalCode Phone Fax Email

1 AB Canada T5K 2N1 +1 (780) 428-9482 +1 (780) 428-3457 andrew@chinookcorp.com

2 AB Canada T2P 2T3 +1 (403) 262-3443 +1 (403) 262-3322 nancy@chinookcorp.com

3 AB Canada T2P 5M5 +1 (403) 262-3443 +1 (403) 262-6712 jane@chinookcorp.com

4 AB Canada T2P 5G3 +1 (403) 263-4423 +1 (403) 263-4289 margaret@chinookcorp.com

5 AB Canada T3B 1Y7 1 (780) 836-9987 1 (780) 836-9543 steve@chinookcorp.com

6 AB Canada T3B 0C5 +1 (403) 246-9887 +1 (403) 246-9899 michael@chinookcorp.com

> genres <- dbReadTable(db, "genres")

> head(genres)

GenreId Name

1 1 Rock

2 2 Jazz

3 3 Metal

4 4 Alternative & Punk

5 5 Rock And Roll

6 6 Blues

> invoice\_items <- dbReadTable(db, "invoice\_items")

> head(invoice\_items)

InvoiceLineId InvoiceId TrackId UnitPrice Quantity

1 1 1 2 0.99 1

2 2 1 4 0.99 1

3 3 2 6 0.99 1

4 4 2 8 0.99 1

5 5 2 10 0.99 1

6 6 2 12 0.99 1

> invoices <- dbReadTable(db, "invoices")

> head(invoices)

InvoiceId CustomerId InvoiceDate BillingAddress BillingCity BillingState BillingCountry BillingPostalCode Total

1 1 2 2009-01-01 00:00:00 Theodor-Heuss-Straße 34 Stuttgart <NA> Germany 70174 1.98

2 2 4 2009-01-02 00:00:00 Ullevålsveien 14 Oslo <NA> Norway 0171 3.96

3 3 8 2009-01-03 00:00:00 Grétrystraat 63 Brussels <NA> Belgium 1000 5.94

4 4 14 2009-01-06 00:00:00 8210 111 ST NW Edmonton AB Canada T6G 2C7 8.91

5 5 23 2009-01-11 00:00:00 69 Salem Street Boston MA USA 2113 13.86

6 6 37 2009-01-19 00:00:00 Berger Straße 10 Frankfurt <NA> Germany 60316 0.99

> media\_types <- dbReadTable(db, "media\_types")

> head(media\_types)

MediaTypeId Name

1 1 MPEG audio file

2 2 Protected AAC audio file

3 3 Protected MPEG-4 video file

4 4 Purchased AAC audio file

5 5 AAC audio file

> playlist\_track <- dbReadTable(db, "playlist\_track")

> head(playlist\_track)

PlaylistId TrackId

1 1 3402

2 1 3389

3 1 3390

4 1 3391

5 1 3392

6 1 3393

> playlists <- dbReadTable(db, "playlists")

> head(playlists)

PlaylistId Name

1 1 Music

2 2 Movies

3 3 TV Shows

4 4 Audiobooks

5 5 90’s Music

6 6 Audiobooks

> tracks <- dbReadTable(db, "tracks")

> head(tracks)

TrackId Name AlbumId MediaTypeId GenreId

1 1 For Those About To Rock (We Salute You) 1 1 1

2 2 Balls to the Wall 2 2 1

3 3 Fast As a Shark 3 2 1

4 4 Restless and Wild 3 2 1

5 5 Princess of the Dawn 3 2 1

6 6 Put The Finger On You 1 1 1

Composer Milliseconds Bytes UnitPrice

1 Angus Young, Malcolm Young, Brian Johnson 343719 11170334 0.99

2 <NA> 342562 5510424 0.99

3 F. Baltes, S. Kaufman, U. Dirkscneider & W. Hoffman 230619 3990994 0.99

4 F. Baltes, R.A. Smith-Diesel, S. Kaufman, U. Dirkscneider & W. Hoffman 252051 4331779 0.99

5 Deaffy & R.A. Smith-Diesel 375418 6290521 0.99

6 Angus Young, Malcolm Young, Brian Johnson 205662 6713451 0.99

>

> #II. Print the different types of music available

> genres$Name

[1] "Rock" "Jazz" "Metal" "Alternative & Punk" "Rock And Roll" "Blues"

[7] "Latin" "Reggae" "Pop" "Soundtrack" "Bossa Nova" "Easy Listening"

[13] "Heavy Metal" "R&B/Soul" "Electronica/Dance" "World" "Hip Hop/Rap" "Science Fiction"

[19] "TV Shows" "Sci Fi & Fantasy" "Drama" "Comedy" "Alternative" "Classical"

[25] "Opera"

>

> #III. List out all the artists from the entire database

> artists$Name

[1] "AC/DC"

[2] "Accept"

[3] "Aerosmith"

[4] "Alanis Morissette"

[5] "Alice In Chains"

[6] "Antônio Carlos Jobim"

[7] "Apocalyptica"

[8] "Audioslave"

[9] "BackBeat"

[10] "Billy Cobham"

[11] "Black Label Society"

[12] "Black Sabbath"

[13] "Body Count"

[14] "Bruce Dickinson"

[15] "Buddy Guy"

[16] "Caetano Veloso"

[17] "Chico Buarque"

[18] "Chico Science & Nação Zumbi"

[19] "Cidade Negra"

[20] "Cláudio Zoli"

[21] "Various Artists"

[22] "Led Zeppelin"

[23] "Frank Zappa & Captain Beefheart"

[24] "Marcos Valle"

[25] "Milton Nascimento & Bebeto"

[26] "Azymuth"

[27] "Gilberto Gil"

[28] "João Gilberto"

[29] "Bebel Gilberto"

[30] "Jorge Vercilo"

[31] "Baby Consuelo"

[32] "Ney Matogrosso"

[33] "Luiz Melodia"

[34] "Nando Reis"

[35] "Pedro Luís & A Parede"

[36] "O Rappa"

[37] "Ed Motta"

[38] "Banda Black Rio"

[39] "Fernanda Porto"

[40] "Os Cariocas"

[41] "Elis Regina"

[42] "Milton Nascimento"

[43] "A Cor Do Som"

[44] "Kid Abelha"

[45] "Sandra De Sá"

[46] "Jorge Ben"

[47] "Hermeto Pascoal"

[48] "Barão Vermelho"

[49] "Edson, DJ Marky & DJ Patife Featuring Fernanda Porto"

[50] "Metallica"

[51] "Queen"

[52] "Kiss"

[53] "Spyro Gyra"

[54] "Green Day"

[55] "David Coverdale"

[56] "Gonzaguinha"

[57] "Os Mutantes"

[58] "Deep Purple"

[59] "Santana"

[60] "Santana Feat. Dave Matthews"

[61] "Santana Feat. Everlast"

[62] "Santana Feat. Rob Thomas"

[63] "Santana Feat. Lauryn Hill & Cee-Lo"

[64] "Santana Feat. The Project G&B"

[65] "Santana Feat. Maná"

[66] "Santana Feat. Eagle-Eye Cherry"

[67] "Santana Feat. Eric Clapton"

[68] "Miles Davis"

[69] "Gene Krupa"

[70] "Toquinho & Vinícius"

[71] "Vinícius De Moraes & Baden Powell"

[72] "Vinícius De Moraes"

[73] "Vinícius E Qurteto Em Cy"

[74] "Vinícius E Odette Lara"

[75] "Vinicius, Toquinho & Quarteto Em Cy"

[76] "Creedence Clearwater Revival"

[77] "Cássia Eller"

[78] "Def Leppard"

[79] "Dennis Chambers"

[80] "Djavan"

[81] "Eric Clapton"

[82] "Faith No More"

[83] "Falamansa"

[84] "Foo Fighters"

[85] "Frank Sinatra"

[86] "Funk Como Le Gusta"

[87] "Godsmack"

[88] "Guns N' Roses"

[89] "Incognito"

[90] "Iron Maiden"

[91] "James Brown"

[92] "Jamiroquai"

[93] "JET"

[94] "Jimi Hendrix"

[95] "Joe Satriani"

[96] "Jota Quest"

[97] "João Suplicy"

[98] "Judas Priest"

[99] "Legião Urbana"

[100] "Lenny Kravitz"

[101] "Lulu Santos"

[102] "Marillion"

[103] "Marisa Monte"

[104] "Marvin Gaye"

[105] "Men At Work"

[106] "Motörhead"

[107] "Motörhead & Girlschool"

[108] "Mônica Marianno"

[109] "Mötley Crüe"

[110] "Nirvana"

[111] "O Terço"

[112] "Olodum"

[113] "Os Paralamas Do Sucesso"

[114] "Ozzy Osbourne"

[115] "Page & Plant"

[116] "Passengers"

[117] "Paul D'Ianno"

[118] "Pearl Jam"

[119] "Peter Tosh"

[120] "Pink Floyd"

[121] "Planet Hemp"

[122] "R.E.M. Feat. Kate Pearson"

[123] "R.E.M. Feat. KRS-One"

[124] "R.E.M."

[125] "Raimundos"

[126] "Raul Seixas"

[127] "Red Hot Chili Peppers"

[128] "Rush"

[129] "Simply Red"

[130] "Skank"

[131] "Smashing Pumpkins"

[132] "Soundgarden"

[133] "Stevie Ray Vaughan & Double Trouble"

[134] "Stone Temple Pilots"

[135] "System Of A Down"

[136] "Terry Bozzio, Tony Levin & Steve Stevens"

[137] "The Black Crowes"

[138] "The Clash"

[139] "The Cult"

[140] "The Doors"

[141] "The Police"

[142] "The Rolling Stones"

[143] "The Tea Party"

[144] "The Who"

[145] "Tim Maia"

[146] "Titãs"

[147] "Battlestar Galactica"

[148] "Heroes"

[149] "Lost"

[150] "U2"

[151] "UB40"

[152] "Van Halen"

[153] "Velvet Revolver"

[154] "Whitesnake"

[155] "Zeca Pagodinho"

[156] "The Office"

[157] "Dread Zeppelin"

[158] "Battlestar Galactica (Classic)"

[159] "Aquaman"

[160] "Christina Aguilera featuring BigElf"

[161] "Aerosmith & Sierra Leone's Refugee Allstars"

[162] "Los Lonely Boys"

[163] "Corinne Bailey Rae"

[164] "Dhani Harrison & Jakob Dylan"

[165] "Jackson Browne"

[166] "Avril Lavigne"

[167] "Big & Rich"

[168] "Youssou N'Dour"

[169] "Black Eyed Peas"

[170] "Jack Johnson"

[171] "Ben Harper"

[172] "Snow Patrol"

[173] "Matisyahu"

[174] "The Postal Service"

[175] "Jaguares"

[176] "The Flaming Lips"

[177] "Jack's Mannequin & Mick Fleetwood"

[178] "Regina Spektor"

[179] "Scorpions"

[180] "House Of Pain"

[181] "Xis"

[182] "Nega Gizza"

[183] "Gustavo & Andres Veiga & Salazar"

[184] "Rodox"

[185] "Charlie Brown Jr."

[186] "Pedro Luís E A Parede"

[187] "Los Hermanos"

[188] "Mundo Livre S/A"

[189] "Otto"

[190] "Instituto"

[191] "Nação Zumbi"

[192] "DJ Dolores & Orchestra Santa Massa"

[193] "Seu Jorge"

[194] "Sabotage E Instituto"

[195] "Stereo Maracana"

[196] "Cake"

[197] "Aisha Duo"

[198] "Habib Koité and Bamada"

[199] "Karsh Kale"

[200] "The Posies"

[201] "Luciana Souza/Romero Lubambo"

[202] "Aaron Goldberg"

[203] "Nicolaus Esterhazy Sinfonia"

[204] "Temple of the Dog"

[205] "Chris Cornell"

[206] "Alberto Turco & Nova Schola Gregoriana"

[207] "Richard Marlow & The Choir of Trinity College, Cambridge"

[208] "English Concert & Trevor Pinnock"

[209] "Anne-Sophie Mutter, Herbert Von Karajan & Wiener Philharmoniker"

[210] "Hilary Hahn, Jeffrey Kahane, Los Angeles Chamber Orchestra & Margaret Batjer"

[211] "Wilhelm Kempff"

[212] "Yo-Yo Ma"

[213] "Scholars Baroque Ensemble"

[214] "Academy of St. Martin in the Fields & Sir Neville Marriner"

[215] "Academy of St. Martin in the Fields Chamber Ensemble & Sir Neville Marriner"

[216] "Berliner Philharmoniker, Claudio Abbado & Sabine Meyer"

[217] "Royal Philharmonic Orchestra & Sir Thomas Beecham"

[218] "Orchestre Révolutionnaire et Romantique & John Eliot Gardiner"

[219] "Britten Sinfonia, Ivor Bolton & Lesley Garrett"

[220] "Chicago Symphony Chorus, Chicago Symphony Orchestra & Sir Georg Solti"

[221] "Sir Georg Solti & Wiener Philharmoniker"

[222] "Academy of St. Martin in the Fields, John Birch, Sir Neville Marriner & Sylvia McNair"

[223] "London Symphony Orchestra & Sir Charles Mackerras"

[224] "Barry Wordsworth & BBC Concert Orchestra"

[225] "Herbert Von Karajan, Mirella Freni & Wiener Philharmoniker"

[226] "Eugene Ormandy"

[227] "Luciano Pavarotti"

[228] "Leonard Bernstein & New York Philharmonic"

[229] "Boston Symphony Orchestra & Seiji Ozawa"

[230] "Aaron Copland & London Symphony Orchestra"

[231] "Ton Koopman"

[232] "Sergei Prokofiev & Yuri Temirkanov"

[233] "Chicago Symphony Orchestra & Fritz Reiner"

[234] "Orchestra of The Age of Enlightenment"

[235] "Emanuel Ax, Eugene Ormandy & Philadelphia Orchestra"

[236] "James Levine"

[237] "Berliner Philharmoniker & Hans Rosbaud"

[238] "Maurizio Pollini"

[239] "Academy of St. Martin in the Fields, Sir Neville Marriner & William Bennett"

[240] "Gustav Mahler"

[241] "Felix Schmidt, London Symphony Orchestra & Rafael Frühbeck de Burgos"

[242] "Edo de Waart & San Francisco Symphony"

[243] "Antal Doráti & London Symphony Orchestra"

[244] "Choir Of Westminster Abbey & Simon Preston"

[245] "Michael Tilson Thomas & San Francisco Symphony"

[246] "Chor der Wiener Staatsoper, Herbert Von Karajan & Wiener Philharmoniker"

[247] "The King's Singers"

[248] "Berliner Philharmoniker & Herbert Von Karajan"

[249] "Sir Georg Solti, Sumi Jo & Wiener Philharmoniker"

[250] "Christopher O'Riley"

[251] "Fretwork"

[252] "Amy Winehouse"

[253] "Calexico"

[254] "Otto Klemperer & Philharmonia Orchestra"

[255] "Yehudi Menuhin"

[256] "Philharmonia Orchestra & Sir Neville Marriner"

[257] "Academy of St. Martin in the Fields, Sir Neville Marriner & Thurston Dart"

[258] "Les Arts Florissants & William Christie"

[259] "The 12 Cellists of The Berlin Philharmonic"

[260] "Adrian Leaper & Doreen de Feis"

[261] "Roger Norrington, London Classical Players"

[262] "Charles Dutoit & L'Orchestre Symphonique de Montréal"

[263] "Equale Brass Ensemble, John Eliot Gardiner & Munich Monteverdi Orchestra and Choir"

[264] "Kent Nagano and Orchestre de l'Opéra de Lyon"

[265] "Julian Bream"

[266] "Martin Roscoe"

[267] "Göteborgs Symfoniker & Neeme Järvi"

[268] "Itzhak Perlman"

[269] "Michele Campanella"

[270] "Gerald Moore"

[271] "Mela Tenenbaum, Pro Musica Prague & Richard Kapp"

[272] "Emerson String Quartet"

[273] "C. Monteverdi, Nigel Rogers - Chiaroscuro; London Baroque; London Cornett & Sackbu"

[274] "Nash Ensemble"

[275] "Philip Glass Ensemble"

>

> #IV. List out all the countries where the customer resides and plot a bar graph showing the number of customers from the respective country

> unique(customers$Country)

[1] "Brazil" "Germany" "Canada" "Norway" "Czech Republic" "Austria" "Belgium"

[8] "Denmark" "USA" "Portugal" "France" "Finland" "Hungary" "Ireland"

[15] "Italy" "Netherlands" "Poland" "Spain" "Sweden" "United Kingdom" "Australia"

[22] "Argentina" "Chile" "India"

> plot2 <-

+ ggplot() +

+ geom\_bar(data = customers, aes(x = Country), width = 0.3, fill = "turquoise") +

+ geom\_text(stat='count', data = customers, aes(x = Country, label=..count..), vjust=-0.2) +

+ theme\_bw() +

+ xlab("Country") +

+ ylab("Number of Customers") +

+ theme\_classic() +

+ theme(axis.text.x=element\_text(angle=90, hjust=1)) +

+ ggtitle("Number of Customers by Country") +

+ scale\_fill\_brewer(type = "qual", palette = 1, direction = 1,

+ aesthetics = "fill")

> plot2

**Day 6 – R Programming**

**Happiness ~ Income (Simple Linear Regression)**

> #install.packages("broom")

> #install.packages("ggpubr")

> library(ggplot2)

> library(dplyr)

> library(broom)

> library(ggpubr)

> setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models")

> dev.off()

null device

1

>

> #Importing Data

> income.data <- read.csv("income.data.csv")

> income.data

X income happiness

1 1 3.862647 2.3144890

2 2 4.979381 3.4334898

3 3 4.923957 4.5993734

4 4 3.214372 2.7911138

5 5 7.196409 5.5963983

6 6 3.729643 2.4585559

7 7 4.674517 3.1929918

8 8 4.498104 1.9071368

9 9 3.121631 2.9424499

10 10 4.639914 3.7379416

11 11 4.632840 3.1754061

12 12 2.773179 2.0090465

13 13 7.119479 5.9518141

14 14 7.466653 5.9605473

15 15 2.117742 1.4457989

16 16 2.559166 2.8985831

17 17 2.354793 1.2311675

18 18 2.388157 2.3129881

19 19 4.755680 2.6661160

20 20 1.994275 2.5847290

21 21 7.310916 5.7474441

22 22 3.528319 2.5465246

23 23 2.428752 1.2007855

24 24 3.542748 3.0782934

25 25 5.227201 4.3177609

26 26 6.691993 5.3814787

27 27 3.900410 3.5652243

28 28 2.291055 0.9534130

29 29 2.380513 2.1691613

30 30 2.549609 2.0607943

31 31 6.933296 6.2991013

32 32 1.855645 1.5903559

33 33 3.589023 2.2509294

34 34 6.826478 5.9142477

35 35 2.070602 2.1918337

36 36 5.224205 5.7678144

37 37 2.243114 0.9728829

38 38 7.076166 5.0105774

39 39 4.190672 2.2396650

40 40 1.956486 1.9275788

41 41 5.061758 3.3580716

42 42 3.982190 2.4000873

43 43 3.065059 3.4079800

44 44 3.682877 2.5761763

45 45 3.789429 2.4730794

46 46 5.358716 3.7526595

47 47 5.196120 4.0876312

48 48 5.241190 3.5432037

49 49 7.101620 5.3483529

50 50 3.424021 3.0563767

51 51 2.253399 1.5584226

52 52 5.370337 3.2251328

53 53 6.225606 5.0342310

54 54 5.482862 3.8574243

55 55 4.034172 3.6190555

56 56 6.510219 4.0045377

57 57 6.029214 4.8020918

58 58 6.949113 4.6588904

59 59 7.195037 5.2317030

60 60 2.757338 2.4806065

61 61 6.956079 5.4981472

62 62 4.670193 4.5506370

63 63 6.368293 3.5700136

64 64 6.166681 4.7196653

65 65 6.074158 4.5031082

66 66 5.484719 5.0460818

67 67 1.589575 0.6697159

68 68 1.680474 1.6060724

69 69 5.499948 4.8266027

70 70 4.043891 2.2082405

71 71 5.005093 4.0564931

72 72 4.863582 3.5679052

73 73 1.506275 1.3084873

74 74 2.864664 4.1596093

75 75 5.877906 4.6339151

76 76 6.483984 5.0687479

77 77 4.938037 3.0407973

78 78 5.625434 3.8042989

79 79 7.228265 5.0340038

80 80 5.337460 3.7034379

81 81 2.825827 2.1889381

82 82 5.931367 5.5380475

83 83 3.520255 3.5838752

84 84 3.239941 3.0968856

85 85 3.498386 2.2009822

86 86 7.186112 5.1515983

87 87 4.719166 5.9509863

88 88 3.594802 2.9681871

89 89 3.233942 2.3995613

90 90 1.514153 0.8594991

91 91 4.002537 1.7759326

92 92 6.198104 4.6612612

93 93 2.280651 0.7272212

94 94 2.189866 0.7712866

95 95 3.434151 3.3487882

96 96 5.932270 3.9662154

97 97 5.307839 2.8904474

98 98 5.664345 3.7732607

99 99 7.439248 6.3596000

100 100 2.134702 0.2687221

101 101 6.501275 4.3748323

102 102 3.651183 2.1558433

103 103 2.286495 1.8935569

104 104 4.748859 4.9029916

105 105 5.459161 4.8335064

106 106 3.433065 3.1722995

107 107 7.176400 5.0299517

108 108 5.506395 4.2610130

109 109 3.097616 1.6723906

110 110 4.647556 1.4970241

111 111 1.828306 1.2654889

112 112 3.534566 2.6674654

113 113 4.606176 1.9993255

114 114 5.361503 5.2318633

115 115 6.879333 5.2114013

116 116 4.317032 3.6616565

117 117 3.383164 1.4150347

118 118 4.932207 4.9330441

119 119 4.935597 4.1307783

120 120 2.601553 2.2822669

121 121 5.711264 3.9011703

122 122 6.117531 4.6919989

123 123 3.771415 3.5778007

124 124 7.117220 5.5625455

125 125 2.194882 2.3932281

126 126 5.952002 3.5647237

127 127 3.922303 2.2537215

128 128 7.081589 4.1216477

129 129 6.950745 4.1691008

130 130 3.660877 3.8238987

131 131 1.789092 0.4583776

132 132 3.540341 2.5769400

133 133 4.533395 2.9475315

134 134 4.867339 3.7399958

135 135 4.056005 3.5714465

136 136 5.634643 4.8081504

137 137 5.461636 4.0176112

138 138 3.186176 1.8398020

139 139 4.417666 3.4685738

140 140 5.760289 4.7587855

141 141 3.716700 2.3916775

142 142 2.182562 0.9929174

143 143 4.291984 3.1693802

144 144 3.410030 2.0890424

145 145 3.581097 1.8436758

146 146 3.509663 1.6166074

147 147 6.660216 5.9493475

148 148 6.271786 4.9402278

149 149 3.735018 2.8412387

150 150 4.393208 2.9443913

151 151 3.512217 3.0269182

152 152 6.239740 5.0978025

153 153 3.681486 3.0368199

154 154 7.241313 4.6828170

155 155 6.345370 4.0008192

156 156 5.939742 4.5708011

157 157 2.459321 2.0427393

158 158 2.539089 1.7486511

159 159 6.708604 6.0640130

160 160 6.831322 5.1324015

161 161 5.082658 3.1133421

162 162 6.030607 4.8218103

163 163 6.574595 4.1795210

164 164 3.574297 1.6312611

165 165 5.529908 3.8221796

166 166 2.409382 1.8575419

167 167 4.264790 3.7510893

168 168 3.530345 3.1586186

169 169 6.143150 4.9271326

170 170 5.157697 4.6001148

171 171 4.710847 2.4083799

172 172 6.847515 4.4867037

173 173 5.464640 2.7277157

174 174 4.176532 3.0207244

175 175 3.748093 3.7491807

176 176 2.274523 2.3115542

177 177 1.576366 0.9876032

178 178 1.924134 1.4611444

179 179 5.904246 4.5768565

180 180 5.189031 4.7675956

181 181 1.879868 0.4381716

182 182 2.544348 2.3512025

183 183 3.221394 3.4531027

184 184 7.260374 5.3813985

185 185 6.481617 4.8200912

186 186 5.688488 4.6587427

187 187 6.633619 5.3800702

188 188 5.972741 3.3159895

189 189 3.897738 2.7997475

190 190 6.461243 4.2067549

191 191 6.628036 4.4026632

192 192 3.118959 2.7691181

193 193 4.695964 2.7842445

194 194 1.573694 0.6880906

195 195 3.670377 3.4764991

196 196 7.194407 5.8361967

197 197 1.780479 2.0039261

198 198 2.142360 0.9713325

199 199 3.656486 2.8576144

200 200 2.090354 1.8521177

201 201 3.363097 3.5151792

202 202 2.423144 2.1005525

203 203 7.111584 6.0864783

204 204 3.039942 4.0838212

205 205 2.373232 1.5247823

206 206 1.984564 2.5795165

207 207 2.628483 1.6192261

208 208 7.136760 5.5066215

209 209 3.104918 1.0959993

210 210 1.558657 0.9685273

211 211 7.478447 4.8777255

212 212 2.813900 1.7596987

213 213 5.744540 5.0322110

214 214 6.540988 5.7138023

215 215 6.562794 4.7958429

216 216 5.470125 4.6602900

217 217 2.085131 2.7403954

218 218 4.589572 4.2505681

219 219 5.074502 3.9410193

220 220 7.463510 4.5034454

221 221 5.853906 4.6332287

222 222 3.764540 4.0308649

223 223 7.062792 6.8633880

224 224 6.377376 5.0794759

225 225 1.920863 1.6252684

226 226 7.364213 6.6182798

227 227 6.535799 4.6569986

228 228 7.300903 6.0049875

229 229 3.037232 2.4106356

230 230 6.703267 4.2612200

231 231 1.927997 1.0656238

232 232 4.223554 2.2957001

233 233 2.922706 1.9195111

234 234 4.427109 3.5813810

235 235 2.070562 0.6289421

236 236 5.224070 3.3441084

237 237 7.161873 6.1604341

238 238 2.210696 2.8612744

239 239 7.207060 4.2094706

240 240 2.184085 1.2262981

241 241 4.414998 4.7933252

242 242 5.014810 3.3137965

243 243 2.602037 2.1526984

244 244 2.917049 2.9236839

245 245 6.244342 3.4520672

246 246 6.859654 4.2583115

247 247 2.371230 3.9610328

248 248 5.964058 3.4277232

249 249 7.153674 4.7209873

250 250 2.289897 1.5719498

251 251 6.376228 6.1869456

252 252 3.540504 3.5527370

253 253 3.139826 1.2457859

254 254 6.460742 3.4269117

255 255 2.641348 1.8771470

256 256 2.002214 1.8178891

257 257 6.391428 5.2399095

258 258 2.763720 1.3840441

259 259 6.831258 3.8379778

260 260 3.827255 2.3216977

261 261 3.770671 3.3115782

262 262 3.159855 3.0573878

263 263 5.099417 4.7370460

264 264 5.610391 4.5909705

265 265 1.856372 0.6542421

266 266 5.363730 3.9811277

267 267 2.336134 2.3362760

268 268 4.975851 4.5406361

269 269 2.629547 2.1927449

270 270 2.646458 1.7881763

271 271 3.859892 2.7194322

272 272 4.121531 4.2126973

273 273 6.385941 4.4772714

274 274 3.842710 2.4688600

275 275 4.990549 3.4517725

276 276 3.400597 0.6869208

277 277 3.820115 2.2467457

278 278 1.909499 1.6276951

279 279 2.858464 2.4532091

280 280 7.451501 4.1099447

281 281 3.354252 2.5725982

282 282 6.707825 4.8104241

283 283 6.325906 4.8274163

284 284 1.931181 2.4657611

285 285 5.128545 3.7573790

286 286 4.278210 3.6913482

287 287 1.579470 1.9818099

288 288 2.907682 1.4102296

289 289 5.644714 3.7543014

290 290 3.571175 4.2452156

291 291 2.345108 1.4378767

292 292 5.845197 4.1598871

293 293 5.298480 3.5148918

294 294 3.434700 2.7144980

295 295 1.865995 1.3573731

296 296 5.095615 5.6384604

297 297 1.530808 2.4214647

298 298 1.618311 1.5112051

299 299 6.687677 5.5228917

300 300 7.347246 4.3966223

301 301 5.983846 3.9884528

302 302 5.196082 3.3176068

303 303 4.193007 2.7796826

304 304 2.347688 0.8465055

305 305 4.709489 2.4579217

306 306 2.307198 3.5096047

307 307 2.730769 2.6469045

308 308 3.882514 2.9779167

309 309 3.574394 1.4244505

310 310 4.159576 1.7903423

311 311 1.544634 1.6446366

312 312 3.383897 0.7316363

313 313 3.614745 2.9017886

314 314 6.503882 4.3171332

315 315 1.848413 2.0973691

316 316 4.420312 4.3915930

317 317 6.477153 5.3139569

318 318 6.561420 6.2813702

319 319 7.180907 5.6079666

320 320 2.809091 2.9468704

321 321 5.686205 3.8727888

322 322 4.800344 2.8428684

323 323 2.412912 1.4606163

324 324 2.925704 3.7528248

325 325 3.174176 3.1266032

326 326 2.685530 2.8211926

327 327 2.124429 2.7349601

328 328 2.694022 2.1975921

329 329 4.230889 4.1555409

330 330 5.350516 4.0782088

331 331 5.091580 4.4569636

332 332 6.250302 4.9392590

333 333 5.324633 3.7305700

[ reached 'max' / getOption("max.print") -- omitted 165 rows ]

> dim(income.data)

[1] 498 3

> summary(income.data)

X income happiness

Min. : 1.0 Min. :1.506 Min. :0.266

1st Qu.:125.2 1st Qu.:3.006 1st Qu.:2.266

Median :249.5 Median :4.424 Median :3.473

Mean :249.5 Mean :4.467 Mean :3.393

3rd Qu.:373.8 3rd Qu.:5.992 3rd Qu.:4.503

Max. :498.0 Max. :7.482 Max. :6.863

>

> #Assumptions

> hist(income.data$happiness) #normally distributed

> plot(happiness ~ income, data=income.data) #linearity x ~ y

> #Homoscedasticity or homogeneity of variance will be checked after model building

>

> #Linear Regression Analysis

> income.happiness.lm <- lm(happiness ~ income, data=income.data)

> summary(income.happiness.lm)

Call:

lm(formula = happiness ~ income, data = income.data)

Residuals:

Min 1Q Median 3Q Max

-2.02479 -0.48526 0.04078 0.45898 2.37805

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 0.20427 0.08884 2.299 0.0219 \*

income 0.71383 0.01854 38.505 <2e-16 \*\*\*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.7181 on 496 degrees of freedom

Multiple R-squared: 0.7493, Adjusted R-squared: 0.7488

F-statistic: 1483 on 1 and 496 DF, p-value: < 2.2e-16

> par(mfrow=c(2, 2))

> plot(income.happiness.lm) #Homoscedasticity, Residuals normally distributed

> par(mfrow=c(1, 1))

>

> #Visualize results

> income.graph <- ggplot(income.data, aes(x=income, y=happiness)) + geom\_point()

> income.graph

> income.graph <- income.graph + geom\_smooth(method = "lm", col="black")

> income.graph

`geom\_smooth()` using formula 'y ~ x'

> income.graph <- income.graph + stat\_regline\_equation(label.x=3, label.y=7) #regression line eq. y = mx + c

> income.graph

`geom\_smooth()` using formula 'y ~ x'

> income.graph + theme\_bw() +

+ labs(title="Reported Happiness as a function of Income", x="Income(x$10,000)", y="Happiness(1 to 10)")

`geom\_smooth()` using formula 'y ~ x'

**Cars Distance ~ Speed (Simple Linear Regression)**

> cars

speed dist

1 4 2

2 4 10

3 7 4

4 7 22

5 8 16

6 9 10

7 10 18

8 10 26

9 10 34

10 11 17

11 11 28

12 12 14

13 12 20

14 12 24

15 12 28

16 13 26

17 13 34

18 13 34

19 13 46

20 14 26

21 14 36

22 14 60

23 14 80

24 15 20

25 15 26

26 15 54

27 16 32

28 16 40

29 17 32

30 17 40

31 17 50

32 18 42

33 18 56

34 18 76

35 18 84

36 19 36

37 19 46

38 19 68

39 20 32

40 20 48

41 20 52

42 20 56

43 20 64

44 22 66

45 23 54

46 24 70

47 24 92

48 24 93

49 24 120

50 25 85

> ?cars

> summary(cars)

speed dist

Min. : 4.0 Min. : 2.00

1st Qu.:12.0 1st Qu.: 26.00

Median :15.0 Median : 36.00

Mean :15.4 Mean : 42.98

3rd Qu.:19.0 3rd Qu.: 56.00

Max. :25.0 Max. :120.00

> plot(cars, col="blue", pch=20, cex=2, main="Relationship between Speed and Stopping Distance for 10 Cars", xlab="Speed in mph", ylab="Stopping Distance in feet")

> set.seed(1) #generates random numbers, gives same set of numbers (Set seed every time if we need same number)

> sample(3)

[1] 1 2 3

>

> mt <- matrix(1:10, ncol = 5)

> mt

[,1] [,2] [,3] [,4] [,5]

[1,] 1 3 5 7 9

[2,] 2 4 6 8 10

> scale(mt, center=TRUE, scale=FALSE)

[,1] [,2] [,3] [,4] [,5]

[1,] -0.5 -0.5 -0.5 -0.5 -0.5

[2,] 0.5 0.5 0.5 0.5 0.5

attr(,"scaled:center")

[1] 1.5 3.5 5.5 7.5 9.5

>

> set.seed(2) #Works like random\_state from python

> speed.c <- scale(cars$speed, center=TRUE, scale=FALSE)

> mod1 <- lm(formula=dist ~ speed.c, data=cars)

> mod1

Call:

lm(formula = dist ~ speed.c, data = cars)

Coefficients:

(Intercept) speed.c

42.980 3.932

> summary(mod1)

Call:

lm(formula = dist ~ speed.c, data = cars)

Residuals:

Min 1Q Median 3Q Max

-29.069 -9.525 -2.272 9.215 43.201

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 42.9800 2.1750 19.761 < 2e-16 \*\*\*

speed.c 3.9324 0.4155 9.464 1.49e-12 \*\*\*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 15.38 on 48 degrees of freedom

Multiple R-squared: 0.6511, Adjusted R-squared: 0.6438

F-statistic: 89.57 on 1 and 48 DF, p-value: 1.49e-12

**Heart Disease Prediction (Simple Linear Regression)**

> library(ggplot2)

> library(dplyr)

> library(broom)

> library(ggpubr)

> setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models")

> dev.off()

null device

1

>

> #Importing Data

> heart.data <- read.csv("heart.data.csv")

> heart.data

X biking smoking heart.disease

1 1 30.801246 10.8966080 11.7694228

2 2 65.129215 2.2195632 2.8540815

3 3 1.959665 17.5883305 17.1778035

4 4 44.800196 2.8025589 6.8166469

5 5 69.428454 15.9745046 4.0622235

6 6 54.403626 29.3331755 9.5500460

7 7 49.056162 9.0608458 7.6245070

8 8 4.784604 12.8350208 15.8546544

9 9 65.730788 11.9912973 3.0674617

10 10 35.257449 23.2776834 12.0984844

11 11 51.825567 14.4351184 6.4302482

12 12 52.936197 25.0748686 8.6082721

13 13 48.767478 11.0232710 6.7225238

14 14 26.166801 6.6457495 10.5978071

15 15 10.553075 5.9905063 14.0794783

16 16 47.163716 14.0978372 8.7448453

17 17 61.685256 16.8408167 5.4433420

18 18 33.944394 5.7585952 9.1623064

19 19 39.697624 12.6628694 9.7471858

20 20 63.124698 22.9174800 5.8582779

21 21 28.510129 14.8551064 11.7247416

22 22 18.525973 26.4049774 16.0281877

23 23 24.479470 26.9249607 15.0007154

24 24 18.358646 23.4319568 16.4882059

25 25 30.388184 16.9860864 12.3566075

26 26 52.985220 27.6890270 9.0884449

27 27 60.509448 3.9819621 3.2172143

28 28 45.247110 2.1374753 6.5937191

29 29 48.597044 10.3884264 6.6594202

30 30 25.139771 5.8363728 11.4829371

31 31 44.173095 3.9676057 7.9822275

32 32 61.146946 27.7834060 7.7224625

33 33 27.267898 16.8532932 12.1648166

34 34 49.527100 15.2497308 8.0274043

35 35 20.197206 10.3314895 13.4165474

36 36 18.811228 16.7534420 15.0873602

37 37 67.350765 23.8737268 5.2798634

38 38 29.904475 24.5845499 13.5076192

39 39 14.011760 21.0121418 15.9929864

40 40 45.815488 4.7161269 7.0406211

41 41 31.477251 22.1658255 13.2385262

42 42 17.108204 1.3528783 11.5357354

43 43 9.665082 3.5042963 12.8868168

44 44 23.933005 4.1858692 10.8944571

45 45 22.636301 13.6789828 13.4660327

46 46 27.247477 13.3797768 12.3288989

47 47 20.789602 19.4554286 14.4157831

48 48 46.613715 9.2493326 6.8093546

49 49 28.622632 12.4827339 11.3683650

50 50 21.127498 18.9413483 14.8253623

51 51 68.574349 1.8047036 0.6839264

52 52 41.684367 13.0672050 9.0888493

53 53 69.879593 17.3516599 4.2564834

54 54 9.817277 23.8189949 17.8341328

55 55 4.379280 20.6629714 17.4118109

56 56 28.610378 1.1479621 10.0558055

57 57 21.460016 22.9760018 15.0086341

58 58 27.601656 4.3883804 10.8936852

59 59 57.230504 12.8050000 5.3068180

60 60 26.397282 7.7639305 11.0243252

61 61 39.010480 0.7676801 8.7639297

62 62 11.527487 6.7396220 14.6003016

63 63 17.684287 8.2780091 13.8021255

64 64 19.935253 6.0764383 11.6320723

65 65 42.310040 8.4123966 7.4630017

66 66 1.119154 19.5503583 17.7101910

67 67 23.276821 14.3066349 13.2663850

68 68 14.965816 12.8691532 15.3003824

69 69 30.663350 16.6632038 11.7531562

70 70 22.925183 24.5987873 16.1991180

71 71 59.770308 8.7007692 5.6856819

72 72 70.456061 12.7407109 2.9059872

73 73 21.750385 18.8575107 14.1798442

74 74 49.360686 23.2094802 9.4660260

75 75 4.487242 23.4190000 18.7669334

76 76 14.693269 17.8743936 16.3479313

77 77 40.611628 25.9937106 12.0466432

78 78 8.764197 3.8990404 13.3730055

79 79 56.725412 16.1809774 6.7357709

80 80 60.551149 18.0652019 6.5167036

81 81 64.384893 10.5295309 4.5668945

82 82 20.262798 11.1787830 12.3790734

83 83 30.520086 12.4334774 11.1407355

84 84 30.461542 29.8608106 14.3299759

85 85 3.705894 21.4941886 17.8776920

86 86 15.082469 16.6152001 14.9359167

87 87 30.997842 29.0164264 13.7579867

88 88 14.625411 6.7983462 14.4789601

89 89 28.103061 14.7313505 12.7945548

90 90 34.680241 8.6381050 8.3317181

91 91 6.947463 26.1056583 18.6897979

92 92 26.860662 16.7194132 13.4876889

93 93 41.019323 12.9991873 10.2648899

94 94 31.932738 28.1828730 13.1737410

95 95 69.877147 26.3311967 6.0724855

96 96 63.029854 22.2471319 6.3567192

97 97 21.349999 12.8558535 13.7996830

98 98 3.811338 17.7237882 18.4623513

99 99 67.514106 26.9553999 6.5826851

100 100 12.580893 16.9897825 14.8556848

101 101 61.232197 4.6135505 4.3616062

102 102 64.332304 29.4237378 7.7073976

103 103 31.872439 16.2418978 10.5260293

104 104 11.936562 3.4865672 14.3914484

105 105 52.360268 19.8410769 7.8163886

106 106 22.516638 7.6951729 11.6647648

107 107 49.764822 3.5729441 6.2645744

108 108 22.792636 9.8168286 10.9117655

109 109 49.748748 20.4918307 8.7001979

110 110 68.204122 2.1929445 1.9664482

111 111 15.185101 14.5203621 14.5878253

112 112 58.046901 15.7135850 6.5593358

113 113 69.499688 23.1678748 5.7536536

114 114 2.616135 4.3190804 14.8517766

115 115 2.136343 25.8401303 19.2426878

116 116 25.771571 28.5403473 14.4293484

117 117 11.615646 6.3455289 14.4114830

118 118 17.197456 20.7334559 15.1981843

119 119 27.681662 18.6370085 11.5075951

120 120 9.648096 8.3700383 15.5763683

121 121 65.621956 14.1066235 4.0442469

122 122 46.556228 26.8937498 10.5427902

123 123 48.300472 12.0117870 7.2992774

124 124 15.141292 7.8937497 13.6191300

125 125 71.579351 18.9378855 4.0907648

126 126 4.681250 10.9882819 15.8685828

127 127 22.476723 25.9723233 14.8303440

128 128 49.296201 5.0887881 6.0737923

129 129 17.648135 27.1925636 15.1389680

130 130 9.413778 8.6085378 13.5250712

131 131 64.915668 10.8893906 3.7743880

132 132 3.950367 6.3595796 14.6357693

133 133 67.342457 16.6226193 3.7444984

134 134 71.238955 25.1941518 6.0015227

135 135 70.323878 26.2334743 5.2357312

136 136 28.424901 20.2084486 13.0038423

137 137 73.713732 14.1016522 2.9890677

138 138 56.058032 8.2061159 5.5239310

139 139 21.588199 2.5734949 11.3742898

140 140 16.276161 3.4634491 13.5987548

141 141 26.988690 15.8833260 12.9216726

142 142 11.326814 9.2306549 14.5243489

143 143 55.580584 7.6713074 5.7268270

144 144 50.603802 28.9184712 10.6355905

145 145 60.401739 24.8321410 7.5726142

146 146 71.486751 21.6373684 3.6684273

147 147 37.978507 13.9453443 10.1067938

148 148 48.692115 23.5640881 9.5990941

149 149 40.016400 7.8116349 7.6581870

150 150 32.148553 0.9690843 8.8739847

151 151 12.318283 26.8908059 17.7585948

152 152 31.659667 21.3995087 12.0931244

153 153 55.841893 2.2487162 4.5002273

154 154 28.826953 11.4098666 12.8126371

155 155 55.472287 5.2674378 4.9163834

156 156 54.354034 16.3415202 7.5917973

157 157 70.331699 15.0588637 3.0374318

158 158 54.062609 20.3888136 8.0511951

159 159 59.575645 24.7926381 8.5199279

160 160 2.818204 23.2461405 18.4829598

161 161 30.460335 2.5256544 8.9365829

162 162 22.343450 23.2046425 15.9085493

163 163 14.696886 9.8316822 13.2582035

164 164 70.902815 29.9140032 6.3350215

165 165 35.335113 9.1475020 9.7518942

166 166 72.173766 15.2736628 2.8283567

167 167 44.698217 10.0025889 7.4494126

168 168 70.361366 20.3399150 3.8971099

169 169 7.619084 26.6615229 18.6881304

170 170 29.673634 2.3967956 9.3879078

171 171 28.485683 12.6628036 11.2860570

172 172 67.423291 28.6574311 5.8094945

173 173 10.145069 11.3175197 14.8048065

174 174 59.989904 25.4558391 7.4743720

175 175 38.155015 20.1042221 11.5622808

176 176 15.466010 11.5711484 13.3774300

177 177 73.767713 16.1513316 2.3548085

178 178 31.179629 5.5684413 9.8617288

179 179 5.201611 4.3599032 15.6431142

180 180 50.249614 4.1290591 5.5419066

181 181 60.940141 21.8644959 5.4159174

182 182 20.068674 11.9294173 12.6884954

183 183 41.211215 4.1514402 7.5901660

184 184 72.394856 7.5198372 1.8701100

185 185 10.610969 19.3015155 16.7460356

186 186 45.579836 20.6168515 9.7984834

187 187 29.658506 12.1518990 12.8178071

188 188 40.056854 16.5064944 9.3926393

189 189 5.510300 17.8842193 16.0139208

190 190 32.056529 12.4794809 11.5360652

191 191 46.842870 27.3216486 10.2505847

192 192 42.425007 10.9547393 8.8282361

193 193 31.212374 7.7973828 9.7753859

194 194 13.176628 9.9874669 14.5477545

195 195 33.779739 0.9653903 6.9442975

196 196 70.690083 22.7107707 2.7084606

197 197 60.284951 15.1081402 4.9479908

198 198 16.003605 19.8941489 15.3662877

199 199 39.677219 10.2721672 9.5436557

200 200 12.885185 25.2101825 16.2725863

201 201 35.023450 22.6640373 12.5158362

202 202 10.343753 27.6468493 17.4485160

203 203 20.640893 15.3841384 14.5572879

204 204 63.238037 20.5047412 5.5609216

205 205 23.984565 7.6121169 11.5562573

206 206 44.014897 6.5796621 8.5037463

207 207 67.127924 5.8203635 2.5511506

208 208 36.538050 2.0528831 8.4950339

209 209 7.831481 26.8269709 17.5604514

210 210 40.395401 7.0274602 6.7390807

211 211 16.249914 28.3617369 17.3545771

212 212 47.584661 29.4683524 11.5999032

213 213 15.481362 18.8152012 14.9407560

214 214 70.085196 10.3826455 2.2392169

215 215 1.330485 28.7937440 20.4534962

216 216 61.542692 12.8374854 4.9734613

217 217 23.097771 0.9073611 10.6947889

218 218 65.069917 1.4876797 2.1856508

219 219 71.014542 15.2819055 4.0768235

220 220 64.065982 28.4724464 7.2862524

221 221 61.152760 2.1900536 3.5229763

222 222 22.672368 28.7353995 16.7786346

223 223 49.728740 3.4945424 5.0730746

224 224 35.480794 15.8501562 11.3729972

225 225 59.461885 18.8075341 5.6906489

226 226 31.697593 23.1906637 12.5378281

227 227 62.772108 15.2398175 4.9345783

228 228 58.668542 19.5857407 6.6620753

229 229 25.254140 7.1689519 12.0465147

230 230 22.722701 8.2882507 11.2963162

231 231 1.616922 1.4584368 16.3351186

232 232 10.353648 16.0131718 14.0886540

233 233 44.721586 7.2730788 7.6450248

234 234 29.224098 27.3570273 13.6443726

235 235 66.111593 18.6293941 4.5900481

236 236 46.728488 8.4995461 7.8255359

237 237 39.172427 17.5563764 10.7150869

238 238 9.937617 22.3426031 16.3846780

239 239 61.393845 22.9195492 6.8381847

240 240 21.608228 9.3488357 13.9959895

241 241 6.283610 20.1753293 17.5981661

242 242 61.436136 24.4659138 7.6206629

243 243 1.257841 15.1309519 16.7368633

244 244 4.699863 9.8599366 15.5694794

245 245 54.938223 13.0462165 6.2944988

246 246 7.749030 8.3870192 13.2815287

247 247 49.563424 16.2590213 8.1434851

248 248 29.731403 23.3339016 12.9964758

249 249 45.716267 23.8302604 9.2300743

250 250 47.537321 20.0742953 8.9378932

[ reached 'max' / getOption("max.print") -- omitted 248 rows ]

> dim(heart.data)

[1] 498 4

> summary(heart.data)

X biking smoking heart.disease

Min. : 1.0 Min. : 1.119 Min. : 0.5259 Min. : 0.5519

1st Qu.:125.2 1st Qu.:20.205 1st Qu.: 8.2798 1st Qu.: 6.5137

Median :249.5 Median :35.824 Median :15.8146 Median :10.3853

Mean :249.5 Mean :37.788 Mean :15.4350 Mean :10.1745

3rd Qu.:373.8 3rd Qu.:57.853 3rd Qu.:22.5689 3rd Qu.:13.7240

Max. :498.0 Max. :74.907 Max. :29.9467 Max. :20.4535

>

> #Assumptions

> cor(heart.data$biking, heart.data$smoking) #independent predictors

[1] 0.01513618

> hist(heart.data$heart.disease) #normally distributed

> plot(heart.disease ~ biking, data=heart.data) #linearity x ~ y

> plot(heart.disease ~ smoking, data=heart.data) #linearity x ~ y

> #Homoscedasticity or homogeneity of variance will be checked after model building

>

> #Linear Regression Analysis

> heart.disease.lm <- lm(heart.disease ~ biking+smoking, data=heart.data)

> summary(heart.disease.lm)

Call:

lm(formula = heart.disease ~ biking + smoking, data = heart.data)

Residuals:

Min 1Q Median 3Q Max

-2.1789 -0.4463 0.0362 0.4422 1.9331

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 14.984658 0.080137 186.99 <2e-16 \*\*\*

biking -0.200133 0.001366 -146.53 <2e-16 \*\*\*

smoking 0.178334 0.003539 50.39 <2e-16 \*\*\*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.654 on 495 degrees of freedom

Multiple R-squared: 0.9796, Adjusted R-squared: 0.9795

F-statistic: 1.19e+04 on 2 and 495 DF, p-value: < 2.2e-16

> par(mfrow=c(2, 2))

> plot(heart.disease.lm) #Homoscedasticity, Residuals normally distributed

> par(mfrow=c(1, 1))

>

> #Visualize results

> #1. Create a new dataframe with the information needed to plot the model

> plotting.data <- expand.grid(biking=seq(min(heart.data$biking), max(heart.data$biking), length.out=30),

+ smoking=c(min(heart.data$smoking), mean(heart.data$smoking), max(heart.data$smoking)))

> #2. Predict the values of heart disease based on your linear model

> plotting.data$predicted.y <- predict.lm(heart.disease.lm, newdata = plotting.data)

> #3. Round the smoking numbers to two decimals

> plotting.data$smoking <- round(plotting.data$smoking, digits = 2)

> #4. Change the 'smoking' variable into a factor

> plotting.data$smoking <- as.factor(plotting.data$smoking)

> #5. Plot the original data

> heart.plot <- ggplot(heart.data, aes(x=biking, y=heart.disease)) + geom\_point()

> heart.plot

> #6. Add the regression lines

> heart.plot <- heart.plot +

+ geom\_line(data=plotting.data, aes(x=biking, y=predicted.y, color=smoking), size=1.25)

> heart.plot

> #7. Make the graph ready for publication

> heart.plot <-

+ heart.plot +

+ theme\_bw() +

+ labs(title = "Rates of heart disease (% of population) \n as a function of biking to work and smoking",

+ x = "Biking to work (% of population)",

+ y = "Heart disease (% of population)",

+ color = "Smoking \n (% of population)")

> heart.plot

>

> heart.plot + annotate(geom="text", x=30, y=1.75, label=" = 15 + (-0.2\*biking) + (0.178\*smoking)")

**Day 7 – R Programming**

**Class Assessment – Property Price Prediction**

> # In this case study we build a linear regression model

> # We use the model to predict our test data

> # We check the model performance using

> # RMSE metric

> # We demonstrate tests for autocorrelation & heteroskedasticity

> # We demonstrate VIF to detect multicollinearity

>

> library(ggplot2)

> library(dplyr)

> library(broom)

> library(ggpubr)

> # Set your working directory.

> setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models")

>

> #Importing Data

> propertytrainData <- read.csv("PropertyTrainData.csv")

> head(propertytrainData)

Price Sea Area Elevation Sewer Days Flood Distance

1 4.5 1 138.4 10 3000 -103 0 0.3

2 10.6 1 52.0 4 0 -103 0 2.5

3 1.7 0 16.1 0 2640 -98 1 10.3

4 5.0 0 1695.2 1 3500 -93 0 14.0

5 5.0 0 845.0 1 1000 -92 1 14.0

6 3.3 1 6.9 2 10000 -86 0 0.0

> dim(propertytrainData)

[1] 31 8

> summary(propertytrainData)

Price Sea Area Elevation Sewer Days Flood Distance

Min. : 1.70 Min. :0.0000 Min. : 6.90 Min. : 0.000 Min. : 0 Min. :-103.00 Min. :0.0000 Min. : 0.000

1st Qu.: 5.35 1st Qu.:0.0000 1st Qu.: 20.35 1st Qu.: 2.000 1st Qu.: 0 1st Qu.: -63.50 1st Qu.:0.0000 1st Qu.: 0.850

Median :11.70 Median :1.0000 Median : 51.40 Median : 4.000 Median : 900 Median : -59.00 Median :0.0000 Median : 4.900

Mean :11.95 Mean :0.6129 Mean : 139.97 Mean : 4.645 Mean : 1981 Mean : -58.65 Mean :0.1613 Mean : 5.132

3rd Qu.:16.05 3rd Qu.:1.0000 3rd Qu.: 104.10 3rd Qu.: 7.000 3rd Qu.: 3450 3rd Qu.: -51.00 3rd Qu.:0.0000 3rd Qu.: 5.500

Max. :37.20 Max. :1.0000 Max. :1695.20 Max. :20.000 Max. :10000 Max. : -4.00 Max. :1.0000 Max. :16.500

> propertytestData <- read.csv("PropertyTestData.csv")

> head(propertytestData)

Price Sea Area Elevation Sewer Days Flood Distance

1 12 1 1472 20 4811 -36 1 8

2 5 0 1301 1 4070 -79 0 1

3 12 1 39 17 1200 -40 1 4

4 36 0 7 18 3240 -46 0 12

5 2 0 357 7 5619 -88 1 1

6 9 1 686 12 5056 -39 1 12

> dim(propertytestData)

[1] 31 8

> summary(propertytestData)

Price Sea Area Elevation Sewer Days Flood Distance

Min. : 2.00 Min. :0.0000 Min. : 7.0 Min. : 1.00 Min. : 0 Min. :-96.00 Min. :0.0000 Min. : 0.000

1st Qu.: 6.50 1st Qu.:0.0000 1st Qu.: 325.5 1st Qu.: 7.00 1st Qu.:1142 1st Qu.:-77.00 1st Qu.:0.0000 1st Qu.: 2.500

Median : 9.00 Median :0.0000 Median : 657.0 Median :12.00 Median :2814 Median :-49.00 Median :1.0000 Median : 6.000

Mean :11.76 Mean :0.4839 Mean : 733.7 Mean :11.32 Mean :2819 Mean :-55.39 Mean :0.6129 Mean : 6.145

3rd Qu.:16.90 3rd Qu.:1.0000 3rd Qu.:1166.5 3rd Qu.:16.50 3rd Qu.:4273 3rd Qu.:-39.50 3rd Qu.:1.0000 3rd Qu.: 9.500

Max. :36.00 Max. :1.0000 Max. :1556.0 Max. :20.00 Max. :5775 Max. : -7.00 Max. :1.0000 Max. :12.000

>

> #EDA ~ Assumptions

> #Check for normality of dependent variable

> hist(propertytrainData$Price)

> shapiro.test(propertytrainData$Price) #Price is not normality distributed

Shapiro-Wilk normality test

data: propertytrainData$Price

W = 0.90607, p-value = 0.01025

> logPrice <- log(propertytrainData$Price)

> hist(logPrice)

> shapiro.test(logPrice) #Price is now normality distributed (p-value > 0.05)

Shapiro-Wilk normality test

data: logPrice

W = 0.95854, p-value = 0.2668

> propertytrainData$Logprice <- logPrice

> dim(propertytrainData)

[1] 31 9

> names(propertytrainData)

[1] "Price" "Sea" "Area" "Elevation" "Sewer" "Days" "Flood" "Distance" "Logprice"

> summary(propertytrainData)

Price Sea Area Elevation Sewer Days Flood Distance Logprice

Min. : 1.70 Min. :0.0000 Min. : 6.90 Min. : 0.000 Min. : 0 Min. :-103.00 Min. :0.0000 Min. : 0.000 Min. :0.5306

1st Qu.: 5.35 1st Qu.:0.0000 1st Qu.: 20.35 1st Qu.: 2.000 1st Qu.: 0 1st Qu.: -63.50 1st Qu.:0.0000 1st Qu.: 0.850 1st Qu.:1.6750

Median :11.70 Median :1.0000 Median : 51.40 Median : 4.000 Median : 900 Median : -59.00 Median :0.0000 Median : 4.900 Median :2.4596

Mean :11.95 Mean :0.6129 Mean : 139.97 Mean : 4.645 Mean : 1981 Mean : -58.65 Mean :0.1613 Mean : 5.132 Mean :2.2594

3rd Qu.:16.05 3rd Qu.:1.0000 3rd Qu.: 104.10 3rd Qu.: 7.000 3rd Qu.: 3450 3rd Qu.: -51.00 3rd Qu.:0.0000 3rd Qu.: 5.500 3rd Qu.:2.7746

Max. :37.20 Max. :1.0000 Max. :1695.20 Max. :20.000 Max. :10000 Max. : -4.00 Max. :1.0000 Max. :16.500 Max. :3.6163

> #Check Correlation

> cor(propertytrainData[, -1]) #Read all rows, skip 1st column. Use a negative index to skip the column from the left

Sea Area Elevation Sewer Days Flood Distance Logprice

Sea 1.00000000 -0.33944108 0.47517280 -0.05004423 -0.36983885 -0.55180357 -0.74220440 -0.04416109

Area -0.33944108 1.00000000 -0.20945610 0.05338087 -0.34946290 0.10890203 0.55694587 -0.22024015

Elevation 0.47517280 -0.20945610 1.00000000 -0.35940756 -0.05650853 -0.37308077 -0.36246039 0.43335591

Sewer -0.05004423 0.05338087 -0.35940756 1.00000000 -0.15149473 -0.11305464 -0.15865389 -0.46759131

Days -0.36983885 -0.34946290 -0.05650853 -0.15149473 1.00000000 0.01536084 0.04438251 0.62016026

Flood -0.55180357 0.10890203 -0.37308077 -0.11305464 0.01536084 1.00000000 0.42330840 -0.40729809

Distance -0.74220440 0.55694587 -0.36246039 -0.15865389 0.04438251 0.42330840 1.00000000 0.06587072

Logprice -0.04416109 -0.22024015 0.43335591 -0.46759131 0.62016026 -0.40729809 0.06587072 1.00000000

> cormat <- round(cor(propertytrainData[, -1]), 3)

> cormat

Sea Area Elevation Sewer Days Flood Distance Logprice

Sea 1.000 -0.339 0.475 -0.050 -0.370 -0.552 -0.742 -0.044

Area -0.339 1.000 -0.209 0.053 -0.349 0.109 0.557 -0.220

Elevation 0.475 -0.209 1.000 -0.359 -0.057 -0.373 -0.362 0.433

Sewer -0.050 0.053 -0.359 1.000 -0.151 -0.113 -0.159 -0.468

Days -0.370 -0.349 -0.057 -0.151 1.000 0.015 0.044 0.620

Flood -0.552 0.109 -0.373 -0.113 0.015 1.000 0.423 -0.407

Distance -0.742 0.557 -0.362 -0.159 0.044 0.423 1.000 0.066

Logprice -0.044 -0.220 0.433 -0.468 0.620 -0.407 0.066 1.000

> write.csv(cormat, "corrmatrix.csv")

>

> #install.packages("GGally")

> library(GGally)

> GGally::ggpairs(propertytrainData[, -1]) #Pairplot - histogram & lineplot

> # Note we see variables which are faily correlated with log(price)

> # are Elevation, Sewer, Date & Flood

> # Note we also see some of the IVs are also correlated with each other

> # like Elevation & Sea, Distance & Sea, Area & Distance and so on

>

> # Another way to better appreciate the relationship

> # between variables is to look at scatter plot

> # Lets plot log(price) and Date

> plot(propertytrainData$Logprice, propertytrainData$Days)

> plot(propertytrainData$Logprice, propertytrainData$Area)

> #Linear Regression Analysis

> reg\_model <- lm(Logprice ~ ., data = propertytrainData[, -1]) # . refers to rest all variables

> summary(reg\_model)

Call:

lm(formula = Logprice ~ ., data = propertytrainData[, -1])

Residuals:

Min 1Q Median 3Q Max

-0.41605 -0.22833 0.01037 0.22662 0.63418

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 3.099e+00 2.815e-01 11.006 1.22e-10 \*\*\*

Sea -1.596e-01 2.685e-01 -0.594 0.558013

Area -2.578e-04 2.574e-04 -1.002 0.327001

Elevation 5.053e-02 1.754e-02 2.880 0.008448 \*\*

Sewer -8.338e-05 3.066e-05 -2.720 0.012214 \*

Days 1.479e-02 3.577e-03 4.135 0.000403 \*\*\*

Flood -9.819e-01 2.198e-01 -4.468 0.000175 \*\*\*

Distance 4.889e-02 2.496e-02 1.958 0.062407 .

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3258 on 23 degrees of freedom

Multiple R-squared: 0.8416, Adjusted R-squared: 0.7934

F-statistic: 17.46 on 7 and 23 DF, p-value: 8.112e-08

> #White Spaces - Not significant, . - Poorly Significant(0.05-0.1), \* - Average Significance(0.01-0.05), \*\* - Significant(0.001-0.01), \*\*\* - Highly Significant(0-0.001) (in Coefficients)

>

> #New models without Sea, Area

> reg\_model1 <- lm(Logprice ~ Area+Days+Distance+Flood+Elevation+Sewer, data = propertytrainData[, -1])

> summary(reg\_model1)

Call:

lm(formula = Logprice ~ Area + Days + Distance + Flood + Elevation +

Sewer, data = propertytrainData[, -1])

Residuals:

Min 1Q Median 3Q Max

-0.37796 -0.22920 -0.01371 0.20334 0.68359

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 3.006e+00 2.310e-01 13.009 2.31e-12 \*\*\*

Area -2.256e-04 2.482e-04 -0.909 0.37240

Days 1.614e-02 2.729e-03 5.914 4.22e-06 \*\*\*

Distance 5.826e-02 1.908e-02 3.053 0.00547 \*\*

Flood -9.154e-01 1.866e-01 -4.906 5.27e-05 \*\*\*

Elevation 4.992e-02 1.727e-02 2.890 0.00806 \*\*

Sewer -7.653e-05 2.802e-05 -2.731 0.01164 \*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3214 on 24 degrees of freedom

Multiple R-squared: 0.8392, Adjusted R-squared: 0.799

F-statistic: 20.87 on 6 and 24 DF, p-value: 1.978e-08

> reg\_model2 <- lm(Logprice ~ Days+Distance+Flood+Elevation+Sewer, data = propertytrainData[, -1])

> summary(reg\_model2)

Call:

lm(formula = Logprice ~ Days + Distance + Flood + Elevation +

Sewer, data = propertytrainData[, -1])

Residuals:

Min 1Q Median 3Q Max

-0.38511 -0.25256 -0.01794 0.20994 0.72640

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 3.089e+00 2.115e-01 14.603 9.60e-14 \*\*\*

Days 1.724e-02 2.435e-03 7.080 2.02e-07 \*\*\*

Distance 4.784e-02 1.521e-02 3.147 0.00424 \*\*

Flood -8.835e-01 1.826e-01 -4.838 5.66e-05 \*\*\*

Elevation 5.048e-02 1.720e-02 2.934 0.00707 \*\*

Sewer -7.859e-05 2.783e-05 -2.824 0.00919 \*\*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3203 on 25 degrees of freedom

Multiple R-squared: 0.8336, Adjusted R-squared: 0.8003

F-statistic: 25.05 on 5 and 25 DF, p-value: 5.474e-09

>

> library(car)

> car::vif(reg\_model) #Lower the value, relevant is the variable

Sea Area Elevation Sewer Days Flood Distance

4.995597 2.003925 1.649759 1.635122 2.174889 1.907942 3.623612

> car::vif(reg\_model1)

Area Days Distance Flood Elevation Sewer

1.915504 1.300847 2.176858 1.412978 1.644029 1.403977

> car::vif(reg\_model2)

Days Distance Flood Elevation Sewer

1.043122 1.391449 1.363245 1.641901 1.394802

> #property.train1 <- subset(property.train, select=-c(Sea, Distance))

> #head(property.train1)

>

> par(mfrow=c(2, 2))

> plot(reg\_model2) #Homoscedasticity, Residuals normally distributed

> par(mfrow=c(1, 1))

> # Check residual vs fitted plot to check Heteroscedasticity

> # If there is absolutely no heteroscedasticity, you should

> # see a completely random, equal distribution of points

> # throughout the range of X axis and a flat red line.

> # In our case,

> # the red line is slightly curved and the residuals seem to

> # increase as the fitted Y values increase.

> # So, the inference here is, heteroscedasticity exists.

> # Check the Residuals Vs Fitted Curve

>

> # Alternate Check for Breusch-Pagan Test for Heteroscedasticity;

> # Ho: Homoscedasticity (Variance of residuals is constant)

> # Ha: Heteroscedasticity

> #install.packages("lmtest")

> library(lmtest)

> lmtest::bptest(reg\_model)

studentized Breusch-Pagan test

data: reg\_model

BP = 15.953, df = 7, p-value = 0.02555

> lmtest::bptest(reg\_model2)

studentized Breusch-Pagan test

data: reg\_model2

BP = 7.7561, df = 5, p-value = 0.1702

> library(e1071)

> library(caret)

Loading required package: lattice

> # How to rectify?

> # Re-build the model with new predictors.

> # Variable transformation such as Box-Cox transformation can also be tried instead of log price

> # (Normal Distribution).

> boxcoxprice <- caret::BoxCoxTrans(propertytrainData$Price) #Normalizing Price using BoxCox Transformation

> print(boxcoxprice)

Box-Cox Transformation

31 data points used to estimate Lambda

Input data summary:

Min. 1st Qu. Median Mean 3rd Qu. Max.

1.70 5.35 11.70 11.95 16.05 37.20

Largest/Smallest: 21.9

Sample Skewness: 1.03

Estimated Lambda: 0.3

> propertytrainData <- cbind(propertytrainData, Newprice=predict(boxcoxprice, propertytrainData$Price)) #add predicted normalized price column

> head(propertytrainData)

Price Sea Area Elevation Sewer Days Flood Distance Logprice Newprice

1 4.5 1 138.4 10 3000 -103 0 0.3 1.5040774 1.9007725

2 10.6 1 52.0 4 0 -103 0 2.5 2.3608540 3.4348249

3 1.7 0 16.1 0 2640 -98 1 10.3 0.5306283 0.5751964

4 5.0 0 1695.2 1 3500 -93 0 14.0 1.6094379 2.0688553

5 5.0 0 845.0 1 1000 -92 1 14.0 1.6094379 2.0688553

6 3.3 1 6.9 2 10000 -86 0 0.0 1.1939225 1.4357282

> reg\_model22 <- lm(Newprice ~ Days+Distance+Flood+Elevation+Sewer, data = propertytrainData)

> summary(reg\_model22)

Call:

lm(formula = Newprice ~ Days + Distance + Flood + Elevation +

Sewer, data = propertytrainData)

Residuals:

Min 1Q Median 3Q Max

-0.7648 -0.4730 -0.0573 0.4420 1.7239

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 4.944e+00 4.399e-01 11.238 2.89e-11 \*\*\*

Days 3.365e-02 5.064e-03 6.644 5.81e-07 \*\*\*

Distance 9.468e-02 3.162e-02 2.994 0.006128 \*\*

Flood -1.619e+00 3.798e-01 -4.262 0.000252 \*\*\*

Elevation 9.871e-02 3.578e-02 2.759 0.010694 \*

Sewer -1.401e-04 5.789e-05 -2.421 0.023095 \*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.6661 on 25 degrees of freedom

Multiple R-squared: 0.8072, Adjusted R-squared: 0.7686

F-statistic: 20.93 on 5 and 25 DF, p-value: 3.31e-08

> lmtest::bptest(reg\_model22)

studentized Breusch-Pagan test

data: reg\_model22

BP = 4.3918, df = 5, p-value = 0.4945

> plot(reg\_model22)

Hit <Return> to see next plot:

Hit <Return> to see next plot:

Hit <Return> to see next plot:

Hit <Return> to see next plot:

>

> #Autocorrelation: Durbin watson Test

> #H0: No Autocorrelation, Ha: Autocorrelation present

> lmtest::dwtest(reg\_model) #p-vale: 0.74

Durbin-Watson test

data: reg\_model

DW = 2.4103, p-value = 0.7465

alternative hypothesis: true autocorrelation is greater than 0

> lmtest::dwtest(reg\_model1) #p-vale: 0.73

Durbin-Watson test

data: reg\_model1

DW = 2.3327, p-value = 0.7328

alternative hypothesis: true autocorrelation is greater than 0

> lmtest::dwtest(reg\_model2) #p-vale: 0.67

Durbin-Watson test

data: reg\_model2

DW = 2.265, p-value = 0.6728

alternative hypothesis: true autocorrelation is greater than 0

>

> #Fitting the model

> predicted\_salesPrice <- predict(reg\_model2, newdata = propertytrainData)

> predicted\_salesPrice

1 2 3 4 5 6 7 8 9 10 11 12 13

1.5963200 1.6344573 0.8009036 1.9305666 1.2607307 0.9211005 2.1182612 2.1872227 2.9673940 1.5482586 1.5654990 1.8520608 1.9548896

14 15 16 17 18 19 20 21 22 23 24 25 26

2.6858571 2.7772486 2.7411216 2.7002102 2.6088186 2.8468662 2.7145633 2.6327763 2.6588934 2.5390465 1.8259669 1.7226961 3.0131863

27 28 29 30 31

2.5844959 2.8667676 3.0611836 2.4123110 3.3130961

> propertytestData$PredictedPrice <- exp(predicted\_salesPrice)

> write.csv(propertytestData, "predictedresult.csv")

>

> cor(propertytestData$Price, propertytestData$PredictedPrice)

[1] 0.2907895

> plot(propertytestData$Price, propertytestData$PredictedPrice)

>

> #install.packages("Metrics")

> library(Metrics)

> Metrics::rmse(propertytestData$Price, propertytestData$PredictedPrice)

[1] 8.158264

**Day 8 – R Programming**

**Admission Classification – Logistic Regression**

> df <- read.csv("https://stats.idre.ucla.edu/stat/data/binary.csv")

> head(df)

admit gre gpa rank

1 0 380 3.61 3

2 1 660 3.67 3

3 1 800 4.00 1

4 1 640 3.19 4

5 0 520 2.93 4

6 1 760 3.00 2

> str(df)

'data.frame': 400 obs. of 4 variables:

$ admit: int 0 1 1 1 0 1 1 0 1 0 ...

$ gre : int 380 660 800 640 520 760 560 400 540 700 ...

$ gpa : num 3.61 3.67 4 3.19 2.93 3 2.98 3.08 3.39 3.92 ...

$ rank : int 3 3 1 4 4 2 1 2 3 2 ...

> dim(df)

[1] 400 4

> edit(df)

admit gre gpa rank

1 0 380 3.61 3

2 1 660 3.67 3

3 1 800 4.00 1

4 1 640 3.19 4

5 0 520 2.93 4

6 1 760 3.00 2

7 1 560 2.98 1

8 0 400 3.08 2

9 1 540 3.39 3

10 0 700 3.92 2

11 0 800 4.00 4

12 0 440 3.22 1

13 1 760 4.00 1

14 0 700 3.08 2

15 1 700 4.00 1

16 0 480 3.44 3

17 0 780 3.87 4

18 0 360 2.56 3

19 0 800 3.75 2

20 1 540 3.81 1

21 0 500 3.17 3

22 1 660 3.63 2

23 0 600 2.82 4

24 0 680 3.19 4

25 1 760 3.35 2

26 1 800 3.66 1

27 1 620 3.61 1

28 1 520 3.74 4

29 1 780 3.22 2

30 0 520 3.29 1

31 0 540 3.78 4

32 0 760 3.35 3

33 0 600 3.40 3

34 1 800 4.00 3

35 0 360 3.14 1

36 0 400 3.05 2

37 0 580 3.25 1

38 0 520 2.90 3

39 1 500 3.13 2

40 1 520 2.68 3

41 0 560 2.42 2

42 1 580 3.32 2

43 1 600 3.15 2

44 0 500 3.31 3

45 0 700 2.94 2

46 1 460 3.45 3

47 1 580 3.46 2

48 0 500 2.97 4

49 0 440 2.48 4

50 0 400 3.35 3

51 0 640 3.86 3

52 0 440 3.13 4

53 0 740 3.37 4

54 1 680 3.27 2

55 0 660 3.34 3

56 1 740 4.00 3

57 0 560 3.19 3

58 0 380 2.94 3

59 0 400 3.65 2

60 0 600 2.82 4

61 1 620 3.18 2

62 0 560 3.32 4

63 0 640 3.67 3

64 1 680 3.85 3

65 0 580 4.00 3

66 0 600 3.59 2

67 0 740 3.62 4

68 0 620 3.30 1

69 0 580 3.69 1

70 0 800 3.73 1

71 0 640 4.00 3

72 0 300 2.92 4

73 0 480 3.39 4

74 0 580 4.00 2

75 0 720 3.45 4

76 0 720 4.00 3

77 0 560 3.36 3

78 1 800 4.00 3

79 0 540 3.12 1

80 1 620 4.00 1

81 0 700 2.90 4

82 0 620 3.07 2

83 0 500 2.71 2

84 0 380 2.91 4

85 1 500 3.60 3

86 0 520 2.98 2

87 0 600 3.32 2

88 0 600 3.48 2

89 0 700 3.28 1

90 1 660 4.00 2

91 0 700 3.83 2

92 1 720 3.64 1

93 0 800 3.90 2

94 0 580 2.93 2

95 1 660 3.44 2

96 0 660 3.33 2

97 0 640 3.52 4

98 0 480 3.57 2

99 0 700 2.88 2

100 0 400 3.31 3

101 0 340 3.15 3

102 0 580 3.57 3

103 0 380 3.33 4

104 0 540 3.94 3

105 1 660 3.95 2

106 1 740 2.97 2

107 1 700 3.56 1

108 0 480 3.13 2

109 0 400 2.93 3

110 0 480 3.45 2

111 0 680 3.08 4

112 0 420 3.41 4

113 0 360 3.00 3

114 0 600 3.22 1

115 0 720 3.84 3

116 0 620 3.99 3

117 1 440 3.45 2

118 0 700 3.72 2

119 1 800 3.70 1

120 0 340 2.92 3

121 1 520 3.74 2

122 1 480 2.67 2

123 0 520 2.85 3

124 0 500 2.98 3

125 0 720 3.88 3

126 0 540 3.38 4

127 1 600 3.54 1

128 0 740 3.74 4

129 0 540 3.19 2

130 0 460 3.15 4

131 1 620 3.17 2

132 0 640 2.79 2

133 0 580 3.40 2

134 0 500 3.08 3

135 0 560 2.95 2

136 0 500 3.57 3

137 0 560 3.33 4

138 0 700 4.00 3

139 0 620 3.40 2

140 1 600 3.58 1

141 0 640 3.93 2

142 1 700 3.52 4

143 0 620 3.94 4

144 0 580 3.40 3

145 0 580 3.40 4

146 0 380 3.43 3

147 0 480 3.40 2

148 0 560 2.71 3

149 1 480 2.91 1

150 0 740 3.31 1

151 1 800 3.74 1

152 0 400 3.38 2

153 1 640 3.94 2

154 0 580 3.46 3

155 0 620 3.69 3

156 1 580 2.86 4

157 0 560 2.52 2

158 1 480 3.58 1

159 0 660 3.49 2

160 0 700 3.82 3

161 0 600 3.13 2

162 0 640 3.50 2

163 1 700 3.56 2

164 0 520 2.73 2

165 0 580 3.30 2

166 0 700 4.00 1

167 0 440 3.24 4

168 0 720 3.77 3

169 0 500 4.00 3

170 0 600 3.62 3

171 0 400 3.51 3

172 0 540 2.81 3

173 0 680 3.48 3

174 1 800 3.43 2

175 0 500 3.53 4

176 1 620 3.37 2

177 0 520 2.62 2

178 1 620 3.23 3

179 0 620 3.33 3

180 0 300 3.01 3

181 0 620 3.78 3

182 0 500 3.88 4

183 0 700 4.00 2

184 1 540 3.84 2

185 0 500 2.79 4

186 0 800 3.60 2

187 0 560 3.61 3

188 0 580 2.88 2

189 0 560 3.07 2

190 0 500 3.35 2

191 1 640 2.94 2

192 0 800 3.54 3

193 0 640 3.76 3

194 0 380 3.59 4

195 1 600 3.47 2

196 0 560 3.59 2

197 0 660 3.07 3

198 1 400 3.23 4

199 0 600 3.63 3

200 0 580 3.77 4

201 0 800 3.31 3

202 1 580 3.20 2

203 1 700 4.00 1

204 0 420 3.92 4

205 1 600 3.89 1

206 1 780 3.80 3

207 0 740 3.54 1

208 1 640 3.63 1

209 0 540 3.16 3

210 0 580 3.50 2

211 0 740 3.34 4

212 0 580 3.02 2

213 0 460 2.87 2

214 0 640 3.38 3

215 1 600 3.56 2

216 1 660 2.91 3

217 0 340 2.90 1

218 1 460 3.64 1

219 0 460 2.98 1

220 1 560 3.59 2

221 0 540 3.28 3

222 0 680 3.99 3

223 1 480 3.02 1

224 0 800 3.47 3

225 0 800 2.90 2

226 1 720 3.50 3

227 0 620 3.58 2

228 0 540 3.02 4

229 0 480 3.43 2

230 1 720 3.42 2

231 0 580 3.29 4

232 0 600 3.28 3

233 0 380 3.38 2

234 0 420 2.67 3

235 1 800 3.53 1

236 0 620 3.05 2

237 1 660 3.49 2

238 0 480 4.00 2

239 0 500 2.86 4

240 0 700 3.45 3

241 0 440 2.76 2

242 1 520 3.81 1

243 1 680 2.96 3

244 0 620 3.22 2

245 0 540 3.04 1

246 0 800 3.91 3

247 0 680 3.34 2

248 0 440 3.17 2

249 0 680 3.64 3

250 0 640 3.73 3

[ reached 'max' / getOption("max.print") -- omitted 150 rows ]

> sum(is.na(df))

[1] 0

> summary(df)

admit gre gpa rank

Min. :0.0000 Min. :220.0 Min. :2.260 Min. :1.000

1st Qu.:0.0000 1st Qu.:520.0 1st Qu.:3.130 1st Qu.:2.000

Median :0.0000 Median :580.0 Median :3.395 Median :2.000

Mean :0.3175 Mean :587.7 Mean :3.390 Mean :2.485

3rd Qu.:1.0000 3rd Qu.:660.0 3rd Qu.:3.670 3rd Qu.:3.000

Max. :1.0000 Max. :800.0 Max. :4.000 Max. :4.000

> #Mean < 0.5 means more rejection of students for admission then acceptance

> xtabs(~ admit + rank, data = df) #Frequency table

rank

admit 1 2 3 4

0 28 97 93 55

1 33 54 28 12

> df$rank <- as.factor(df$rank)

> logit <- glm(admit ~ gre+gpa+rank, data=df, family="binomial")

> summary(logit)

Call:

glm(formula = admit ~ gre + gpa + rank, family = "binomial",

data = df)

Deviance Residuals:

Min 1Q Median 3Q Max

-1.6268 -0.8662 -0.6388 1.1490 2.0790

Coefficients:

Estimate Std. Error z value Pr(>|z|)

(Intercept) -3.989979 1.139951 -3.500 0.000465 \*\*\*

gre 0.002264 0.001094 2.070 0.038465 \*

gpa 0.804038 0.331819 2.423 0.015388 \*

rank2 -0.675443 0.316490 -2.134 0.032829 \*

rank3 -1.340204 0.345306 -3.881 0.000104 \*\*\*

rank4 -1.551464 0.417832 -3.713 0.000205 \*\*\*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 499.98 on 399 degrees of freedom

Residual deviance: 458.52 on 394 degrees of freedom

AIC: 470.52

Number of Fisher Scoring iterations: 4

> #Predicting raw data

> x <- data.frame(gre=790, gpa=3.8, rank=as.factor(1))

> p <- predict(logit, x)

> p

1

0.85426

> x <- data.frame(gre=600, gpa=3.0, rank=as.factor(3))

> p <- predict(logit, x)

> p

1

-1.559415

**Automatic/Manual Car Classification – Logistic Regression**

> #The in-built data set "mtcars" describes different models of a car with their various engine specifications. In "mtcars" data set, the transmission mode (automatic or manual) is described by the column am which is a binary value (0 or 1). We can create a logistic regression model between the columns "am" and 3 other columns - hp, wt and cyl.

> mtcars

mpg cyl disp hp drat wt qsec vs am gear carb

Mazda RX4 21.0 6 160.0 110 3.90 2.620 16.46 0 1 4 4

Mazda RX4 Wag 21.0 6 160.0 110 3.90 2.875 17.02 0 1 4 4

Datsun 710 22.8 4 108.0 93 3.85 2.320 18.61 1 1 4 1

Hornet 4 Drive 21.4 6 258.0 110 3.08 3.215 19.44 1 0 3 1

Hornet Sportabout 18.7 8 360.0 175 3.15 3.440 17.02 0 0 3 2

Valiant 18.1 6 225.0 105 2.76 3.460 20.22 1 0 3 1

Duster 360 14.3 8 360.0 245 3.21 3.570 15.84 0 0 3 4

Merc 240D 24.4 4 146.7 62 3.69 3.190 20.00 1 0 4 2

Merc 230 22.8 4 140.8 95 3.92 3.150 22.90 1 0 4 2

Merc 280 19.2 6 167.6 123 3.92 3.440 18.30 1 0 4 4

Merc 280C 17.8 6 167.6 123 3.92 3.440 18.90 1 0 4 4

Merc 450SE 16.4 8 275.8 180 3.07 4.070 17.40 0 0 3 3

Merc 450SL 17.3 8 275.8 180 3.07 3.730 17.60 0 0 3 3

Merc 450SLC 15.2 8 275.8 180 3.07 3.780 18.00 0 0 3 3

Cadillac Fleetwood 10.4 8 472.0 205 2.93 5.250 17.98 0 0 3 4

Lincoln Continental 10.4 8 460.0 215 3.00 5.424 17.82 0 0 3 4

Chrysler Imperial 14.7 8 440.0 230 3.23 5.345 17.42 0 0 3 4

Fiat 128 32.4 4 78.7 66 4.08 2.200 19.47 1 1 4 1

Honda Civic 30.4 4 75.7 52 4.93 1.615 18.52 1 1 4 2

Toyota Corolla 33.9 4 71.1 65 4.22 1.835 19.90 1 1 4 1

Toyota Corona 21.5 4 120.1 97 3.70 2.465 20.01 1 0 3 1

Dodge Challenger 15.5 8 318.0 150 2.76 3.520 16.87 0 0 3 2

AMC Javelin 15.2 8 304.0 150 3.15 3.435 17.30 0 0 3 2

Camaro Z28 13.3 8 350.0 245 3.73 3.840 15.41 0 0 3 4

Pontiac Firebird 19.2 8 400.0 175 3.08 3.845 17.05 0 0 3 2

Fiat X1-9 27.3 4 79.0 66 4.08 1.935 18.90 1 1 4 1

Porsche 914-2 26.0 4 120.3 91 4.43 2.140 16.70 0 1 5 2

Lotus Europa 30.4 4 95.1 113 3.77 1.513 16.90 1 1 5 2

Ford Pantera L 15.8 8 351.0 264 4.22 3.170 14.50 0 1 5 4

Ferrari Dino 19.7 6 145.0 175 3.62 2.770 15.50 0 1 5 6

Maserati Bora 15.0 8 301.0 335 3.54 3.570 14.60 0 1 5 8

Volvo 142E 21.4 4 121.0 109 4.11 2.780 18.60 1 1 4 2

> str(mtcars)

'data.frame': 32 obs. of 11 variables:

$ mpg : num 21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 ...

$ cyl : num 6 6 4 6 8 6 8 4 4 6 ...

$ disp: num 160 160 108 258 360 ...

$ hp : num 110 110 93 110 175 105 245 62 95 123 ...

$ drat: num 3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.92 ...

$ wt : num 2.62 2.88 2.32 3.21 3.44 ...

$ qsec: num 16.5 17 18.6 19.4 17 ...

$ vs : num 0 0 1 1 0 1 0 1 1 1 ...

$ am : num 1 1 1 0 0 0 0 0 0 0 ...

$ gear: num 4 4 4 3 3 3 3 4 4 4 ...

$ carb: num 4 4 1 1 2 1 4 2 2 4 ...

> dim(mtcars)

[1] 32 11

> sum(is.na(mtcars))

[1] 0

> summary(mtcars)

mpg cyl disp hp drat wt

Min. :10.40 Min. :4.000 Min. : 71.1 Min. : 52.0 Min. :2.760 Min. :1.513

1st Qu.:15.43 1st Qu.:4.000 1st Qu.:120.8 1st Qu.: 96.5 1st Qu.:3.080 1st Qu.:2.581

Median :19.20 Median :6.000 Median :196.3 Median :123.0 Median :3.695 Median :3.325

Mean :20.09 Mean :6.188 Mean :230.7 Mean :146.7 Mean :3.597 Mean :3.217

3rd Qu.:22.80 3rd Qu.:8.000 3rd Qu.:326.0 3rd Qu.:180.0 3rd Qu.:3.920 3rd Qu.:3.610

Max. :33.90 Max. :8.000 Max. :472.0 Max. :335.0 Max. :4.930 Max. :5.424

qsec vs am gear carb

Min. :14.50 Min. :0.0000 Min. :0.0000 Min. :3.000 Min. :1.000

1st Qu.:16.89 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:3.000 1st Qu.:2.000

Median :17.71 Median :0.0000 Median :0.0000 Median :4.000 Median :2.000

Mean :17.85 Mean :0.4375 Mean :0.4062 Mean :3.688 Mean :2.812

3rd Qu.:18.90 3rd Qu.:1.0000 3rd Qu.:1.0000 3rd Qu.:4.000 3rd Qu.:4.000

Max. :22.90 Max. :1.0000 Max. :1.0000 Max. :5.000 Max. :8.000

> xtabs(~ am + cyl, data=mtcars)

cyl

am 4 6 8

0 3 4 12

1 8 3 2

> table(mtcars$am, mtcars$cyl)

4 6 8

0 3 4 12

1 8 3 2

>

> cars1 <- mtcars[, c("cyl", "hp", "wt", "am")]

> head(cars1)

cyl hp wt am

Mazda RX4 6 110 2.620 1

Mazda RX4 Wag 6 110 2.875 1

Datsun 710 4 93 2.320 1

Hornet 4 Drive 6 110 3.215 0

Hornet Sportabout 8 175 3.440 0

Valiant 6 105 3.460 0

>

> logit <- glm(formula=am ~ cyl+hp+wt, data=cars1, family="binomial")

> summary(logit)

Call:

glm(formula = am ~ cyl + hp + wt, family = "binomial", data = cars1)

Deviance Residuals:

Min 1Q Median 3Q Max

-2.17272 -0.14907 -0.01464 0.14116 1.27641

Coefficients:

Estimate Std. Error z value Pr(>|z|)

(Intercept) 19.70288 8.11637 2.428 0.0152 \*

cyl 0.48760 1.07162 0.455 0.6491

hp 0.03259 0.01886 1.728 0.0840 .

wt -9.14947 4.15332 -2.203 0.0276 \*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 43.2297 on 31 degrees of freedom

Residual deviance: 9.8415 on 28 degrees of freedom

AIC: 17.841

Number of Fisher Scoring iterations: 8

> x <- data.frame(cyl=6, hp=110, wt=3.200)

> p <- predict(logit, x)

> p

1

-3.064753

**Day 9 – R Programming**

**German Credit – Decision Tree**

> setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models")

>

> #Read the data file

> data <- read.csv("german\_credit.csv")

> #Check attributes of data

> str(data)

'data.frame': 1000 obs. of 21 variables:

$ Creditability : int 1 1 1 1 1 1 1 1 1 1 ...

$ Account.Balance : int 1 1 2 1 1 1 1 1 4 2 ...

$ Duration.of.Credit..month. : int 18 9 12 12 12 10 8 6 18 24 ...

$ Payment.Status.of.Previous.Credit: int 4 4 2 4 4 4 4 4 4 2 ...

$ Purpose : int 2 0 9 0 0 0 0 0 3 3 ...

$ Credit.Amount : int 1049 2799 841 2122 2171 2241 3398 1361 1098 3758 ...

$ Value.Savings.Stocks : int 1 1 2 1 1 1 1 1 1 3 ...

$ Length.of.current.employment : int 2 3 4 3 3 2 4 2 1 1 ...

$ Instalment.per.cent : int 4 2 2 3 4 1 1 2 4 1 ...

$ Sex...Marital.Status : int 2 3 2 3 3 3 3 3 2 2 ...

$ Guarantors : int 1 1 1 1 1 1 1 1 1 1 ...

$ Duration.in.Current.address : int 4 2 4 2 4 3 4 4 4 4 ...

$ Most.valuable.available.asset : int 2 1 1 1 2 1 1 1 3 4 ...

$ Age..years. : int 21 36 23 39 38 48 39 40 65 23 ...

$ Concurrent.Credits : int 3 3 3 3 1 3 3 3 3 3 ...

$ Type.of.apartment : int 1 1 1 1 2 1 2 2 2 1 ...

$ No.of.Credits.at.this.Bank : int 1 2 1 2 2 2 2 1 2 1 ...

$ Occupation : int 3 3 2 2 2 2 2 2 1 1 ...

$ No.of.dependents : int 1 2 1 2 1 2 1 2 1 1 ...

$ Telephone : int 1 1 1 1 1 1 1 1 1 1 ...

$ Foreign.Worker : int 1 1 1 2 2 2 2 2 1 1 ...

> #Columns of data

> names(data)

[1] "Creditability" "Account.Balance"

[3] "Duration.of.Credit..month." "Payment.Status.of.Previous.Credit"

[5] "Purpose" "Credit.Amount"

[7] "Value.Savings.Stocks" "Length.of.current.employment"

[9] "Instalment.per.cent" "Sex...Marital.Status"

[11] "Guarantors" "Duration.in.Current.address"

[13] "Most.valuable.available.asset" "Age..years."

[15] "Concurrent.Credits" "Type.of.apartment"

[17] "No.of.Credits.at.this.Bank" "Occupation"

[19] "No.of.dependents" "Telephone"

[21] "Foreign.Worker"

> #Check no. of rows & columns

> dim(data)

[1] 1000 21

> head(data) #First 6 rows

Creditability Account.Balance Duration.of.Credit..month. Payment.Status.of.Previous.Credit Purpose

1 1 1 18 4 2

2 1 1 9 4 0

3 1 2 12 2 9

4 1 1 12 4 0

5 1 1 12 4 0

6 1 1 10 4 0

Credit.Amount Value.Savings.Stocks Length.of.current.employment Instalment.per.cent Sex...Marital.Status

1 1049 1 2 4 2

2 2799 1 3 2 3

3 841 2 4 2 2

4 2122 1 3 3 3

5 2171 1 3 4 3

6 2241 1 2 1 3

Guarantors Duration.in.Current.address Most.valuable.available.asset Age..years. Concurrent.Credits

1 1 4 2 21 3

2 1 2 1 36 3

3 1 4 1 23 3

4 1 2 1 39 3

5 1 4 2 38 1

6 1 3 1 48 3

Type.of.apartment No.of.Credits.at.this.Bank Occupation No.of.dependents Telephone Foreign.Worker

1 1 1 3 1 1 1

2 1 2 3 2 1 1

3 1 1 2 1 1 1

4 1 2 2 2 1 2

5 2 2 2 1 1 2

6 1 2 2 2 1 2

>

> #Make dependent variable Credibility into factor (categorical)

> class(data$Creditability)

[1] "integer"

> data$Creditability <- as.factor(data$Creditability)

> class(data$Creditability)

[1] "factor"

> class(data)

[1] "data.frame"

>

> set.seed(123) #Maintains the state

> #Splitting the data into training 70% and validation 30%

> dt <- sort(sample(nrow(data), nrow(data) \* .7)) #Select 70% random row indices

> train <- data[dt, ] #Selected 70% rows & all the columns

> val <- data[-dt, ] #Not selected rows 30% & all the columns

> #Check no.of rows in training data set

> nrow(train)

[1] 700

> #Check no.of rows in validation data set

> nrow(val)

[1] 300

> #View datasets

> edit(train)

Creditability Account.Balance Duration.of.Credit..month. Payment.Status.of.Previous.Credit Purpose

2 1 1 9 4 0

5 1 1 12 4 0

6 1 1 10 4 0

8 1 1 6 4 0

10 1 2 24 2 3

11 1 1 11 4 0

13 1 1 6 4 3

14 1 2 48 3 10

16 1 1 6 2 3

19 1 2 36 4 3

20 1 4 11 4 0

23 0 2 36 2 5

24 1 2 12 4 4

26 1 2 11 3 3

29 1 4 15 2 0

30 1 3 42 4 1

31 1 3 30 4 3

33 1 4 36 4 0

34 1 4 24 2 3

36 1 1 6 4 0

37 1 4 12 4 0

38 1 4 12 4 3

39 1 4 18 2 1

40 1 4 24 4 1

41 1 4 12 4 5

45 1 2 18 2 6

46 0 1 18 2 0

48 0 4 18 4 6

49 1 4 24 2 0

51 1 4 12 2 0

52 1 3 36 2 3

53 1 4 9 4 0

54 1 4 12 4 3

55 1 4 24 2 1

56 1 1 12 4 3

57 1 4 12 4 3

59 1 4 21 2 3

61 1 4 12 4 0

64 1 4 36 3 0

65 1 1 12 3 0

67 1 4 12 2 3

68 1 4 24 2 3

69 1 2 12 2 3

71 1 2 21 4 2

72 1 4 30 2 3

74 1 4 24 2 2

76 1 2 9 2 2

Credit.Amount Value.Savings.Stocks Length.of.current.employment Instalment.per.cent Sex...Marital.Status

2 2799 1 3 2 3

5 2171 1 3 4 3

6 2241 1 2 1 3

8 1361 1 2 2 3

10 3758 3 1 1 2

11 3905 1 3 2 3

13 1957 1 4 1 2

14 7582 2 1 2 3

16 2647 3 3 2 3

19 2337 1 5 4 3

20 7228 1 3 1 3

23 2384 1 2 4 3

24 1424 1 4 4 3

26 4771 1 4 2 3

29 3556 5 3 3 3

30 4796 1 5 4 3

31 3017 1 5 4 3

33 6614 1 5 4 3

34 1376 3 4 4 2

36 860 1 5 1 2

37 1495 1 5 4 3

38 1934 1 5 2 3

39 3378 5 3 2 3

40 3868 1 5 4 2

41 996 5 4 4 2

45 1239 5 3 4 3

46 1216 1 2 4 2

48 1864 2 3 4 2

49 1474 2 2 4 4

51 640 1 3 4 1

52 3919 1 3 2 3

53 1224 1 3 3 3

54 2331 5 5 1 3

55 6313 5 5 3 3

56 385 1 4 4 2

57 1655 1 5 2 3

59 3160 5 5 4 3

61 1163 3 3 4 3

64 10875 1 5 2 3

65 1344 1 3 4 3

67 3077 1 3 2 3

68 2284 1 4 4 3

69 1567 1 3 1 2

71 2745 4 4 3 3

72 1867 5 5 4 3

74 929 5 4 4 3

76 2030 5 4 2 3

Guarantors Duration.in.Current.address Most.valuable.available.asset Age..years. Concurrent.Credits

2 1 2 1 36 3

5 1 4 2 38 1

6 1 3 1 48 3

8 1 4 1 40 3

10 1 4 4 23 3

11 1 2 1 36 3

13 1 4 3 31 3

14 1 4 4 31 3

16 1 3 1 44 3

19 1 4 1 36 3

20 1 4 2 39 3

23 1 1 4 33 3

24 1 3 2 26 3

26 1 4 2 51 3

29 1 2 4 29 3

30 1 4 4 56 3

31 1 4 2 47 3

33 1 4 3 34 3

34 1 1 3 28 3

36 1 4 4 39 3

37 1 1 1 38 3

38 1 2 4 26 3

39 1 1 2 31 3

40 1 2 3 41 3

41 1 4 1 23 3

45 1 4 4 61 3

46 1 3 3 23 3

48 1 2 1 30 3

49 1 3 1 33 3

51 1 2 1 49 3

52 1 2 1 23 3

53 1 1 1 30 3

54 2 4 1 49 3

55 1 4 3 41 3

56 1 3 1 58 3

57 1 4 1 63 3

59 1 3 2 41 3

61 1 4 1 44 3

64 1 2 3 45 3

65 1 2 1 43 3

67 1 4 3 52 3

68 1 2 3 28 3

69 1 1 3 22 3

71 1 2 3 32 3

72 1 4 3 58 3

74 1 2 3 31 2

76 1 1 3 24 3

Type.of.apartment No.of.Credits.at.this.Bank Occupation No.of.dependents Telephone Foreign.Worker

2 1 2 3 2 1 1

5 2 2 2 1 1 2

6 1 2 2 2 1 2

8 2 1 2 2 1 2

10 1 1 1 1 1 1

11 1 2 3 2 1 1

13 2 1 3 1 1 1

14 2 1 4 1 2 1

16 1 1 3 2 1 1

19 2 1 3 1 1 1

20 2 2 2 1 1 1

23 1 1 2 1 1 1

24 2 1 3 1 1 1

26 2 1 3 1 1 1

29 2 1 3 1 1 1

30 3 1 3 1 1 1

31 2 1 3 1 1 1

33 2 2 4 1 2 1

34 2 1 3 1 1 1

36 2 2 3 1 2 1

37 2 2 2 2 1 1

38 2 2 3 1 1 1

39 2 1 3 1 2 1

40 1 2 4 1 2 1

41 2 2 3 1 1 1

45 3 1 3 1 1 1

46 1 1 3 1 2 1

48 2 2 3 1 1 1

49 2 1 3 1 2 1

51 2 1 2 1 1 1

52 2 1 3 1 2 1

53 2 2 3 1 1 1

54 2 1 3 1 2 1

55 2 1 4 2 2 1

56 2 4 2 1 2 1

57 2 2 2 1 2 1

59 2 1 3 1 2 1

61 2 1 3 1 2 1

64 2 2 3 2 2 1

65 2 2 2 2 1 1

67 2 1 3 1 2 1

68 2 1 3 1 2 1

69 2 1 3 1 2 1

71 2 2 3 1 2 1

72 2 1 3 1 2 1

74 2 1 3 1 2 1

76 2 1 3 1 2 1

[ reached 'max' / getOption("max.print") -- omitted 653 rows ]

> edit(val)

Creditability Account.Balance Duration.of.Credit..month. Payment.Status.of.Previous.Credit Purpose

1 1 1 18 4 2

3 1 2 12 2 9

4 1 1 12 4 0

7 1 1 8 4 0

9 1 4 18 4 3

12 1 1 30 4 1

15 1 1 18 2 3

17 1 1 11 4 0

18 1 2 18 2 3

21 1 1 6 4 0

22 1 2 12 4 0

25 1 1 6 4 0

27 1 1 12 2 2

28 1 2 9 4 3

32 1 4 36 4 0

35 1 1 15 2 0

42 1 1 24 2 10

43 1 4 18 4 0

44 1 2 24 4 9

47 1 4 24 2 9

50 1 1 24 4 9

58 1 1 15 2 3

60 1 4 36 2 0

62 1 4 24 2 1

63 1 4 48 4 3

66 1 4 6 4 3

70 1 4 24 3 0

73 1 4 36 2 3

75 1 3 12 2 3

77 1 4 21 4 1

82 1 4 36 4 3

86 1 1 12 2 0

92 1 2 30 2 3

93 1 2 30 0 9

97 1 2 12 4 3

99 1 1 9 2 2

101 1 4 24 4 2

102 1 1 15 2 9

103 1 2 24 3 9

107 1 4 12 4 9

109 1 4 24 2 3

112 1 1 6 2 2

114 1 4 12 2 2

123 1 2 6 2 3

126 1 4 24 4 3

133 1 3 6 2 2

140 1 3 24 4 3

Credit.Amount Value.Savings.Stocks Length.of.current.employment Instalment.per.cent Sex...Marital.Status

1 1049 1 2 4 2

3 841 2 4 2 2

4 2122 1 3 3 3

7 3398 1 4 1 3

9 1098 1 1 4 2

12 6187 2 4 1 4

15 1936 5 4 2 4

17 3939 1 3 1 3

18 3213 3 2 1 4

21 3676 1 3 1 3

22 3124 1 2 1 3

25 4716 5 2 1 3

27 652 1 5 4 2

28 1154 1 5 2 3

32 3535 1 4 4 3

35 1721 1 2 2 3

42 1755 1 5 4 2

43 1028 1 3 4 2

44 2825 5 4 4 3

47 1258 1 4 4 3

50 1382 2 4 4 3

58 1053 1 2 4 4

60 3079 5 3 4 3

62 2679 1 2 4 2

63 3578 5 5 4 3

66 1237 2 3 1 2

70 2032 1 5 4 3

73 2299 3 5 4 3

75 3399 5 5 2 3

77 3275 1 5 1 3

82 3342 5 5 4 3

86 3651 4 3 1 3

92 2991 5 5 2 2

93 4221 1 3 2 2

97 3573 1 3 1 2

99 2136 1 3 3 3

101 3777 4 3 4 3

102 806 1 3 4 2

103 4712 5 3 4 3

107 1412 1 3 4 2

109 1533 1 2 4 2

112 428 1 5 2 2

114 763 1 3 4 2

123 2063 1 2 4 4

126 5103 1 2 3 4

133 2116 1 3 2 3

140 3148 5 3 3 3

Guarantors Duration.in.Current.address Most.valuable.available.asset Age..years. Concurrent.Credits

1 1 4 2 21 3

3 1 4 1 23 3

4 1 2 1 39 3

7 1 4 1 39 3

9 1 4 3 65 3

12 1 4 3 24 3

15 1 4 3 23 3

17 1 2 1 40 3

18 1 3 1 25 3

21 1 3 1 37 3

22 1 3 1 49 1

25 1 3 1 44 3

27 1 4 2 24 3

28 1 4 1 37 3

32 1 4 3 37 3

35 1 3 1 36 3

42 3 4 1 58 3

43 1 3 1 36 3

44 1 3 4 34 3

47 1 1 1 25 3

50 1 1 1 26 3

58 1 2 1 27 3

60 1 4 1 36 3

62 1 1 4 29 3

63 1 1 1 47 3

66 1 1 2 27 3

70 1 4 4 60 3

73 1 4 3 39 3

75 1 3 3 37 3

77 1 4 3 36 3

82 1 2 3 51 3

86 1 3 2 31 3

92 1 4 3 25 3

93 1 1 3 28 3

97 1 1 1 23 3

99 1 2 1 25 3

101 1 4 1 40 3

102 1 4 2 22 3

103 1 2 2 34 1

107 3 2 1 29 3

109 1 3 3 38 2

112 1 1 2 49 1

114 1 1 1 26 3

123 1 3 3 30 3

126 1 3 4 47 3

133 1 2 1 41 3

140 1 2 3 31 3

Type.of.apartment No.of.Credits.at.this.Bank Occupation No.of.dependents Telephone Foreign.Worker

1 1 1 3 1 1 1

3 1 1 2 1 1 1

4 1 2 2 2 1 2

7 2 2 2 1 1 2

9 2 2 1 1 1 1

12 1 2 3 1 1 1

15 1 2 2 1 1 1

17 2 2 2 2 1 1

18 1 1 3 1 1 1

21 1 3 3 2 1 1

22 2 2 2 2 1 1

25 2 2 2 2 1 1

27 1 1 3 1 1 1

28 2 3 2 1 1 1

32 2 2 3 1 2 1

35 2 1 3 1 1 1

42 2 1 2 1 2 1

43 2 2 3 1 1 1

44 2 2 3 2 2 1

47 2 1 3 1 2 1

50 2 2 3 1 2 1

58 2 1 3 1 1 2

60 2 1 3 1 1 1

62 2 1 4 1 2 1

63 2 1 3 1 2 1

66 2 2 3 1 1 1

70 3 2 3 1 2 1

73 2 1 3 1 1 1

75 2 1 4 1 1 1

77 2 1 4 1 2 1

82 2 1 3 1 2 1

86 2 1 3 2 1 1

92 2 1 3 1 1 1

93 2 2 3 1 1 1

97 2 1 2 1 1 1

99 2 1 3 1 1 1

101 2 1 3 1 2 1

102 2 1 2 1 1 1

103 2 2 4 1 2 1

107 2 2 4 1 2 1

109 2 1 3 1 2 1

112 2 1 3 1 2 1

114 2 1 3 1 2 1

123 1 1 4 1 2 1

126 3 3 3 1 2 1

133 2 1 3 1 2 1

140 2 2 3 1 2 1

[ reached 'max' / getOption("max.print") -- omitted 253 rows ]

>

> #Decision Tree model

> library(rpart)

> mtree <- rpart(Creditability ~ ., data=train, method="class",

+ control=rpart.control(minsplit=20, minbucket=7, maxdepth=10, usesurrogate=2, xval=10))

> #xval = no. of cross validation

> #rpart.control to group multiple parameters

> #method="class" for classification

> #usesurrogate dealing with missing values

> mtree

n= 700

node), split, n, loss, yval, (yprob)

\* denotes terminal node

1) root 700 205 1 (0.29285714 0.70714286)

2) Account.Balance< 2.5 375 168 1 (0.44800000 0.55200000)

4) Duration.of.Credit..month.>=22.5 160 69 0 (0.56875000 0.43125000)

8) Value.Savings.Stocks< 3.5 134 50 0 (0.62686567 0.37313433)

16) Age..years.< 26.5 37 8 0 (0.78378378 0.21621622) \*

17) Age..years.>=26.5 97 42 0 (0.56701031 0.43298969)

34) Instalment.per.cent>=2.5 66 22 0 (0.66666667 0.33333333) \*

35) Instalment.per.cent< 2.5 31 11 1 (0.35483871 0.64516129) \*

9) Value.Savings.Stocks>=3.5 26 7 1 (0.26923077 0.73076923) \*

5) Duration.of.Credit..month.< 22.5 215 77 1 (0.35813953 0.64186047)

10) Payment.Status.of.Previous.Credit< 1.5 15 3 0 (0.80000000 0.20000000) \*

11) Payment.Status.of.Previous.Credit>=1.5 200 65 1 (0.32500000 0.67500000)

22) Guarantors< 1.5 169 62 1 (0.36686391 0.63313609)

44) Payment.Status.of.Previous.Credit< 2.5 109 50 1 (0.45871560 0.54128440)

88) Credit.Amount< 971 23 7 0 (0.69565217 0.30434783)

176) Most.valuable.available.asset>=1.5 13 0 0 (1.00000000 0.00000000) \*

177) Most.valuable.available.asset< 1.5 10 3 1 (0.30000000 0.70000000) \*

89) Credit.Amount>=971 86 34 1 (0.39534884 0.60465116)

178) Value.Savings.Stocks< 1.5 50 25 0 (0.50000000 0.50000000)

356) Credit.Amount< 1354.5 15 4 0 (0.73333333 0.26666667) \*

357) Credit.Amount>=1354.5 35 14 1 (0.40000000 0.60000000) \*

179) Value.Savings.Stocks>=1.5 36 9 1 (0.25000000 0.75000000) \*

45) Payment.Status.of.Previous.Credit>=2.5 60 12 1 (0.20000000 0.80000000) \*

23) Guarantors>=1.5 31 3 1 (0.09677419 0.90322581) \*

3) Account.Balance>=2.5 325 37 1 (0.11384615 0.88615385) \*

> #Plot tree

> plot(mtree)

> text(mtree) #Add text to the plot

>

> #Beautify tree

> #install.packages("rattle")

> library(RColorBrewer)

> library(rattle)

> library(rpart.plot)

> #view1

> prp(mtree, faclen=0, cex=0.8, extra=1)

> #faclen = Length of factor level names in splits

> #cex = text size

> #extra = Number of obs. that fall in the node

> #view2 - total count of each node

> tot\_count <- function(x, labs, digits, varlen) {

+ paste(labs, "\n\nn=", x$frame$n)

+ }

> prp(mtree, faclen=0, cex=0.8, node.fun=tot\_count)

> #node.fun - function generates the text at the node labels

> #Pruning

> printcp(mtree) #Provides optimal pruning based on cp value. Select one with small cross validated error(xerror).

Classification tree:

rpart(formula = Creditability ~ ., data = train, method = "class",

control = rpart.control(minsplit = 20, minbucket = 7, maxdepth = 10,

usesurrogate = 2, xval = 10))

Variables actually used in tree construction:

[1] Account.Balance Age..years. Credit.Amount Duration.of.Credit..month.

[5] Guarantors Instalment.per.cent Most.valuable.available.asset Payment.Status.of.Previous.Credit

[9] Value.Savings.Stocks

Root node error: 205/700 = 0.29286

n= 700

CP nsplit rel error xerror xstd

1 0.053659 0 1.00000 1.00000 0.058732

2 0.043902 3 0.83415 1.00000 0.058732

3 0.021951 4 0.79024 1.00000 0.058732

4 0.014634 6 0.74634 0.98537 0.058477

5 0.010000 12 0.64878 0.92683 0.057393

> bestcp <- mtree$cptable[which.min(mtree$cptable[,"xerror"]), "CP"]

> bestcp

[1] 0.01

> #Prune the tree using best cp

> pruned <- prune(mtree, cp=bestcp)

> #Plot pruned tree

> prp(pruned, faclen=0, cex=0.8, extra=1)

>

> #Confusion matrix (training data)

> conf.matrix <- table(train$Creditability, predict(pruned, type="class"))

> rownames(conf.matrix) <- paste("Actual", rownames(conf.matrix), sep = ":")

> colnames(conf.matrix) <- paste("Pred", colnames(conf.matrix), sep = ":")

> print(conf.matrix)

Pred:0 Pred:1

Actual:0 109 96

Actual:1 37 458

> accuracy\_test <- sum(diag(conf.matrix)) /sum(conf.matrix)

> accuracy\_test

[1] 0.81

**Day 10 – R Programming**

**Iris – Random Forest**

> #Load dataset

> data("iris")

> #Structure

> str(iris)

'data.frame': 150 obs. of 5 variables:

$ Sepal.Length: num 5.1 4.9 4.7 4.6 5 5.4 4.6 5 4.4 4.9 ...

$ Sepal.Width : num 3.5 3 3.2 3.1 3.6 3.9 3.4 3.4 2.9 3.1 ...

$ Petal.Length: num 1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1.5 ...

$ Petal.Width : num 0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0.1 ...

$ Species : Factor w/ 3 levels "setosa","versicolor",..: 1 1 1 1 1 1 1 1 1 1 ...

> 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

> #Installing packages

> #install.packages("caTools") #For sampling dataset

> #install.packages("randomForest") #For implementing Random Forest Algorithm

> #Loading packages

> library(caTools)

> library(randomForest)

>

> #Splitting data in train and test data

> dim(iris)

[1] 150 5

> split <- sample.split(iris, SplitRatio = 0.7)

> split

[1] FALSE FALSE TRUE TRUE TRUE

> train <- subset(iris, split == "TRUE")

> dim(train)

[1] 90 5

> test <- subset(iris, split == "FALSE")

> dim(test)

[1] 60 5

> #Fitting Random Forest to train dataset

> set.seed(120)

> classifier\_RF = randomForest(x=train[-5], y=train$Species, ntree=500) #First 4 columns as features, Species as dependent variable

> classifier\_RF

Call:

randomForest(x = train[-5], y = train$Species, ntree = 500)

Type of random forest: classification

Number of trees: 500

No. of variables tried at each split: 2

OOB estimate of error rate: 5.56%

Confusion matrix:

setosa versicolor virginica class.error

setosa 30 0 0 0.00000000

versicolor 0 27 3 0.10000000

virginica 0 2 28 0.06666667

>

> #Predicting the Test set results

> y\_pred = predict(classifier\_RF, newdata=test[-5])

> #Confusion Matrix

> confusion\_mtx <- table(test[, 5], y\_pred)

> confusion\_mtx

y\_pred

setosa versicolor virginica

setosa 20 0 0

versicolor 0 19 1

virginica 0 1 19

> #Plotting the model

> plot(classifier\_RF)

> #Important features

> importance(classifier\_RF)

MeanDecreaseGini

Sepal.Length 4.778206

Sepal.Width 2.705124

Petal.Length 27.798137

Petal.Width 24.011866

> #Variable importance plot

> varImpPlot(classifier\_RF)

**R Programming Exercise:**

> #1. Execute the following lines which create two vectors of random integers which are chosen with

> #replacement from the integers 0, 1, : : : , 999. Both vectors have length 250.

> set.seed(100)

> x <- sample(0:999, 250, replace=T)

> y <- sample(0:999, 250, replace=T)

> x

[1] 713 502 357 623 984 717 918 469 965 515 822 837 97 902 6 182 298 503 465 956 907 994 306 455 145 792 257 434 323 67 509 947 559 287 340 346 166 376 783 970 627 449 965 604 300 669 157 732 86 606 864 222 924 731 250

[56] 542 693 424 488 296 501 919 170 518 702 448 392 997 659 909 362 845 599 386 877 419 370 882 922 429 954 941 253 964 46 438 942 707 11 946 120 15 951 405 977 948 642 132 555 852 155 947 756 280 553 654 184 297 843 420

[111] 665 489 870 791 395 136 249 362 566 842 702 290 313 537 232 47 254 847 117 36 221 730 657 327 90 583 193 146 862 662 843 793 260 758 333 295 878 848 843 221 999 447 222 693 169 386 741 335 729 421 727 426 722 899 713

[166] 493 817 779 894 315 812 363 804 489 963 99 200 921 282 926 941 70 660 550 987 704 271 81 647 393 708 470 669 209 480 710 457 176 227 129 650 46 113 0 713 799 456 124 632 268 317 394 99 441 909 249 169 915 575 718

[221] 14 275 689 127 748 558 182 401 893 613 472 52 851 522 204 917 598 307 639 934 926 333 228 971 813 984 228 447 491 506

> y

[1] 658 650 971 659 841 301 337 667 527 324 134 976 695 164 371 246 839 998 969 260 851 875 466 45 115 531 721 823 448 803 505 805 183 554 394 572 402 629 425 525 382 825 877 514 554 475 391 953 331 659 566 208 114 792 490

[56] 559 681 303 550 219 895 702 518 552 509 762 350 18 176 353 944 129 636 465 693 55 139 382 291 904 128 86 110 396 694 810 296 326 618 75 324 964 980 572 719 953 460 223 37 373 903 684 236 97 162 716 220 902 897 614

[111] 694 232 638 823 584 174 903 922 27 11 106 678 643 118 810 295 751 145 624 358 217 323 400 119 754 908 354 975 22 736 792 84 1 405 326 567 267 128 81 844 945 388 423 983 702 82 288 339 488 129 734 958 295 893 804

[166] 655 639 365 946 20 626 633 401 684 246 886 13 608 556 132 370 399 369 696 25 164 640 186 321 996 173 231 916 348 196 307 591 592 595 955 30 752 885 487 680 515 261 508 78 975 897 287 871 276 697 212 628 12 272 280

[221] 75 730 302 329 617 466 848 536 282 815 986 811 137 697 116 325 247 669 646 97 575 595 759 193 213 470 422 900 473 782

> #(a) Identify out the values in y which are > 500.

> y[y > 500]

[1] 658 650 971 659 841 667 527 976 695 839 998 969 851 875 531 721 823 803 505 805 554 572 629 525 825 877 514 554 953 659 566 792 559 681 550 895 702 518 552 509 762 944 636 693 904 694 810 618 964 980 572 719 953 903 684

[56] 716 902 897 614 694 638 823 584 903 922 678 643 810 751 624 754 908 975 736 792 567 844 945 983 702 734 958 893 804 655 639 946 626 633 684 886 608 556 696 640 996 916 591 592 595 955 752 885 680 515 508 975 897 871 697

[111] 628 730 617 848 536 815 986 811 697 669 646 575 595 759 900 782

> #(b) Identify the index positions in y of the values which are > 700?

> which(y > 700)

[1] 3 5 12 17 18 19 21 22 27 28 30 32 42 43 48 54 61 62 66 71 80 86 92 93 95 96 101 106 108 109 114 117 118 125 127 135 136 138 140 141 150 151 154 155 161 162 164 165 169 176 190 193 200 202 203

[56] 210 211 213 222 227 230 231 232 243 248 250

> #(c) What are the values in x which are in same index position to the values in y which are > 400?

> y1 <- which(y > 400)

> y1

[1] 1 2 3 4 5 8 9 12 13 17 18 19 21 22 23 26 27 28 29 30 31 32 34 36 37 38 39 40 42 43 44 45 46 48 50 51 54 55 56 57 59 61 62 63 64 65 66 71 73 74 75 80 85 86 89

[56] 92 93 94 95 96 97 101 102 106 108 109 110 111 113 114 115 117 118 122 123 125 127 129 135 136 138 140 141 144 146 150 151 153 154 155 159 161 162 164 165 166 167 169 171 172 173 174 176 178 179 184 187 190 193 197

[111] 198 199 200 202 203 204 205 206 208 210 211 213 215 217 222 225 226 227 228 230 231 232 234 238 239 241 242 243 246 247 248 249 250

> x[y1]

[1] 713 502 357 623 984 469 965 837 97 298 503 465 907 994 306 792 257 434 323 67 509 947 287 346 166 376 783 970 449 965 604 300 669 732 606 864 731 250 542 693 488 501 919 170 518 702 448 362 599 386 877 429 46 438 11

[56] 15 951 405 977 948 642 155 947 654 297 843 420 665 870 791 395 249 362 290 313 232 254 117 90 583 146 662 843 758 295 221 999 222 693 169 729 727 426 899 713 493 817 894 812 363 804 489 99 921 282 550 271 393 669 457

[111] 176 227 129 46 113 0 713 799 124 268 317 99 909 169 275 748 558 182 401 613 472 52 522 307 639 926 333 228 984 228 447 491 506

> #(d) How many values in y are within 200 of the maximum value of the terms in y?

> count <-length(which(y <= 200))

> count

[1] 48

> #(e) How many numbers in x are divisible by 2?

> n <- length(x[x%%2 == 0])

> n

[1] 119

> #(f) Sort the numbers in the vector x in the order of increasing values in y.

> y2 <- order(y)

> y2

[1] 143 120 218 177 68 170 139 185 119 201 99 24 76 90 221 209 149 156 142 82 104 240 121 83 53 25 235 124 134 81 148 72 160 180 11 233 77 128 105 14 186 191 116 69 33 188 244 195 52 216 245 131 60 107 98

[56] 192 112 103 16 175 237 20 207 147 219 214 220 229 212 157 79 126 163 87 6 223 58 196 189 132 10 91 236 88 145 224 49 7 158 194 67 70 137 130 168 183 181 15 100 41 78 152 47 35 84 182 133 173 37 144

[111] 247 153 39 29 97 74 23 226 246 249 46 204 159 55 31 208 65 44 206 63 40 9 26 228 59 64 34 45 179 56 51 146 36 94 241 115 197 198 199 242 178 110 225 89 129 171 217 38 172 73 113 167 187 123 239

[166] 2 166 1 4 50 8 238 122 205 57 102 174 75 85 111 13 184 215 234 62 155 106 95 27 222 161 140 127 202 135 243 66 250 54 141 30 165 32 86 125 232 230 28 114 42 17 5 150 227 21 213 22 43 203 176

[221] 164 61 109 211 248 108 101 117 80 136 193 118 71 151 169 48 96 200 162 92 19 3 138 210 12 93 154 231 190 18

> x[y2]

[1] 260 842 915 200 997 315 862 987 566 650 555 455 419 946 14 632 843 386 793 941 280 934 702 253 924 145 204 537 327 954 848 845 421 926 822 851 370 847 553 902 704 708 136 659 559 81 971 480 222 249 813 221 296 184 132

[56] 470 489 756 182 963 598 956 456 878 575 441 718 893 394 741 922 47 722 942 717 689 424 710 647 730 515 120 917 707 333 127 86 918 335 209 392 909 193 36 779 660 941 6 852 627 882 447 157 340 964 70 657 804 166 758

[111] 228 222 783 323 642 386 306 558 984 491 669 0 729 250 509 124 702 604 799 170 970 965 792 401 488 518 287 300 282 542 864 295 346 405 926 395 457 176 227 333 921 420 748 11 117 812 169 376 363 599 870 817 271 313 639

[166] 502 493 713 623 606 469 307 290 713 693 947 489 877 46 665 97 550 909 522 919 169 654 977 257 275 727 662 254 46 90 228 448 506 731 843 67 713 947 438 232 52 613 434 791 449 298 984 221 182 907 99 994 965 113 99

[221] 899 501 843 317 447 297 155 249 429 583 669 362 362 999 894 732 948 129 426 15 465 357 146 268 837 951 693 472 393 503

>

> #2. Use the function paste to create the following character vectors of length 30:

> #(a) ("Label 1", "Label 2", ....., "Label 30").

> #\*Note that there is a single space between label and the number following.

> v <- c(1:30)

> v

[1] 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

> paste("Label", v)

[1] "Label 1" "Label 2" "Label 3" "Label 4" "Label 5" "Label 6" "Label 7" "Label 8" "Label 9" "Label 10" "Label 11" "Label 12" "Label 13" "Label 14" "Label 15" "Label 16" "Label 17" "Label 18" "Label 19" "Label 20"

[21] "Label 21" "Label 22" "Label 23" "Label 24" "Label 25" "Label 26" "Label 27" "Label 28" "Label 29" "Label 30"

> #(b) ("FN1", "FN2", ..., "FN30").

> #\*\*In this case, there is no space between fn and the number following.

> paste("FN", v, sep="")

[1] "FN1" "FN2" "FN3" "FN4" "FN5" "FN6" "FN7" "FN8" "FN9" "FN10" "FN11" "FN12" "FN13" "FN14" "FN15" "FN16" "FN17" "FN18" "FN19" "FN20" "FN21" "FN22" "FN23" "FN24" "FN25" "FN26" "FN27" "FN28" "FN29" "FN30"

>

> #3. Compound interest can be computed using the formula

> #A = P × (1 + R/100)n, where P is the original money lent, A is what it amounts to in n years at R

> #percent per year interest.

> #Write R code to calculate the amount of money owed after n years, where n changes from 1 to 15 in yearly increments, if the money lent originally is 10000 Rupees and the interest rate remains constant throughout the period at 11.5%.

> P <- 10000

> R <- 11.5

> n <- 1

> for(i in 1:15) {

+ A <- P \* (1 + (R / 100)) \* n

+ P <- A

+ cat("For ", n, " year(s), A = ", A, "\n")

+ }

For 1 year(s), A = 11150

For 1 year(s), A = 12432.25

For 1 year(s), A = 13861.96

For 1 year(s), A = 15456.08

For 1 year(s), A = 17233.53

For 1 year(s), A = 19215.39

For 1 year(s), A = 21425.16

For 1 year(s), A = 23889.05

For 1 year(s), A = 26636.29

For 1 year(s), A = 29699.47

For 1 year(s), A = 33114.91

For 1 year(s), A = 36923.12

For 1 year(s), A = 41169.28

For 1 year(s), A = 45903.75

For 1 year(s), A = 51182.68

>

> #4. Generate the following matrices.

> #[,1] [,2] [,3] [,4]

> #[1,] 1 101 201 301

> #[2,] 2 102 202 302

> #[3,] 3 103 203 303

> #[4,] 4 104 204 304

> #[5,] 5 105 205 305

> v <- c(1:5, 101:105, 201:205, 301:305)

> v

[1] 1 2 3 4 5 101 102 103 104 105 201 202 203 204 205 301 302 303 304 305

> matrix(v, nrow = 5)

[,1] [,2] [,3] [,4]

[1,] 1 101 201 301

[2,] 2 102 202 302

[3,] 3 103 203 303

[4,] 4 104 204 304

[5,] 5 105 205 305

>

> #5. Create a 6 by 10 matrix of random integers chosen from 1 to 10 by executing the following two lines of code:

> set.seed(100)

> GMAT <- matrix(sample(10, size=60, replace=T), nr=6)

> GMAT

[,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]

[1,] 10 7 2 3 3 9 6 7 3 7

[2,] 7 6 7 3 4 4 9 1 4 4

[3,] 6 6 7 8 4 2 9 9 3 3

[4,] 3 4 7 2 4 6 9 6 3 9

[5,] 9 7 8 9 5 7 6 4 4 8

[6,] 10 6 2 2 7 1 8 8 5 6

> #(a) Find the number of entries in each row which are greater than 4.

> apply(GMAT, 1, function(x) { sum(x > 4) })

[1] 6 4 6 5 8 7

> #(b) Which rows contain exactly two occurrences of the number seven?

> which(apply(GMAT, 1, function(x) { sum(x == 7) == 2 }))

[1] 2 5

> #(c) Find those pairs of columns whose total (over both columns) is >= 50. The answer should be a matrix with two columns.

> n <- ncol(GMAT) - 1

> n

[1] 9

> m <- matrix(ncol=2)

> s <- sapply(1:n, function(x) {

+ if(sum(GMAT[,x]) + sum(GMAT[,x + 1]) >= 50) {

+ c(x, x + 1)

+

+ }

+

+ })

> t(s)

[,1] [,2]

[1,] 1 2

[2,] 2 3

[3,] 3 4

[4,] 4 5

[5,] 5 6

[6,] 6 7

[7,] 7 8

[8,] 8 9

[9,] 9 10

**Day 11 – R Programming**

**Iris – KNearestNeighbors**

> #Load data

> df <- iris

> head(df)

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

> str(df)

'data.frame': 150 obs. of 5 variables:

$ Sepal.Length: num 5.1 4.9 4.7 4.6 5 5.4 4.6 5 4.4 4.9 ...

$ Sepal.Width : num 3.5 3 3.2 3.1 3.6 3.9 3.4 3.4 2.9 3.1 ...

$ Petal.Length: num 1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1.5 ...

$ Petal.Width : num 0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0.1 ...

$ Species : Factor w/ 3 levels "setosa","versicolor",..: 1 1 1 1 1 1 1 1 1 1 ...

> dim(df)

[1] 150 5

>

> #Generate a random number that is 90% of the total no. of rows in dataset

> ran <- sample(1:nrow(df), 0.9 \* nrow(df))

> ran

[1] 75 46 51 60 62 117 55 114 22 12 115 44 100 61 123 66 19 77 103 94 56 108 107 83 102 130

[27] 26 129 45 38 10 40 120 121 91 148 29 131 87 54 85 135 112 64 134 106 133 33 145 128 37 71

[53] 124 81 47 138 32 122 119 36 125 50 68 92 28 90 111 144 116 149 86 141 11 30 78 17 23 84

[79] 4 70 41 48 7 140 24 101 147 16 65 96 18 143 49 25 63 5 74 3 6 57 105 76 43 79

[105] 132 8 88 15 95 35 139 13 20 9 137 14 80 42 113 67 73 72 89 97 2 109 150 82 99 118

[131] 136 110 98 21 53

> #Normalizing data

> nor <- function(x) { (x - min(x)) / (max(x) - min(x)) }

> iris\_norm <- as.data.frame(lapply(df[, c(1, 2, 3, 4)], nor)) #Appling normalization function on predictors i.e. first 4 columns

> summary(iris\_norm)

Sepal.Length Sepal.Width Petal.Length Petal.Width

Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0.00000

1st Qu.:0.2222 1st Qu.:0.3333 1st Qu.:0.1017 1st Qu.:0.08333

Median :0.4167 Median :0.4167 Median :0.5678 Median :0.50000

Mean :0.4287 Mean :0.4406 Mean :0.4675 Mean :0.45806

3rd Qu.:0.5833 3rd Qu.:0.5417 3rd Qu.:0.6949 3rd Qu.:0.70833

Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1.00000

> head(iris\_norm)

Sepal.Length Sepal.Width Petal.Length Petal.Width

1 0.22222222 0.6250000 0.06779661 0.04166667

2 0.16666667 0.4166667 0.06779661 0.04166667

3 0.11111111 0.5000000 0.05084746 0.04166667

4 0.08333333 0.4583333 0.08474576 0.04166667

5 0.19444444 0.6666667 0.06779661 0.04166667

6 0.30555556 0.7916667 0.11864407 0.12500000

>

> #Extract Training data

> iris\_train = iris\_norm[ran,]

> dim(iris\_train)

[1] 135 4

> head(iris\_train)

Sepal.Length Sepal.Width Petal.Length Petal.Width

75 0.5833333 0.3750000 0.55932203 0.50000000

46 0.1388889 0.4166667 0.06779661 0.08333333

51 0.7500000 0.5000000 0.62711864 0.54166667

60 0.2500000 0.2916667 0.49152542 0.54166667

62 0.4444444 0.4166667 0.54237288 0.58333333

117 0.6111111 0.4166667 0.76271186 0.70833333

> #Extract Test data

> iris\_test = iris\_norm[-ran,]

> dim(iris\_test)

[1] 15 4

> head(iris\_test)

Sepal.Length Sepal.Width Petal.Length Petal.Width

1 0.22222222 0.6250000 0.06779661 0.04166667

27 0.19444444 0.5833333 0.10169492 0.12500000

31 0.13888889 0.4583333 0.10169492 0.04166667

34 0.33333333 0.9166667 0.06779661 0.04166667

39 0.02777778 0.4166667 0.05084746 0.04166667

52 0.58333333 0.5000000 0.59322034 0.58333333

> #Extract dependent variable of train dataset

> iris\_target\_category <- df[ran, 5]

> head(iris\_target\_category)

[1] versicolor setosa versicolor versicolor versicolor virginica

Levels: setosa versicolor virginica

> #Extract dependent variable of test dataset

> iris\_test\_category <- df[-ran, 5]

> head(iris\_test\_category)

[1] setosa setosa setosa setosa setosa versicolor

Levels: setosa versicolor virginica

> library(class)

> #Run KNN function

> pr <- knn(iris\_train, iris\_test, cl=iris\_target\_category, k=13)

> pr

[1] setosa setosa setosa setosa setosa versicolor versicolor versicolor versicolor

[10] versicolor virginica virginica virginica virginica virginica

Levels: setosa versicolor virginica

> #Create confusion matrix

> tab <- table(pr, iris\_test\_category)

> tab

iris\_test\_category

pr setosa versicolor virginica

setosa 5 0 0

versicolor 0 5 0

virginica 0 0 5

> #Accuracy score

> accuracy <- function(x) { sum(diag(x) / sum(rowSums(x))) \* 100 }

> accuracy(tab)

[1] 100

**Day 12 – R Programming**

**Social Ads Marketing – SVM**

setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models")

> #Importing Dataset

> dataset <- read.csv("Social\_Network\_Ads.csv")

> head(dataset)

User.ID Gender Age EstimatedSalary Purchased

1 15624510 Male 19 19000 0

2 15810944 Male 35 20000 0

3 15668575 Female 26 43000 0

4 15603246 Female 27 57000 0

5 15804002 Male 19 76000 0

6 15728773 Male 27 58000 0

> str(dataset)

'data.frame': 400 obs. of 5 variables:

$ User.ID : int 15624510 15810944 15668575 15603246 15804002 15728773 15598044 15694829 15600575 15727311 ...

$ Gender : chr "Male" "Male" "Female" "Female" ...

$ Age : int 19 35 26 27 19 27 27 32 25 35 ...

$ EstimatedSalary: int 19000 20000 43000 57000 76000 58000 84000 150000 33000 65000 ...

$ Purchased : int 0 0 0 0 0 0 0 1 0 0 ...

> dim(dataset)

[1] 400 5

> dataset <- dataset[3:5] #User.ID and Gender are not considered

> head(dataset)

Age EstimatedSalary Purchased

1 19 19000 0

2 35 20000 0

3 26 43000 0

4 27 57000 0

5 19 76000 0

6 27 58000 0

> #Encoding target feature by factorizing

> dataset$Purchased <- factor(dataset$Purchased, labels=c(0, 1))

> class(dataset$Purchased)

[1] "factor"

>

> #Splitting the dataset

> library(caTools)

> set.seed(123)

> split <- sample.split(dataset$Purchased, SplitRatio=0.75)

> split

[1] TRUE FALSE TRUE FALSE FALSE TRUE TRUE TRUE FALSE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE FALSE FALSE

[21] TRUE FALSE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE FALSE TRUE FALSE FALSE TRUE TRUE FALSE TRUE TRUE

[41] TRUE TRUE TRUE TRUE FALSE FALSE TRUE FALSE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE

[61] TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE FALSE TRUE TRUE TRUE TRUE FALSE FALSE TRUE TRUE TRUE TRUE TRUE

[81] TRUE FALSE TRUE FALSE FALSE FALSE FALSE TRUE FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE

[101] TRUE TRUE FALSE FALSE TRUE TRUE FALSE FALSE FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE

[121] TRUE TRUE TRUE FALSE TRUE FALSE FALSE TRUE TRUE TRUE FALSE TRUE TRUE FALSE TRUE TRUE TRUE TRUE FALSE TRUE

[141] TRUE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE TRUE FALSE TRUE TRUE FALSE TRUE

[161] TRUE FALSE FALSE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE FALSE FALSE TRUE TRUE TRUE TRUE

[181] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE FALSE

[201] TRUE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE

[221] TRUE TRUE TRUE FALSE TRUE FALSE TRUE FALSE FALSE FALSE TRUE TRUE TRUE FALSE TRUE FALSE FALSE TRUE FALSE TRUE

[241] FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE

[261] TRUE TRUE TRUE FALSE FALSE FALSE TRUE TRUE TRUE TRUE TRUE TRUE FALSE FALSE TRUE TRUE TRUE TRUE TRUE TRUE

[281] FALSE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE

[301] TRUE FALSE TRUE TRUE FALSE TRUE FALSE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE

[321] TRUE TRUE TRUE FALSE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE TRUE FALSE TRUE

[341] FALSE TRUE FALSE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE TRUE TRUE

[361] TRUE TRUE FALSE FALSE TRUE TRUE FALSE FALSE FALSE TRUE TRUE FALSE FALSE TRUE TRUE TRUE TRUE TRUE TRUE FALSE

[381] TRUE TRUE FALSE TRUE TRUE TRUE TRUE TRUE FALSE TRUE TRUE FALSE TRUE TRUE FALSE TRUE TRUE TRUE TRUE FALSE

> training\_set <- subset(dataset, split == TRUE)

> test\_set <- subset(dataset, split == FALSE)

> dim(training\_set)

[1] 300 3

> dim(test\_set)

[1] 100 3

> #Feature scaling

> training\_set[-3] <- scale(training\_set[-3]) #Except target feature, scale all the features

> test\_set[-3] <- scale(test\_set[-3])

> head(training\_set)

Age EstimatedSalary Purchased

1 -1.7655475 -1.4733414 0

3 -1.0962966 -0.7883761 0

6 -1.0006894 -0.3602727 0

7 -1.0006894 0.3817730 0

8 -0.5226531 2.2654277 1

10 -0.2358313 -0.1604912 0

> head(test\_set)

Age EstimatedSalary Purchased

2 -0.3041906 -1.5135434 0

4 -1.0599437 -0.3245603 0

5 -1.8156969 0.2859986 0

9 -1.2488820 -1.0957926 0

12 -1.1544129 -0.4852337 0

18 0.6405008 -1.3207353 1

> #Fitting SVM to training set

> library(e1071)

> classifier <- svm(formula=Purchased ~ ., data=training\_set, type="C-classification", kernel="linear")

> #Predicting the test set result

> y\_pred <- predict(classifier, newdata=test\_set[-3])

> y\_pred

2 4 5 9 12 18 19 20 22 29 32 34 35 38 45 46 48 52 66 69 74 75 82 84 85 86 87 89 103 104 107

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0

108 109 117 124 126 127 131 134 139 148 154 156 159 162 163 170 175 176 193 199 200 208 213 224 226 228 229 230 234 236 237

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 1 1 1 0

239 241 255 264 265 266 273 274 281 286 292 299 302 305 307 310 316 324 326 332 339 341 343 347 353 363 364 367 368 369 372

1 1 1 0 1 1 1 1 1 0 1 1 1 0 1 0 0 0 0 1 0 1 0 1 1 0 1 1 1 0 1

373 380 383 389 392 395 400

0 1 1 0 0 0 0

Levels: 0 1

> #Making confusion matrix

> cm <- table(test\_set[, 3], y\_pred)

> cm

y\_pred

0 1

0 57 7

1 13 23

> #Visualizing results

> # Download package tarball from CRAN archive

> # Download package tarball from CRAN archive

> url <- "https://cran.r-project.org/src/contrib/Archive/ElemStatLearn/ElemStatLearn\_2015.6.26.2.tar.gz"

> pkgFile <- "ElemStatLearn\_2015.6.26.2.tar.gz"

> download.file(url = url, destfile = pkgFile)

trying URL 'https://cran.r-project.org/src/contrib/Archive/ElemStatLearn/ElemStatLearn\_2015.6.26.2.tar.gz'

Content type 'application/x-gzip' length 12169918 bytes (11.6 MB)

downloaded 11.6 MB

> # Install package

> install.packages(pkgs=pkgFile, type="source", repos=NULL)

WARNING: Rtools is required to build R packages but is not currently installed. Please download and install the appropriate version of Rtools before proceeding:

https://cran.rstudio.com/bin/windows/Rtools/

Installing package into ‘C:/Users/ashraf/Documents/R/win-library/4.1’

(as ‘lib’ is unspecified)

\* installing \*source\* package 'ElemStatLearn' ...

\*\* package 'ElemStatLearn' successfully unpacked and MD5 sums checked

\*\* using staged installation

\*\* R

\*\* data

\*\*\* moving datasets to lazyload DB

\*\* byte-compile and prepare package for lazy loading

\*\* help

\*\*\* installing help indices

converting help for package 'ElemStatLearn'

finding HTML links ... done

SAheart html

bone html

countries html

galaxy html

marketing html

mixture.example html

nci html

orange10.test html

orange10.train html

orange4.test html

orange4.train html

ozone html

phoneme html

prostate html

simple.ridge html

spam html

vowel.test html

vowel.train html

waveform html

waveform.test html

waveform.train html

zip.test html

zip.train html

zip2image html

\*\* building package indices

\*\* testing if installed package can be loaded from temporary location

\*\*\* arch - i386

\*\*\* arch - x64

\*\* testing if installed package can be loaded from final location

\*\*\* arch - i386

\*\*\* arch - x64

\*\* testing if installed package keeps a record of temporary installation path

\* DONE (ElemStatLearn)

> # Delete package tarball

> unlink(pkgFile)

> library(ElemStatLearn)

> # Plotting the training data set results

> set = training\_set

> X1 = seq(min(set[, 1]) - 1, max(set[, 1]) + 1, by = 0.01)

> X2 = seq(min(set[, 2]) - 1, max(set[, 2]) + 1, by = 0.01)

>

> grid\_set = expand.grid(X1, X2)

> #expand.grid() - Create a data frame from all combinations of the supplied vectors or factors.

> colnames(grid\_set) = c('Age', 'EstimatedSalary')

> y\_grid = predict(classifier, newdata = grid\_set)

>

> plot(set[, -3],

+ main = 'SVM (Training set)',

+ xlab = 'Age', ylab = 'Estimated Salary',

+ xlim = range(X1), ylim = range(X2))

>

> contour(X1, X2, matrix(as.numeric(y\_grid), length(X1), length(X2)), add = TRUE)

>

> points(grid\_set, pch = '.', col = ifelse(y\_grid == 1, 'coral1', 'aquamarine'))

>

> points(set, pch = 21, bg = ifelse(set[, 3] == 1, 'green4', 'red3'))

> #Plotting the test set results

> set = test\_set

> X1 = seq(min(set[, 1]) - 1, max(set[, 1]) + 1, by = 0.01)

> X2 = seq(min(set[, 2]) - 1, max(set[, 2]) + 1, by = 0.01)

>

> grid\_set = expand.grid(X1, X2)

> colnames(grid\_set) = c('Age', 'EstimatedSalary')

> y\_grid = predict(classifier, newdata = grid\_set)

>

> plot(set[, -3], main = 'SVM (Test set)',

+ xlab = 'Age', ylab = 'Estimated Salary',

+ xlim = range(X1), ylim = range(X2))

>

> contour(X1, X2, matrix(as.numeric(y\_grid), length(X1), length(X2)), add = TRUE)

>

> points(grid\_set, pch = '.', col = ifelse(y\_grid == 1, 'coral1', 'aquamarine'))

>

> points(set, pch = 21, bg = ifelse(set[, 3] == 1, 'green4', 'red3'))

**Chemical Classification – SVM**

> setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models")

> #Import dataset

> biodeg <- read.csv("biodeg.csv", sep=";")

> head(biodeg)

X3.919 X2.6909 X0 X0.1 X0.2 X0.3 X0.4 X31.4 X2 X0.5 X0.6 X0.7 X3.106 X2.55 X9.002 X0.8 X0.96 X1.142 X0.9 X0.10 X0.11 X1.201 X0.12 X0.13 X0.14 X0.15 X1.932

1 4.170 2.1144 0 0 0 0 0 30.8 1 1 0 0.000 2.461 1.393 8.723 1 0.989 1.144 0 0 0 1.104 1 0 0 0 2.214

2 3.932 3.2512 0 0 0 0 0 26.7 2 4 0 0.000 3.279 2.585 9.110 0 1.009 1.152 0 0 0 1.092 0 0 0 0 1.942

3 3.000 2.7098 0 0 0 0 0 20.0 0 2 0 0.000 2.100 0.918 6.594 0 1.108 1.167 0 0 0 1.024 0 0 0 0 1.414

4 4.236 3.3944 0 0 0 0 0 29.4 2 4 0 -0.271 3.449 2.753 9.528 2 1.004 1.147 0 0 0 1.137 0 0 0 0 1.985

5 4.236 3.4286 0 0 0 0 0 28.6 2 4 0 -0.275 3.313 2.522 9.383 1 1.014 1.149 0 0 0 1.119 0 0 0 0 1.980

6 5.000 5.0476 1 0 0 0 0 11.1 0 3 0 0.000 2.872 0.722 9.657 0 1.092 1.153 0 0 0 1.125 0 0 0 0 2.000

X0.011 X0.16 X0.17 X4.489 X0.18 X0.19 X0.20 X0.21 X2.949 X1.591 X0.22 X7.253 X0.23 X0.24 RB

1 -0.204 0 0.000 1.542 0 0 0 0 3.315 1.967 0 7.257 0 0 RB

2 -0.008 0 0.000 4.891 0 0 0 1 3.076 2.417 0 7.601 0 0 RB

3 1.073 0 8.361 1.333 0 0 0 1 3.046 5.000 0 6.690 0 0 RB

4 -0.002 0 10.348 5.588 0 0 0 0 3.351 2.405 0 8.003 0 0 RB

5 -0.008 0 10.276 4.746 0 0 0 0 3.351 2.556 0 7.904 0 0 RB

6 0.446 0 18.375 0.800 0 0 0 1 4.712 4.583 0 9.303 0 0 RB

> str(biodeg)

'data.frame': 1054 obs. of 42 variables:

$ X3.919 : num 4.17 3.93 3 4.24 4.24 ...

$ X2.6909: num 2.11 3.25 2.71 3.39 3.43 ...

$ X0 : int 0 0 0 0 0 1 0 0 0 0 ...

$ X0.1 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.2 : int 0 0 0 0 0 0 0 0 1 0 ...

$ X0.3 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.4 : int 0 0 0 0 0 0 0 2 2 2 ...

$ X31.4 : num 30.8 26.7 20 29.4 28.6 11.1 31.6 44.4 41.2 52.9 ...

$ X2 : int 1 2 0 2 2 0 3 2 0 0 ...

$ X0.5 : int 1 4 2 4 4 3 2 0 4 2 ...

$ X0.6 : int 0 0 0 0 0 0 0 0 3 0 ...

$ X0.7 : num 0 0 0 -0.271 -0.275 0 -0.039 0 -1.29 -0.302 ...

$ X3.106 : num 2.46 3.28 2.1 3.45 3.31 ...

$ X2.55 : num 1.393 2.585 0.918 2.753 2.522 ...

$ X9.002 : num 8.72 9.11 6.59 9.53 9.38 ...

$ X0.8 : int 1 0 0 2 1 0 5 0 8 5 ...

$ X0.96 : num 0.989 1.009 1.108 1.004 1.014 ...

$ X1.142 : num 1.14 1.15 1.17 1.15 1.15 ...

$ X0.9 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.10 : int 0 0 0 0 0 0 0 0 1 0 ...

$ X0.11 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X1.201 : num 1.1 1.09 1.02 1.14 1.12 ...

$ X0.12 : int 1 0 0 0 0 0 0 1 1 3 ...

$ X0.13 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.14 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.15 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X1.932 : num 2.21 1.94 1.41 1.99 1.98 ...

$ X0.011 : num -0.204 -0.008 1.073 -0.002 -0.008 ...

$ X0.16 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.17 : num 0 0 8.36 10.35 10.28 ...

$ X4.489 : num 1.54 4.89 1.33 5.59 4.75 ...

$ X0.18 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.19 : int 0 0 0 0 0 0 0 0 1 1 ...

$ X0.20 : int 0 0 0 0 0 0 0 0 2 0 ...

$ X0.21 : int 0 1 1 0 0 1 0 0 1 0 ...

$ X2.949 : num 3.31 3.08 3.05 3.35 3.35 ...

$ X1.591 : num 1.97 2.42 5 2.4 2.56 ...

$ X0.22 : int 0 0 0 0 0 0 0 0 1 0 ...

$ X7.253 : num 7.26 7.6 6.69 8 7.9 ...

$ X0.23 : int 0 0 0 0 0 0 0 0 0 0 ...

$ X0.24 : int 0 0 0 0 0 0 0 0 0 0 ...

$ RB : chr "RB" "RB" "RB" "RB" ...

> dim(biodeg)

[1] 1054 42

> sum(is.na(biodeg))

[1] 0

> #Data Pre-processing

> biodeg$RB <- ifelse(biodeg$RB == "RB", 1, 0)

> class(biodeg$RB)

[1] "numeric"

> biodeg$RB <- factor(biodeg$RB, labels=c(1, 0))

> class(biodeg$RB)

[1] "factor"

> #Feature Selection

> biodeg[-42] <- scale(biodeg[-42])

> head(biodeg)

X3.919 X2.6909 X0 X0.1 X0.2 X0.3 X0.4 X31.4 X2 X0.5 X0.6 X0.7 X3.106 X2.55

1 -1.1224746 -1.1489213 -0.4902786 -0.1666917 -0.4203431 -0.2702577 -0.7405779 -0.6844765 -0.1912642 -0.4537005 -0.4613371 0.25625322 -1.7391211 0.05526774

2 -1.5579514 0.2180477 -0.4902786 -0.1666917 -0.4203431 -0.2702577 -0.7405779 -1.1327038 0.3178077 1.2360533 -0.4613371 0.25625322 -0.3391925 1.57244420

3 -3.2632642 -0.4329701 -0.4902786 -0.1666917 -0.4203431 -0.2702577 -0.7405779 -1.8651727 -0.7003361 0.1095508 -0.4613371 0.25625322 -2.3569379 -0.54931181

4 -1.0017121 0.3902415 -0.4902786 -0.1666917 -0.4203431 -0.2702577 -0.7405779 -0.8375297 0.3178077 1.2360533 -0.4613371 -0.09569312 -0.0482538 1.78627444

5 -1.0017121 0.4313660 -0.4902786 -0.1666917 -0.4203431 -0.2702577 -0.7405779 -0.9249887 0.3178077 1.2360533 -0.4613371 -0.10088790 -0.2810048 1.49225786

6 0.3962053 2.3781666 0.1932580 -0.1666917 -0.4203431 -0.2702577 -0.7405779 -2.8381539 -0.7003361 0.6728020 -0.4613371 0.25625322 -1.0357340 -0.79878043

X9.002 X0.8 X0.96 X1.142 X0.9 X0.10 X0.11 X1.201 X0.12 X0.13 X0.14 X0.15 X1.932 X0.011

1 -1.3086107 -0.5908038 -0.52386167 0.4279226 -0.08383824 -0.2329964 -0.1348551 -1.396441 -0.08496205 -0.2036237 -0.4165988 -0.156832 -0.008448142 -1.275335545

2 -0.8918860 -0.8151220 -0.09363711 0.6932151 -0.08383824 -0.2329964 -0.1348551 -1.520787 -0.29370332 -0.2036237 -0.4165988 -0.156832 -1.211617959 -0.042657773

3 -3.6011346 -0.8151220 2.03597445 1.1906385 -0.08383824 -0.2329964 -0.1348551 -2.225418 -0.29370332 -0.2036237 -0.4165988 -0.156832 -3.547182898 6.755937489

4 -0.4417803 -0.3664857 -0.20119325 0.5274073 -0.08383824 -0.2329964 -0.1348551 -1.054488 -0.29370332 -0.2036237 -0.4165988 -0.156832 -1.021410966 -0.004922739

5 -0.5979175 -0.5908038 0.01391903 0.5937304 -0.08383824 -0.2329964 -0.1348551 -1.241008 -0.29370332 -0.2036237 -0.4165988 -0.156832 -1.043528058 -0.042657773

6 -0.3028721 -0.8151220 1.69179481 0.7263766 -0.08383824 -0.2329964 -0.1348551 -1.178834 -0.29370332 -0.2036237 -0.4165988 -0.156832 -0.955059689 2.812626453

X0.16 X0.17 X4.489 X0.18 X0.19 X0.20 X0.21 X2.949 X1.591 X0.22 X7.253 X0.23 X0.24 RB

1 -0.1651198 -0.73865380 -0.5363359 -0.2017241 -0.5813821 -0.5609848 -0.7651948 -0.6043829 -0.922097187 -0.6297848 -1.1062502 -0.160547 -0.3231392 0

2 -0.1651198 -0.73865380 1.0608207 -0.2017241 -0.5813821 -0.5609848 0.0301852 -0.8434713 -0.221575026 -0.6297848 -0.8292443 -0.160547 -0.3231392 0

3 -0.1651198 -0.03595765 -0.6360092 -0.2017241 -0.5813821 -0.5609848 0.0301852 -0.8734824 3.799422176 -0.6297848 -1.5628267 -0.160547 -0.3231392 0

4 -0.1651198 0.13103879 1.3932238 -0.2017241 -0.5813821 -0.5609848 -0.7651948 -0.5683696 -0.240255617 -0.6297848 -0.5055340 -0.160547 -0.3231392 0

5 -0.1651198 0.12498758 0.9916694 -0.2017241 -0.5813821 -0.5609848 -0.7651948 -0.5683696 -0.005191515 -0.6297848 -0.5852537 -0.160547 -0.3231392 0

6 -0.1651198 0.80566407 -0.8901998 -0.2017241 -0.5813821 -0.5609848 0.0301852 0.7931339 3.150271640 -0.6297848 0.5412904 -0.160547 -0.3231392 0

> #install.packages("mlbench")

> library(mlbench)

> library(caret)

> control <- trainControl(method="repeatedcv", number=15, repeats=3)

> # train the model

> set.seed(111)

> model <- train(RB~., data=biodeg, method="lvq", trControl=control)

> # estimate variable importance

> importance <- varImp(model, scale=FALSE)

> # summarize importance

> print(importance)

ROC curve variable importance

only 20 most important variables shown (out of 41)

Importance

X2.949 0.7981

X7.253 0.7737

X3.919 0.7658

X1.932 0.7632

X1.201 0.7604

X9.002 0.7283

X3.106 0.7128

X0.4 0.7034

X0.12 0.7004

X0.19 0.6911

X0 0.6778

X2.55 0.6662

X1.142 0.6590

X0.22 0.6531

X0.6 0.6519

X0.20 0.6496

X0.2 0.6491

X0.24 0.6397

X0.5 0.6308

X31.4 0.6283

> ImpMeasure <- data.frame(importance$importance)

> ImpMeasure<- ImpMeasure[order(-ImpMeasure$X1, -ImpMeasure$X0),]

> ImpMeasure

X1 X0

X2.949 0.7981382 0.7981382

X7.253 0.7736706 0.7736706

X3.919 0.7658184 0.7658184

X1.932 0.7631969 0.7631969

X1.201 0.7604324 0.7604324

X9.002 0.7283463 0.7283463

X3.106 0.7128292 0.7128292

X0.4 0.7033912 0.7033912

X0.12 0.7003627 0.7003627

X0.19 0.6911181 0.6911181

X0 0.6777852 0.6777852

X2.55 0.6662254 0.6662254

X1.142 0.6589957 0.6589957

X0.22 0.6530597 0.6530597

X0.6 0.6519213 0.6519213

X0.20 0.6496444 0.6496444

X0.2 0.6490782 0.6490782

X0.24 0.6396845 0.6396845

X0.5 0.6308046 0.6308046

X31.4 0.6283262 0.6283262

X0.7 0.6192085 0.6192085

X0.14 0.5945979 0.5945979

X0.3 0.5860767 0.5860767

X1.591 0.5830865 0.5830865

X0.17 0.5751677 0.5751677

X4.489 0.5736364 0.5736364

X0.8 0.5432731 0.5432731

X0.10 0.5408692 0.5408692

X2.6909 0.5275182 0.5275182

X2 0.5264926 0.5264926

X0.23 0.5253763 0.5253763

X0.96 0.5253360 0.5253360

X0.13 0.5236716 0.5236716

X0.18 0.5229563 0.5229563

X0.1 0.5214391 0.5214391

X0.15 0.5165085 0.5165085

X0.16 0.5157811 0.5157811

X0.11 0.5157368 0.5157368

X0.21 0.5094501 0.5094501

X0.9 0.5057225 0.5057225

X0.011 0.5031695 0.5031695

> imp\_vars <- row.names(ImpMeasure)[1:15]

> imp\_vars <- append(imp\_vars, "RB")

> imp\_vars

[1] "X2.949" "X7.253" "X3.919" "X1.932" "X1.201" "X9.002" "X3.106" "X0.4" "X0.12" "X0.19" "X0" "X2.55" "X1.142" "X0.22" "X0.6" "RB"

> # plot importance

> plot(importance)

>

> biodeg1 <- biodeg[imp\_vars]

> head(biodeg1)

X2.949 X7.253 X3.919 X1.932 X1.201 X9.002 X3.106 X0.4 X0.12 X0.19 X0 X2.55 X1.142 X0.22

1 -0.6043829 -1.1062502 -1.1224746 -0.008448142 -1.396441 -1.3086107 -1.7391211 -0.7405779 -0.08496205 -0.5813821 -0.4902786 0.05526774 0.4279226 -0.6297848

2 -0.8434713 -0.8292443 -1.5579514 -1.211617959 -1.520787 -0.8918860 -0.3391925 -0.7405779 -0.29370332 -0.5813821 -0.4902786 1.57244420 0.6932151 -0.6297848

3 -0.8734824 -1.5628267 -3.2632642 -3.547182898 -2.225418 -3.6011346 -2.3569379 -0.7405779 -0.29370332 -0.5813821 -0.4902786 -0.54931181 1.1906385 -0.6297848

4 -0.5683696 -0.5055340 -1.0017121 -1.021410966 -1.054488 -0.4417803 -0.0482538 -0.7405779 -0.29370332 -0.5813821 -0.4902786 1.78627444 0.5274073 -0.6297848

5 -0.5683696 -0.5852537 -1.0017121 -1.043528058 -1.241008 -0.5979175 -0.2810048 -0.7405779 -0.29370332 -0.5813821 -0.4902786 1.49225786 0.5937304 -0.6297848

6 0.7931339 0.5412904 0.3962053 -0.955059689 -1.178834 -0.3028721 -1.0357340 -0.7405779 -0.29370332 -0.5813821 0.1932580 -0.79878043 0.7263766 -0.6297848

X0.6 RB

1 -0.4613371 0

2 -0.4613371 0

3 -0.4613371 0

4 -0.4613371 0

5 -0.4613371 0

6 -0.4613371 0

> str(biodeg1)

'data.frame': 1054 obs. of 16 variables:

$ X2.949: num -0.604 -0.843 -0.873 -0.568 -0.568 ...

$ X7.253: num -1.106 -0.829 -1.563 -0.506 -0.585 ...

$ X3.919: num -1.12 -1.56 -3.26 -1 -1 ...

$ X1.932: num -0.00845 -1.21162 -3.54718 -1.02141 -1.04353 ...

$ X1.201: num -1.4 -1.52 -2.23 -1.05 -1.24 ...

$ X9.002: num -1.309 -0.892 -3.601 -0.442 -0.598 ...

$ X3.106: num -1.7391 -0.3392 -2.3569 -0.0483 -0.281 ...

$ X0.4 : num -0.741 -0.741 -0.741 -0.741 -0.741 ...

$ X0.12 : num -0.085 -0.294 -0.294 -0.294 -0.294 ...

$ X0.19 : num -0.581 -0.581 -0.581 -0.581 -0.581 ...

$ X0 : num -0.49 -0.49 -0.49 -0.49 -0.49 ...

$ X2.55 : num 0.0553 1.5724 -0.5493 1.7863 1.4923 ...

$ X1.142: num 0.428 0.693 1.191 0.527 0.594 ...

$ X0.22 : num -0.63 -0.63 -0.63 -0.63 -0.63 ...

$ X0.6 : num -0.461 -0.461 -0.461 -0.461 -0.461 ...

$ RB : Factor w/ 2 levels "1","0": 2 2 2 2 2 2 2 2 2 2 ...

> dim(biodeg1)

[1] 1054 16

> #Splitting dataset

> library(caTools)

> set.seed(122)

> split <- sample.split(biodeg1$RB, SplitRatio=0.80)

> training\_set <- subset(biodeg1, split == TRUE)

> test\_set <- subset(biodeg1, split == FALSE)

> dim(training\_set)

[1] 843 16

> dim(test\_set)

[1] 211 16

> head(training\_set)

X2.949 X7.253 X3.919 X1.932 X1.201 X9.002 X3.106 X0.4 X0.12 X0.19 X0 X2.55 X1.142 X0.22

3 -0.8734824 -1.5628267 -3.2632642 -3.5471829 -2.2254177 -3.6011346 -2.3569379 -0.7405779 -0.29370332 -0.5813821 -0.4902786 -0.5493118 1.1906385 -0.6297848

4 -0.5683696 -0.5055340 -1.0017121 -1.0214110 -1.0544878 -0.4417803 -0.0482538 -0.7405779 -0.29370332 -0.5813821 -0.4902786 1.7862744 0.5274073 -0.6297848

5 -0.5683696 -0.5852537 -1.0017121 -1.0435281 -1.2410076 -0.5979175 -0.2810048 -0.7405779 -0.29370332 -0.5813821 -0.4902786 1.4922579 0.5937304 -0.6297848

6 0.7931339 0.5412904 0.3962053 -0.9550597 -1.1788343 -0.3028721 -1.0357340 -0.7405779 -0.29370332 -0.5813821 0.1932580 -0.7987804 0.7263766 -0.6297848

7 -0.5403592 -0.5482122 -0.4729187 -0.4286729 -0.6192749 -0.1639639 -0.1013073 -0.7405779 -0.29370332 -0.5813821 -0.4902786 1.4235267 0.3615995 -0.6297848

8 -0.2932678 -0.5570700 -0.3430076 -0.1809615 0.9246947 -0.4288587 -0.8680164 0.1581776 -0.08496205 -0.5813821 -0.4902786 -0.6040422 -0.5337627 -0.6297848

X0.6 RB

3 -0.4613371 0

4 -0.4613371 0

5 -0.4613371 0

6 -0.4613371 0

7 -0.4613371 0

8 -0.4613371 0

> head(test\_set)

X2.949 X7.253 X3.919 X1.932 X1.201 X9.002 X3.106 X0.4 X0.12 X0.19 X0 X2.55 X1.142 X0.22

1 -0.6043829 -1.1062502 -1.122475 -0.008448142 -1.3964407 -1.308611 -1.7391211 -0.7405779 -0.08496205 -0.5813821 -0.4902786 0.05526774 0.4279226 -0.6297848

2 -0.8434713 -0.8292443 -1.557951 -1.211617959 -1.5207873 -0.891886 -0.3391925 -0.7405779 -0.29370332 -0.5813821 -0.4902786 1.57244420 0.6932151 -0.6297848

11 -1.1255756 -1.8503008 -2.132488 -2.140535832 -0.6296371 -2.245434 -1.9581808 -0.7405779 -0.29370332 -0.5813821 -0.4902786 0.21945881 0.5274073 -0.6297848

31 -0.6584029 -1.2350901 -1.433529 -2.140535832 -0.4534795 -1.744718 -2.0505966 -0.7405779 -0.29370332 -0.5813821 -0.4902786 -0.68550131 0.4942457 -0.6297848

34 -0.5823748 -1.0764560 -1.122475 -1.627419293 -1.3135431 -1.444288 -1.6518395 -0.7405779 -0.29370332 -0.5813821 -0.4902786 -0.48185346 0.6600535 -0.6297848

36 -0.5393588 -0.8759488 -1.041966 -1.388554697 -0.5467394 -1.274153 -1.3078472 -0.7405779 -0.29370332 -0.5813821 -0.4902786 0.13927247 0.2621148 -0.6297848

X0.6 RB

1 -0.4613371 0

2 -0.4613371 0

11 -0.4613371 0

31 -0.4613371 0

34 -0.4613371 0

36 -0.4613371 0

>

> #Logistic Regression

> logit <- glm(formula=RB ~ ., data=training\_set, family="binomial")

> summary(logit)

Call:

glm(formula = RB ~ ., family = "binomial", data = training\_set)

Deviance Residuals:

Min 1Q Median 3Q Max

-2.3812 -0.5517 -0.1152 0.4973 4.2061

Coefficients:

Estimate Std. Error z value Pr(>|z|)

(Intercept) -2.03660 0.20515 -9.927 < 2e-16 \*\*\*

X2.949 -1.56867 0.83012 -1.890 0.058800 .

X7.253 3.45085 1.16249 2.968 0.002993 \*\*

X3.919 -1.75952 0.48936 -3.596 0.000324 \*\*\*

X1.932 -0.47167 0.50247 -0.939 0.347888

X1.201 -2.08451 0.30669 -6.797 1.07e-11 \*\*\*

X9.002 1.96000 0.75519 2.595 0.009449 \*\*

X3.106 -2.97724 0.73541 -4.048 5.16e-05 \*\*\*

X0.4 -0.76567 0.34152 -2.242 0.024964 \*

X0.12 -0.24686 0.81100 -0.304 0.760836

X0.19 -0.47989 0.31700 -1.514 0.130058

X0 -1.82153 0.43487 -4.189 2.81e-05 \*\*\*

X2.55 0.76591 0.19984 3.833 0.000127 \*\*\*

X1.142 -2.96774 0.51363 -5.778 7.56e-09 \*\*\*

X0.22 -0.38575 0.29209 -1.321 0.186616

X0.6 -0.04537 0.38768 -0.117 0.906845

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 1077.3 on 842 degrees of freedom

Residual deviance: 601.6 on 827 degrees of freedom

AIC: 633.6

Number of Fisher Scoring iterations: 7

> #Predicting the test set result

> y\_pred <- predict(logit, newdata=test\_set[-16], type = "response")

> y\_pred

1 2 11 31 34 36 38 49 50 52 59 61

9.674875e-01 9.674555e-01 8.213433e-01 8.787283e-01 9.225592e-01 9.016214e-01 8.958062e-01 9.136167e-01 9.248425e-01 2.985116e-01 5.135801e-01 2.709491e-01

67 71 72 74 82 89 90 96 99 101 109 112

5.859405e-01 8.057486e-01 5.424879e-01 2.707282e-01 5.677640e-02 6.755034e-02 5.015474e-01 9.255828e-01 7.130585e-01 8.779557e-01 8.622326e-01 7.634211e-01

129 131 136 148 150 155 158 163 167 168 170 193

6.981148e-01 7.369943e-01 3.671884e-01 7.793587e-01 6.381805e-01 7.612499e-01 5.383913e-01 2.726270e-01 6.799265e-01 6.259890e-01 4.471750e-01 6.297829e-01

199 202 209 218 221 237 240 256 258 265 267 269

8.811116e-01 8.789495e-01 5.331796e-01 9.358349e-01 6.525607e-01 9.137068e-01 8.577808e-01 3.285798e-01 3.837453e-01 5.668171e-01 2.534421e-03 8.796237e-01

273 276 280 284 285 287 293 296 301 308 325 331

7.877231e-01 9.788238e-01 1.563304e-01 5.452727e-03 1.056816e-01 1.996479e-08 6.433515e-04 3.470356e-02 6.111223e-07 6.617056e-05 2.675553e-01 1.603295e-01

345 346 351 356 357 358 364 365 367 380 382 385

4.576989e-04 3.203877e-02 7.358303e-02 4.582022e-02 4.388011e-02 1.105999e-01 2.106732e-01 3.267120e-04 8.066657e-08 6.087532e-01 6.779853e-02 1.333534e-02

390 391 395 397 399 402 410 417 420 425 431 435

3.321955e-03 2.877990e-02 5.295935e-02 4.141410e-02 3.322551e-02 7.925728e-03 7.357424e-02 3.594833e-01 7.589268e-02 2.007533e-02 2.406825e-02 1.722865e-02

439 446 449 457 460 462 468 470 471 477 479 487

2.815296e-03 1.901912e-01 5.130638e-01 3.631151e-05 2.716762e-01 4.151631e-02 7.096890e-02 1.048132e-01 3.007797e-03 5.764408e-03 1.437819e-01 7.199900e-02

495 499 509 512 518 530 532 533 538 539 541 544

8.157142e-03 5.296943e-03 2.426239e-01 4.662292e-02 4.144843e-03 4.301046e-03 1.972991e-02 2.875917e-01 4.566659e-02 2.589967e-02 2.383228e-01 3.060365e-01

547 548 566 573 581 588 599 610 611 618 625 628

7.264459e-01 9.746340e-03 2.569285e-09 1.749316e-01 8.118469e-01 9.715693e-05 2.492411e-02 6.956192e-01 6.188371e-01 1.638564e-03 5.471111e-01 2.017040e-01

635 638 649 651 652 653 656 661 662 666 669 673

2.074937e-01 2.691046e-02 6.769847e-04 9.795639e-04 1.808056e-01 6.334276e-05 1.041701e-02 5.483338e-01 2.414291e-02 5.093503e-01 2.342886e-01 4.074473e-01

679 685 692 693 696 698 701 708 713 716 721 723

7.278373e-02 4.944221e-04 2.839162e-03 4.239003e-01 3.892071e-01 1.256617e-01 1.833482e-01 2.164956e-01 2.013613e-01 2.776185e-01 5.707713e-02 6.353242e-01

735 736 737 742 743 753 759 761 771 775 776 778

8.516332e-01 6.972746e-01 8.454286e-01 5.547208e-01 8.295279e-01 6.409358e-01 1.207089e-02 9.207194e-04 1.997617e-01 2.085584e-01 3.011911e-01 1.878334e-01

789 794 795 811 813 816 817 821 825 827 829 835

4.982716e-03 2.532091e-01 8.489912e-01 9.112727e-05 9.886689e-02 1.434788e-02 1.526234e-02 3.056702e-01 3.192758e-08 6.251275e-02 5.554658e-03 1.813295e-01

836 837 840 843 848 850 853 858 862 869 872 876

1.687740e-09 8.181908e-01 7.239384e-01 8.916309e-01 8.743828e-01 4.873044e-01 7.059348e-01 6.402549e-01 7.540568e-01 9.696596e-01 9.414780e-01 8.451545e-01

877 885 888 895 900 902 903 905 907 917 919 941

6.888675e-01 4.181915e-01 9.378296e-01 8.801193e-01 7.665428e-01 9.617948e-01 7.989257e-01 1.275893e-01 5.299961e-01 5.895782e-01 2.998635e-03 4.592207e-02

943 950 957 964 973 975 981 989 995 1000 1009 1010

4.476849e-02 5.737395e-01 8.496155e-02 1.016873e-01 1.058375e-02 7.763831e-01 1.227196e-01 1.245936e-01 3.209016e-05 1.584910e-02 1.299333e-01 1.481877e-01

1013 1014 1017 1018 1019 1025 1048

2.959929e-01 4.728785e-02 1.216112e-01 1.104870e-01 1.009405e-01 2.158973e-04 1.312417e-02

> y\_pred\_final <- factor(ifelse(y\_pred > 0.5, 1, 0))

> y\_pred\_final

1 2 11 31 34 36 38 49 50 52 59 61 67 71 72 74 82 89 90 96 99 101 109 112 129 131 136 148 150 155 158 163

1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 0 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 0

167 168 170 193 199 202 209 218 221 237 240 256 258 265 267 269 273 276 280 284 285 287 293 296 301 308 325 331 345 346 351 356

1 1 0 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0

357 358 364 365 367 380 382 385 390 391 395 397 399 402 410 417 420 425 431 435 439 446 449 457 460 462 468 470 471 477 479 487

0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0

495 499 509 512 518 530 532 533 538 539 541 544 547 548 566 573 581 588 599 610 611 618 625 628 635 638 649 651 652 653 656 661

0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1

662 666 669 673 679 685 692 693 696 698 701 708 713 716 721 723 735 736 737 742 743 753 759 761 771 775 776 778 789 794 795 811

0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0

813 816 817 821 825 827 829 835 836 837 840 843 848 850 853 858 862 869 872 876 877 885 888 895 900 902 903 905 907 917 919 941

0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 0 0

943 950 957 964 973 975 981 989 995 1000 1009 1010 1013 1014 1017 1018 1019 1025 1048

0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

Levels: 0 1

> #Making confusion matrix

> cm <- table(test\_set$RB, y\_pred\_final)

> cm

y\_pred\_final

0 1

1 120 20

0 15 56

> accuracy <- (sum(diag(cm)) / sum(cm)) \* 100

> accuracy

[1] 83.41232

> precision <- (cm[1, "0"] / (cm[1, "0"] + cm[1, "1"])) \* 100

> precision

[1] 85.71429

> sensitivity <- (cm[1, "0"] / (cm[1, "0"] + cm[2, "0"])) \* 100

> sensitivity

[1] 88.88889

> specificity <- (cm[1, "1"] / (cm[1, "1"] + cm[1, "1"])) \* 100

> sensitivity

[1] 88.88889

> #install.packages("ROCR")

> library(ROCR)

> ROCPred <- prediction(as.numeric(y\_pred\_final), as.numeric(test\_set$RB))

> ROCPer <- performance(ROCPred, measure = "tpr", x.measure = "fpr")

> auc <- performance(ROCPred, measure = "auc")

> auc <- auc@y.values[[1]]

> auc

[1] 0.8229376

> # Plotting curve

> plot(ROCPer)

> plot(ROCPer, colorize = TRUE,

+ print.cutoffs.at = seq(0.1, by = 0.1),

+ main = "ROC CURVE")

> abline(a = 0, b = 1)

>

> auc <- round(auc, 4)

> legend(.6, .4, auc, title = "AUC", cex = 1)

>

> #SVM

> library(e1071)

> #Linear

> svc <- svm(formula=RB ~ ., data=training\_set, type="C-classification", kernel="linear")

> #Predicting the test set result

> y\_pred\_final <- predict(svc, newdata=test\_set[-16], type = "class")

> y\_pred\_final

1 2 11 31 34 36 38 49 50 52 59 61 67 71 72 74 82 89 90 96 99 101 109 112 129 131 136 148 150 155 158 163

0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 1 1 0 0 0 0 0 0 0 1 0 0 0 0 1

167 168 170 193 199 202 209 218 221 237 240 256 258 265 267 269 273 276 280 284 285 287 293 296 301 308 325 331 345 346 351 356

0 0 1 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1

357 358 364 365 367 380 382 385 390 391 395 397 399 402 410 417 420 425 431 435 439 446 449 457 460 462 468 470 471 477 479 487

1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1

495 499 509 512 518 530 532 533 538 539 541 544 547 548 566 573 581 588 599 610 611 618 625 628 635 638 649 651 652 653 656 661

1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 0 0 1 0 1 1 1 1 1 1 1 1 1

662 666 669 673 679 685 692 693 696 698 701 708 713 716 721 723 735 736 737 742 743 753 759 761 771 775 776 778 789 794 795 811

1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 0 1 1 1 1 1 1 1 1 1 0 1

813 816 817 821 825 827 829 835 836 837 840 843 848 850 853 858 862 869 872 876 877 885 888 895 900 902 903 905 907 917 919 941

1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1 1

943 950 957 964 973 975 981 989 995 1000 1009 1010 1013 1014 1017 1018 1019 1025 1048

1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1

Levels: 1 0

> #Making confusion matrix

> cm <- table(test\_set$RB, y\_pred\_final)

> cm

y\_pred\_final

1 0

1 125 15

0 17 54

> accuracy <- (sum(diag(cm)) / sum(cm)) \* 100

> accuracy

[1] 84.83412

> precision <- (cm[1, "1"] / (cm[1, "1"] + cm[1, "0"])) \* 100

> precision

[1] 89.28571

> sensitivity <- (cm[1, "1"] / (cm[1, "1"] + cm[2, "1"])) \* 100

> sensitivity

[1] 88.02817

> specificity <- (cm[1, "0"] / (cm[1, "0"] + cm[1, "0"])) \* 100

> sensitivity

[1] 88.02817

> ROCPred <- prediction(as.numeric(y\_pred\_final), as.numeric(test\_set$RB))

> ROCPer <- performance(ROCPred, measure = "tpr", x.measure = "fpr")

> auc <- performance(ROCPred, measure = "auc")

> auc <- auc@y.values[[1]]

> auc

[1] 0.8267103

> # Plotting curve

> plot(ROCPer)

> plot(ROCPer, colorize = TRUE,

+ print.cutoffs.at = seq(0.1, by = 0.1),

+ main = "ROC CURVE")

> abline(a = 0, b = 1)

>

> auc <- round(auc, 4)

> legend(.6, .4, auc, title = "AUC", cex = 1)

>

> #Radial

> svc <- svm(formula=RB ~ ., data=training\_set, type="C-classification", kernel="radial")

> #Predicting the test set result

> y\_pred\_final <- predict(svc, newdata=test\_set[-16])

> y\_pred\_final

1 2 11 31 34 36 38 49 50 52 59 61 67 71 72 74 82 89 90 96 99 101 109 112 129 131 136 148 150 155 158 163

0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 1 1 0 0 0 0 0 0 0 1 0 0 1 0 1

167 168 170 193 199 202 209 218 221 237 240 256 258 265 267 269 273 276 280 284 285 287 293 296 301 308 325 331 345 346 351 356

0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1

357 358 364 365 367 380 382 385 390 391 395 397 399 402 410 417 420 425 431 435 439 446 449 457 460 462 468 470 471 477 479 487

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1

495 499 509 512 518 530 532 533 538 539 541 544 547 548 566 573 581 588 599 610 611 618 625 628 635 638 649 651 652 653 656 661

1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

662 666 669 673 679 685 692 693 696 698 701 708 713 716 721 723 735 736 737 742 743 753 759 761 771 775 776 778 789 794 795 811

1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 0 0 1 0 1 1 1 1 1 1 1 1 1 0 1

813 816 817 821 825 827 829 835 836 837 840 843 848 850 853 858 862 869 872 876 877 885 888 895 900 902 903 905 907 917 919 941

1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1 1

943 950 957 964 973 975 981 989 995 1000 1009 1010 1013 1014 1017 1018 1019 1025 1048

1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1

Levels: 1 0

> #Making confusion matrix

> cm <- table(test\_set$RB, y\_pred\_final)

> cm

y\_pred\_final

1 0

1 127 13

0 17 54

> accuracy <- (sum(diag(cm)) / sum(cm)) \* 100

> accuracy

[1] 85.78199

> precision <- (cm[1, "1"] / (cm[1, "1"] + cm[1, "0"])) \* 100

> precision

[1] 90.71429

> sensitivity <- (cm[1, "1"] / (cm[1, "1"] + cm[2, "1"])) \* 100

> sensitivity

[1] 88.19444

> specificity <- (cm[1, "0"] / (cm[1, "0"] + cm[1, "0"])) \* 100

> sensitivity

[1] 88.19444

> ROCPred <- prediction(as.numeric(y\_pred\_final), as.numeric(test\_set$RB))

> ROCPer <- performance(ROCPred, measure = "tpr", x.measure = "fpr")

> auc <- performance(ROCPred, measure = "auc")

> auc <- auc@y.values[[1]]

> auc

[1] 0.8338531

> # Plotting curve

> plot(ROCPer)

> plot(ROCPer, colorize = TRUE,

+ print.cutoffs.at = seq(0.1, by = 0.1),

+ main = "ROC CURVE")

> abline(a = 0, b = 1)

>

> auc <- round(auc, 4)

> legend(.6, .4, auc, title = "AUC", cex = 1)

>

> #Decision Tree

> library(rpart)

> #Max-Depth - 8

> mtree <- rpart(RB ~ ., data=training\_set, method="class", control=rpart.control(minsplit=20, minbucket=7, maxdepth=8, usesurrogate=2, xval=10))

> #Predicting the test set result

> y\_pred\_final <- predict(mtree, newdata=test\_set[-16], type="class")

> y\_pred\_final

1 2 11 31 34 36 38 49 50 52 59 61 67 71 72 74 82 89 90 96 99 101 109 112 129 131 136 148 150 155 158 163

0 0 0 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 1

167 168 170 193 199 202 209 218 221 237 240 256 258 265 267 269 273 276 280 284 285 287 293 296 301 308 325 331 345 346 351 356

0 0 1 0 0 0 1 0 0 0 0 1 0 0 1 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1

357 358 364 365 367 380 382 385 390 391 395 397 399 402 410 417 420 425 431 435 439 446 449 457 460 462 468 470 471 477 479 487

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1

495 499 509 512 518 530 532 533 538 539 541 544 547 548 566 573 581 588 599 610 611 618 625 628 635 638 649 651 652 653 656 661

1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1

662 666 669 673 679 685 692 693 696 698 701 708 713 716 721 723 735 736 737 742 743 753 759 761 771 775 776 778 789 794 795 811

1 0 0 1 1 1 1 0 0 1 1 1 1 1 1 1 0 0 1 1 0 1 1 1 1 0 1 1 1 1 0 1

813 816 817 821 825 827 829 835 836 837 840 843 848 850 853 858 862 869 872 876 877 885 888 895 900 902 903 905 907 917 919 941

1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 1 1

943 950 957 964 973 975 981 989 995 1000 1009 1010 1013 1014 1017 1018 1019 1025 1048

1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1

Levels: 1 0

> #Making confusion matrix

> cm <- table(test\_set$RB, y\_pred\_final)

> cm

y\_pred\_final

1 0

1 123 17

0 16 55

> accuracy <- (sum(diag(cm)) / sum(cm)) \* 100

> accuracy

[1] 84.36019

> precision <- (cm[1, "1"] / (cm[1, "1"] + cm[1, "0"])) \* 100

> precision

[1] 87.85714

> sensitivity <- (cm[1, "1"] / (cm[1, "1"] + cm[2, "1"])) \* 100

> sensitivity

[1] 88.48921

> specificity <- (cm[1, "0"] / (cm[1, "0"] + cm[1, "0"])) \* 100

> sensitivity

[1] 88.48921

> ROCPred <- prediction(as.numeric(y\_pred\_final), as.numeric(test\_set$RB))

> ROCPer <- performance(ROCPred, measure = "tpr", x.measure = "fpr")

> auc <- performance(ROCPred, measure = "auc")

> auc <- auc@y.values[[1]]

> auc

[1] 0.8266097

> # Plotting curve

> plot(ROCPer)

> plot(ROCPer, colorize = TRUE,

+ print.cutoffs.at = seq(0.1, by = 0.1),

+ main = "ROC CURVE")

> abline(a = 0, b = 1)

>

> auc <- round(auc, 4)

> legend(.6, .4, auc, title = "AUC", cex = 1)

>

> #Max-Depth - 10

> mtree <- rpart(RB ~ ., data=training\_set, method="class", control=rpart.control(minsplit=20, minbucket=7, maxdepth=10, usesurrogate=2, xval=10))

> #Predicting the test set result

> y\_pred\_final <- predict(mtree, newdata=test\_set[-16], type="class")

> y\_pred\_final

1 2 11 31 34 36 38 49 50 52 59 61 67 71 72 74 82 89 90 96 99 101 109 112 129 131 136 148 150 155 158 163

0 0 0 0 0 0 0 0 0 1 0 1 0 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 1

167 168 170 193 199 202 209 218 221 237 240 256 258 265 267 269 273 276 280 284 285 287 293 296 301 308 325 331 345 346 351 356

0 0 1 0 0 0 1 0 0 0 0 1 0 0 1 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1

357 358 364 365 367 380 382 385 390 391 395 397 399 402 410 417 420 425 431 435 439 446 449 457 460 462 468 470 471 477 479 487

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1

495 499 509 512 518 530 532 533 538 539 541 544 547 548 566 573 581 588 599 610 611 618 625 628 635 638 649 651 652 653 656 661

1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1

662 666 669 673 679 685 692 693 696 698 701 708 713 716 721 723 735 736 737 742 743 753 759 761 771 775 776 778 789 794 795 811

1 0 0 1 1 1 1 0 0 1 1 1 1 1 1 1 0 0 1 1 0 1 1 1 1 0 1 1 1 1 0 1

813 816 817 821 825 827 829 835 836 837 840 843 848 850 853 858 862 869 872 876 877 885 888 895 900 902 903 905 907 917 919 941

1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 1 1

943 950 957 964 973 975 981 989 995 1000 1009 1010 1013 1014 1017 1018 1019 1025 1048

1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1

Levels: 1 0

> #Making confusion matrix

> cm <- table(test\_set$RB, y\_pred\_final)

> cm

y\_pred\_final

1 0

1 123 17

0 16 55

> accuracy <- (sum(diag(cm)) / sum(cm)) \* 100

> accuracy

[1] 84.36019

> precision <- (cm[1, "1"] / (cm[1, "1"] + cm[1, "0"])) \* 100

> precision

[1] 87.85714

> sensitivity <- (cm[1, "1"] / (cm[1, "1"] + cm[2, "1"])) \* 100

> sensitivity

[1] 88.48921

> specificity <- (cm[1, "0"] / (cm[1, "0"] + cm[1, "0"])) \* 100

> sensitivity

[1] 88.48921

> ROCPred <- prediction(as.numeric(y\_pred\_final), as.numeric(test\_set$RB))

> ROCPer <- performance(ROCPred, measure = "tpr", x.measure = "fpr")

> auc <- performance(ROCPred, measure = "auc")

> auc <- auc@y.values[[1]]

> auc

[1] 0.8266097

> # Plotting curve

> plot(ROCPer)

> plot(ROCPer, colorize = TRUE,

+ print.cutoffs.at = seq(0.1, by = 0.1),

+ main = "ROC CURVE")

> abline(a = 0, b = 1)

>

> auc <- round(auc, 4)

> legend(.6, .4, auc, title = "AUC", cex = 1)

>

> #Random Forest

> #No. of trees - 500

> library(randomForest)

> classifier\_RF = randomForest(x=training\_set[-16], y=training\_set$RB, ntree=500) #First 4 columns as features, Species as dependent variable

> classifier\_RF

Call:

randomForest(x = training\_set[-16], y = training\_set$RB, ntree = 500)

Type of random forest: classification

Number of trees: 500

No. of variables tried at each split: 3

OOB estimate of error rate: 16.01%

Confusion matrix:

1 0 class.error

1 503 56 0.1001789

0 79 205 0.2781690

> y\_pred\_final <- predict(classifier\_RF, newdata=test\_set[-16], type="class")

> y\_pred\_final

1 2 11 31 34 36 38 49 50 52 59 61 67 71 72 74 82 89 90 96 99 101 109 112 129 131 136 148 150 155 158 163

0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 0 1 1 0 0 0 0 0 0 0 1 0 0 1 0 1

167 168 170 193 199 202 209 218 221 237 240 256 258 265 267 269 273 276 280 284 285 287 293 296 301 308 325 331 345 346 351 356

0 0 1 0 0 0 1 0 1 0 0 0 1 0 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1

357 358 364 365 367 380 382 385 390 391 395 397 399 402 410 417 420 425 431 435 439 446 449 457 460 462 468 470 471 477 479 487

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1

495 499 509 512 518 530 532 533 538 539 541 544 547 548 566 573 581 588 599 610 611 618 625 628 635 638 649 651 652 653 656 661

1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

662 666 669 673 679 685 692 693 696 698 701 708 713 716 721 723 735 736 737 742 743 753 759 761 771 775 776 778 789 794 795 811

1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 0 1 1 1 1 1 1 1 1 1 0 1

813 816 817 821 825 827 829 835 836 837 840 843 848 850 853 858 862 869 872 876 877 885 888 895 900 902 903 905 907 917 919 941

1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 1 1

943 950 957 964 973 975 981 989 995 1000 1009 1010 1013 1014 1017 1018 1019 1025 1048

1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1

Levels: 1 0

> #Making confusion matrix

> cm <- table(test\_set$RB, y\_pred\_final)

> cm

y\_pred\_final

1 0

1 129 11

0 17 54

> accuracy <- (sum(diag(cm)) / sum(cm)) \* 100

> accuracy

[1] 86.72986

> precision <- (cm[1, "1"] / (cm[1, "1"] + cm[1, "0"])) \* 100

> precision

[1] 92.14286

> sensitivity <- (cm[1, "1"] / (cm[1, "1"] + cm[2, "1"])) \* 100

> sensitivity

[1] 88.35616

> specificity <- (cm[1, "0"] / (cm[1, "0"] + cm[1, "0"])) \* 100

> sensitivity

[1] 88.35616

> ROCPred <- prediction(as.numeric(y\_pred\_final), as.numeric(test\_set$RB))

> ROCPer <- performance(ROCPred, measure = "tpr", x.measure = "fpr")

> auc <- performance(ROCPred, measure = "auc")

> auc <- auc@y.values[[1]]

> auc

[1] 0.840996

> # Plotting curve

> plot(ROCPer)

> plot(ROCPer, colorize = TRUE,

+ print.cutoffs.at = seq(0.1, by = 0.1),

+ main = "ROC CURVE")

> abline(a = 0, b = 1)

>

> auc <- round(auc, 4)

> legend(.6, .4, auc, title = "AUC", cex = 1)

>

> #No. of trees - 800

> library(randomForest)

> classifier\_RF = randomForest(x=training\_set[-16], y=training\_set$RB, ntree=800) #First 4 columns as features, Species as dependent variable

> classifier\_RF

Call:

randomForest(x = training\_set[-16], y = training\_set$RB, ntree = 800)

Type of random forest: classification

Number of trees: 800

No. of variables tried at each split: 3

OOB estimate of error rate: 15.54%

Confusion matrix:

1 0 class.error

1 507 52 0.09302326

0 79 205 0.27816901

> y\_pred\_final <- predict(classifier\_RF, newdata=test\_set[-16], type="class")

> y\_pred\_final

1 2 11 31 34 36 38 49 50 52 59 61 67 71 72 74 82 89 90 96 99 101 109 112 129 131 136 148 150 155 158 163

0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 0 1 1 0 0 0 0 0 0 0 1 0 0 1 0 1

167 168 170 193 199 202 209 218 221 237 240 256 258 265 267 269 273 276 280 284 285 287 293 296 301 308 325 331 345 346 351 356

0 0 1 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1

357 358 364 365 367 380 382 385 390 391 395 397 399 402 410 417 420 425 431 435 439 446 449 457 460 462 468 470 471 477 479 487

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1

495 499 509 512 518 530 532 533 538 539 541 544 547 548 566 573 581 588 599 610 611 618 625 628 635 638 649 651 652 653 656 661

1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

662 666 669 673 679 685 692 693 696 698 701 708 713 716 721 723 735 736 737 742 743 753 759 761 771 775 776 778 789 794 795 811

1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 0 1 1 1 1 1 1 1 1 1 0 1

813 816 817 821 825 827 829 835 836 837 840 843 848 850 853 858 862 869 872 876 877 885 888 895 900 902 903 905 907 917 919 941

1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 1 1

943 950 957 964 973 975 981 989 995 1000 1009 1010 1013 1014 1017 1018 1019 1025 1048

1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1

Levels: 1 0

> #Making confusion matrix

> cm <- table(test\_set$RB, y\_pred\_final)

> cm

y\_pred\_final

1 0

1 129 11

0 16 55

> accuracy <- (sum(diag(cm)) / sum(cm)) \* 100

> accuracy

[1] 87.20379

> precision <- (cm[1, "1"] / (cm[1, "1"] + cm[1, "0"])) \* 100

> precision

[1] 92.14286

> sensitivity <- (cm[1, "1"] / (cm[1, "1"] + cm[2, "1"])) \* 100

> sensitivity

[1] 88.96552

> specificity <- (cm[1, "0"] / (cm[1, "0"] + cm[1, "0"])) \* 100

> sensitivity

[1] 88.96552

> ROCPred <- prediction(as.numeric(y\_pred\_final), as.numeric(test\_set$RB))

> ROCPer <- performance(ROCPred, measure = "tpr", x.measure = "fpr")

> auc <- performance(ROCPred, measure = "auc")

> auc <- auc@y.values[[1]]

> auc

[1] 0.8480382

> # Plotting curve

> plot(ROCPer)

> plot(ROCPer, colorize = TRUE,

+ print.cutoffs.at = seq(0.1, by = 0.1),

+ main = "ROC CURVE")

> abline(a = 0, b = 1)

>

> auc <- round(auc, 4)

> legend(.6, .4, auc, title = "AUC", cex = 1)

**Day 13 – R Programming**

**Football Segmentation – KMeans**

> setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models/KMeans/Dataset")

> library(caret)

> library(broom)

> library(dplyr)

> #install.packages("dummy")

> library(dummy)

> library(ggplot2)

> #install.packages("ROCit")

> library(ROCit)

> library(purrr)

> library(tidyverse)

> library(magrittr)

> #install.packages("maps")

> library(maps)

> #install.packages("plotly")

> library(plotly)

> #install.packages("DT")

> library(DT)

> #install.packages("tidytext")

> library(tidytext)

> library(gridExtra)

> #install.packages("factoextra")

> library(factoextra)

>

> #Read the Data

> raw\_data <- read.csv("data.csv")

> head(raw\_data)

ï.. ID Name Age Photo Nationality Flag Overall Potential

1 0 158023 L. Messi 31 https://cdn.sofifa.org/players/4/19/158023.png Argentina https://cdn.sofifa.org/flags/52.png 94 94

2 1 20801 Cristiano Ronaldo 33 https://cdn.sofifa.org/players/4/19/20801.png Portugal https://cdn.sofifa.org/flags/38.png 94 94

3 2 190871 Neymar Jr 26 https://cdn.sofifa.org/players/4/19/190871.png Brazil https://cdn.sofifa.org/flags/54.png 92 93

4 3 193080 De Gea 27 https://cdn.sofifa.org/players/4/19/193080.png Spain https://cdn.sofifa.org/flags/45.png 91 93

5 4 192985 K. De Bruyne 27 https://cdn.sofifa.org/players/4/19/192985.png Belgium https://cdn.sofifa.org/flags/7.png 91 92

6 5 183277 E. Hazard 27 https://cdn.sofifa.org/players/4/19/183277.png Belgium https://cdn.sofifa.org/flags/7.png 91 91

Club Club.Logo Value Wage Special Preferred.Foot International.Reputation Weak.Foot

1 FC Barcelona https://cdn.sofifa.org/teams/2/light/241.png â‚¬110.5M â‚¬565K 2202 Left 5 4

2 Juventus https://cdn.sofifa.org/teams/2/light/45.png â‚¬77M â‚¬405K 2228 Right 5 4

3 Paris Saint-Germain https://cdn.sofifa.org/teams/2/light/73.png â‚¬118.5M â‚¬290K 2143 Right 5 5

4 Manchester United https://cdn.sofifa.org/teams/2/light/11.png â‚¬72M â‚¬260K 1471 Right 4 3

5 Manchester City https://cdn.sofifa.org/teams/2/light/10.png â‚¬102M â‚¬355K 2281 Right 4 5

6 Chelsea https://cdn.sofifa.org/teams/2/light/5.png â‚¬93M â‚¬340K 2142 Right 4 4

Skill.Moves Work.Rate Body.Type Real.Face Position Jersey.Number Joined Loaned.From Contract.Valid.Until Height Weight LS ST RS LW

1 4 Medium/ Medium Messi Yes RF 10 Jul 1, 2004 2021 5'7 159lbs 88+2 88+2 88+2 92+2

2 5 High/ Low C. Ronaldo Yes ST 7 Jul 10, 2018 2022 6'2 183lbs 91+3 91+3 91+3 89+3

3 5 High/ Medium Neymar Yes LW 10 Aug 3, 2017 2022 5'9 150lbs 84+3 84+3 84+3 89+3

4 1 Medium/ Medium Lean Yes GK 1 Jul 1, 2011 2020 6'4 168lbs

5 4 High/ High Normal Yes RCM 7 Aug 30, 2015 2023 5'11 154lbs 82+3 82+3 82+3 87+3

6 4 High/ Medium Normal Yes LF 10 Jul 1, 2012 2020 5'8 163lbs 83+3 83+3 83+3 89+3

LF CF RF RW LAM CAM RAM LM LCM CM RCM RM LWB LDM CDM RDM RWB LB LCB CB RCB RB Crossing Finishing HeadingAccuracy

1 93+2 93+2 93+2 92+2 93+2 93+2 93+2 91+2 84+2 84+2 84+2 91+2 64+2 61+2 61+2 61+2 64+2 59+2 47+2 47+2 47+2 59+2 84 95 70

2 90+3 90+3 90+3 89+3 88+3 88+3 88+3 88+3 81+3 81+3 81+3 88+3 65+3 61+3 61+3 61+3 65+3 61+3 53+3 53+3 53+3 61+3 84 94 89

3 89+3 89+3 89+3 89+3 89+3 89+3 89+3 88+3 81+3 81+3 81+3 88+3 65+3 60+3 60+3 60+3 65+3 60+3 47+3 47+3 47+3 60+3 79 87 62

4 17 13 21

5 87+3 87+3 87+3 87+3 88+3 88+3 88+3 88+3 87+3 87+3 87+3 88+3 77+3 77+3 77+3 77+3 77+3 73+3 66+3 66+3 66+3 73+3 93 82 55

6 88+3 88+3 88+3 89+3 89+3 89+3 89+3 89+3 82+3 82+3 82+3 89+3 66+3 63+3 63+3 63+3 66+3 60+3 49+3 49+3 49+3 60+3 81 84 61

ShortPassing Volleys Dribbling Curve FKAccuracy LongPassing BallControl Acceleration SprintSpeed Agility Reactions Balance ShotPower Jumping Stamina

1 90 86 97 93 94 87 96 91 86 91 95 95 85 68 72

2 81 87 88 81 76 77 94 89 91 87 96 70 95 95 88

3 84 84 96 88 87 78 95 94 90 96 94 84 80 61 81

4 50 13 18 21 19 51 42 57 58 60 90 43 31 67 43

5 92 82 86 85 83 91 91 78 76 79 91 77 91 63 90

6 89 80 95 83 79 83 94 94 88 95 90 94 82 56 83

Strength LongShots Aggression Interceptions Positioning Vision Penalties Composure Marking StandingTackle SlidingTackle GKDiving GKHandling GKKicking

1 59 94 48 22 94 94 75 96 33 28 26 6 11 15

2 79 93 63 29 95 82 85 95 28 31 23 7 11 15

3 49 82 56 36 89 87 81 94 27 24 33 9 9 15

4 64 12 38 30 12 68 40 68 15 21 13 90 85 87

5 75 91 76 61 87 94 79 88 68 58 51 15 13 5

6 66 80 54 41 87 89 86 91 34 27 22 11 12 6

GKPositioning GKReflexes Release.Clause

1 14 8 â‚¬226.5M

2 14 11 â‚¬127.1M

3 15 11 â‚¬228.1M

4 88 94 â‚¬138.6M

5 10 13 â‚¬196.4M

6 8 8 â‚¬172.1M

> names(raw\_data)

[1] "ï.." "ID" "Name" "Age" "Photo"

[6] "Nationality" "Flag" "Overall" "Potential" "Club"

[11] "Club.Logo" "Value" "Wage" "Special" "Preferred.Foot"

[16] "International.Reputation" "Weak.Foot" "Skill.Moves" "Work.Rate" "Body.Type"

[21] "Real.Face" "Position" "Jersey.Number" "Joined" "Loaned.From"

[26] "Contract.Valid.Until" "Height" "Weight" "LS" "ST"

[31] "RS" "LW" "LF" "CF" "RF"

[36] "RW" "LAM" "CAM" "RAM" "LM"

[41] "LCM" "CM" "RCM" "RM" "LWB"

[46] "LDM" "CDM" "RDM" "RWB" "LB"

[51] "LCB" "CB" "RCB" "RB" "Crossing"

[56] "Finishing" "HeadingAccuracy" "ShortPassing" "Volleys" "Dribbling"

[61] "Curve" "FKAccuracy" "LongPassing" "BallControl" "Acceleration"

[66] "SprintSpeed" "Agility" "Reactions" "Balance" "ShotPower"

[71] "Jumping" "Stamina" "Strength" "LongShots" "Aggression"

[76] "Interceptions" "Positioning" "Vision" "Penalties" "Composure"

[81] "Marking" "StandingTackle" "SlidingTackle" "GKDiving" "GKHandling"

[86] "GKKicking" "GKPositioning" "GKReflexes" "Release.Clause"

>

> #Data types & Dimensions

> str(raw\_data)

'data.frame': 18207 obs. of 89 variables:

$ ï.. : int 0 1 2 3 4 5 6 7 8 9 ...

$ ID : int 158023 20801 190871 193080 192985 183277 177003 176580 155862 200389 ...

$ Name : chr "L. Messi" "Cristiano Ronaldo" "Neymar Jr" "De Gea" ...

$ Age : int 31 33 26 27 27 27 32 31 32 25 ...

$ Photo : chr "https://cdn.sofifa.org/players/4/19/158023.png" "https://cdn.sofifa.org/players/4/19/20801.png" "https://cdn.sofifa.org/players/4/19/190871.png" "https://cdn.sofifa.org/players/4/19/193080.png" ...

$ Nationality : chr "Argentina" "Portugal" "Brazil" "Spain" ...

$ Flag : chr "https://cdn.sofifa.org/flags/52.png" "https://cdn.sofifa.org/flags/38.png" "https://cdn.sofifa.org/flags/54.png" "https://cdn.sofifa.org/flags/45.png" ...

$ Overall : int 94 94 92 91 91 91 91 91 91 90 ...

$ Potential : int 94 94 93 93 92 91 91 91 91 93 ...

$ Club : chr "FC Barcelona" "Juventus" "Paris Saint-Germain" "Manchester United" ...

$ Club.Logo : chr "https://cdn.sofifa.org/teams/2/light/241.png" "https://cdn.sofifa.org/teams/2/light/45.png" "https://cdn.sofifa.org/teams/2/light/73.png" "https://cdn.sofifa.org/teams/2/light/11.png" ...

$ Value : chr "â‚¬110.5M" "â‚¬77M" "â‚¬118.5M" "â‚¬72M" ...

$ Wage : chr "â‚¬565K" "â‚¬405K" "â‚¬290K" "â‚¬260K" ...

$ Special : int 2202 2228 2143 1471 2281 2142 2280 2346 2201 1331 ...

$ Preferred.Foot : chr "Left" "Right" "Right" "Right" ...

$ International.Reputation: int 5 5 5 4 4 4 4 5 4 3 ...

$ Weak.Foot : int 4 4 5 3 5 4 4 4 3 3 ...

$ Skill.Moves : int 4 5 5 1 4 4 4 3 3 1 ...

$ Work.Rate : chr "Medium/ Medium" "High/ Low" "High/ Medium" "Medium/ Medium" ...

$ Body.Type : chr "Messi" "C. Ronaldo" "Neymar" "Lean" ...

$ Real.Face : chr "Yes" "Yes" "Yes" "Yes" ...

$ Position : chr "RF" "ST" "LW" "GK" ...

$ Jersey.Number : int 10 7 10 1 7 10 10 9 15 1 ...

$ Joined : chr "Jul 1, 2004" "Jul 10, 2018" "Aug 3, 2017" "Jul 1, 2011" ...

$ Loaned.From : chr "" "" "" "" ...

$ Contract.Valid.Until : chr "2021" "2022" "2022" "2020" ...

$ Height : chr "5'7" "6'2" "5'9" "6'4" ...

$ Weight : chr "159lbs" "183lbs" "150lbs" "168lbs" ...

$ LS : chr "88+2" "91+3" "84+3" "" ...

$ ST : chr "88+2" "91+3" "84+3" "" ...

$ RS : chr "88+2" "91+3" "84+3" "" ...

$ LW : chr "92+2" "89+3" "89+3" "" ...

$ LF : chr "93+2" "90+3" "89+3" "" ...

$ CF : chr "93+2" "90+3" "89+3" "" ...

$ RF : chr "93+2" "90+3" "89+3" "" ...

$ RW : chr "92+2" "89+3" "89+3" "" ...

$ LAM : chr "93+2" "88+3" "89+3" "" ...

$ CAM : chr "93+2" "88+3" "89+3" "" ...

$ RAM : chr "93+2" "88+3" "89+3" "" ...

$ LM : chr "91+2" "88+3" "88+3" "" ...

$ LCM : chr "84+2" "81+3" "81+3" "" ...

$ CM : chr "84+2" "81+3" "81+3" "" ...

$ RCM : chr "84+2" "81+3" "81+3" "" ...

$ RM : chr "91+2" "88+3" "88+3" "" ...

$ LWB : chr "64+2" "65+3" "65+3" "" ...

$ LDM : chr "61+2" "61+3" "60+3" "" ...

$ CDM : chr "61+2" "61+3" "60+3" "" ...

$ RDM : chr "61+2" "61+3" "60+3" "" ...

$ RWB : chr "64+2" "65+3" "65+3" "" ...

$ LB : chr "59+2" "61+3" "60+3" "" ...

$ LCB : chr "47+2" "53+3" "47+3" "" ...

$ CB : chr "47+2" "53+3" "47+3" "" ...

$ RCB : chr "47+2" "53+3" "47+3" "" ...

$ RB : chr "59+2" "61+3" "60+3" "" ...

$ Crossing : int 84 84 79 17 93 81 86 77 66 13 ...

$ Finishing : int 95 94 87 13 82 84 72 93 60 11 ...

$ HeadingAccuracy : int 70 89 62 21 55 61 55 77 91 15 ...

$ ShortPassing : int 90 81 84 50 92 89 93 82 78 29 ...

$ Volleys : int 86 87 84 13 82 80 76 88 66 13 ...

$ Dribbling : int 97 88 96 18 86 95 90 87 63 12 ...

$ Curve : int 93 81 88 21 85 83 85 86 74 13 ...

$ FKAccuracy : int 94 76 87 19 83 79 78 84 72 14 ...

$ LongPassing : int 87 77 78 51 91 83 88 64 77 26 ...

$ BallControl : int 96 94 95 42 91 94 93 90 84 16 ...

$ Acceleration : int 91 89 94 57 78 94 80 86 76 43 ...

$ SprintSpeed : int 86 91 90 58 76 88 72 75 75 60 ...

$ Agility : int 91 87 96 60 79 95 93 82 78 67 ...

$ Reactions : int 95 96 94 90 91 90 90 92 85 86 ...

$ Balance : int 95 70 84 43 77 94 94 83 66 49 ...

$ ShotPower : int 85 95 80 31 91 82 79 86 79 22 ...

$ Jumping : int 68 95 61 67 63 56 68 69 93 76 ...

$ Stamina : int 72 88 81 43 90 83 89 90 84 41 ...

$ Strength : int 59 79 49 64 75 66 58 83 83 78 ...

$ LongShots : int 94 93 82 12 91 80 82 85 59 12 ...

$ Aggression : int 48 63 56 38 76 54 62 87 88 34 ...

$ Interceptions : int 22 29 36 30 61 41 83 41 90 19 ...

$ Positioning : int 94 95 89 12 87 87 79 92 60 11 ...

$ Vision : int 94 82 87 68 94 89 92 84 63 70 ...

$ Penalties : int 75 85 81 40 79 86 82 85 75 11 ...

$ Composure : int 96 95 94 68 88 91 84 85 82 70 ...

$ Marking : int 33 28 27 15 68 34 60 62 87 27 ...

$ StandingTackle : int 28 31 24 21 58 27 76 45 92 12 ...

$ SlidingTackle : int 26 23 33 13 51 22 73 38 91 18 ...

$ GKDiving : int 6 7 9 90 15 11 13 27 11 86 ...

$ GKHandling : int 11 11 9 85 13 12 9 25 8 92 ...

$ GKKicking : int 15 15 15 87 5 6 7 31 9 78 ...

$ GKPositioning : int 14 14 15 88 10 8 14 33 7 88 ...

$ GKReflexes : int 8 11 11 94 13 8 9 37 11 89 ...

$ Release.Clause : chr "â‚¬226.5M" "â‚¬127.1M" "â‚¬228.1M" "â‚¬138.6M" ...

> dim(raw\_data)

[1] 18207 89

> nrow(raw\_data)

[1] 18207

> ncol(raw\_data)

[1] 89

>

> #Data Manipulation

> df <- raw\_data[, c(2:4, 6, 8, 9, 10, 12, 13, 15:23, 27, 28, 55:60, 66:74, 89)]

> head(df)

ID Name Age Nationality Overall Potential Club Value Wage Preferred.Foot International.Reputation Weak.Foot

1 158023 L. Messi 31 Argentina 94 94 FC Barcelona â‚¬110.5M â‚¬565K Left 5 4

2 20801 Cristiano Ronaldo 33 Portugal 94 94 Juventus â‚¬77M â‚¬405K Right 5 4

3 190871 Neymar Jr 26 Brazil 92 93 Paris Saint-Germain â‚¬118.5M â‚¬290K Right 5 5

4 193080 De Gea 27 Spain 91 93 Manchester United â‚¬72M â‚¬260K Right 4 3

5 192985 K. De Bruyne 27 Belgium 91 92 Manchester City â‚¬102M â‚¬355K Right 4 5

6 183277 E. Hazard 27 Belgium 91 91 Chelsea â‚¬93M â‚¬340K Right 4 4

Skill.Moves Work.Rate Body.Type Real.Face Position Jersey.Number Height Weight Crossing Finishing HeadingAccuracy ShortPassing Volleys Dribbling

1 4 Medium/ Medium Messi Yes RF 10 5'7 159lbs 84 95 70 90 86 97

2 5 High/ Low C. Ronaldo Yes ST 7 6'2 183lbs 84 94 89 81 87 88

3 5 High/ Medium Neymar Yes LW 10 5'9 150lbs 79 87 62 84 84 96

4 1 Medium/ Medium Lean Yes GK 1 6'4 168lbs 17 13 21 50 13 18

5 4 High/ High Normal Yes RCM 7 5'11 154lbs 93 82 55 92 82 86

6 4 High/ Medium Normal Yes LF 10 5'8 163lbs 81 84 61 89 80 95

SprintSpeed Agility Reactions Balance ShotPower Jumping Stamina Strength LongShots Release.Clause

1 86 91 95 95 85 68 72 59 94 â‚¬226.5M

2 91 87 96 70 95 95 88 79 93 â‚¬127.1M

3 90 96 94 84 80 61 81 49 82 â‚¬228.1M

4 58 60 90 43 31 67 43 64 12 â‚¬138.6M

5 76 79 91 77 91 63 90 75 91 â‚¬196.4M

6 88 95 90 94 82 56 83 66 80 â‚¬172.1M

> #Create League variable & Sampling

> df <- raw\_data

> bundesliga <- c("1. FC Nürnberg", "1. FSV Mainz 05", "Bayer 04 Leverkusen", "FC Bayern München",

+ "Borussia Dortmund", "Borussia Mönchengladbach", "Eintracht Frankfurt",

+ "FC Augsburg", "FC Schalke 04", "Fortuna Düsseldorf", "Hannover 96",

+ "Hertha BSC", "RB Leipzig", "SC Freiburg", "TSG 1899 Hoffenheim",

+ "VfB Stuttgart", "VfL Wolfsburg", "SV Werder Bremen")

> premierLeague <- c("Arsenal", "Bournemouth", "Brighton & Hove Albion", "Burnley",

+ "Cardiff City", "Chelsea", "Crystal Palace", "Everton", "Fulham",

+ "Huddersfield Town", "Leicester City", "Liverpool", "Manchester City",

+ "Manchester United", "Newcastle United", "Southampton",

+ "Tottenham Hotspur", "Watford", "West Ham United", "Wolverhampton Wanderers")

> laliga <- c("Athletic Club de Bilbao", "Atlético Madrid", "CD Leganés",

+ "Deportivo Alavés", "FC Barcelona", "Getafe CF", "Girona FC",

+ "Levante UD", "Rayo Vallecano", "RC Celta", "RCD Espanyol",

+ "Real Betis", "Real Madrid", "Real Sociedad", "Real Valladolid CF",

+ "SD Eibar", "SD Huesca", "Sevilla FC", "Valencia CF", "Villarreal CF")

> seriea <- c("Atalanta","Bologna","Cagliari","Chievo Verona","Empoli", "Fiorentina","Frosinone","Genoa",

+ "Inter","Juventus","Lazio","Milan","Napoli","Parma","Roma","Sampdoria","Sassuolo","SPAL",

+ "Torino","Udinese")

> superlig <- c("Akhisar Belediyespor","Alanyaspor", "Antalyaspor","Medipol Başakşehir FK","BB Erzurumspor","Beşiktaş JK",

+ "Bursaspor","Çaykur Rizespor","Fenerbahçe SK", "Galatasaray SK","Göztepe SK","Kasimpaşa SK",

+ "Kayserispor","Atiker Konyaspor","MKE Ankaragücü", "Sivasspor","Trabzonspor","Yeni Malatyaspor")

> ligue1 <- c("Amiens SC", "Angers SCO", "AS Monaco", "AS Saint-Étienne", "Dijon FCO", "En Avant de Guingamp",

+ "FC Nantes", "FC Girondins de Bordeaux", "LOSC Lille", "Montpellier HSC", "Nîmes Olympique",

+ "OGC Nice", "Olympique Lyonnais","Olympique de Marseille", "Paris Saint-Germain",

+ "RC Strasbourg Alsace", "Stade Malherbe Caen", "Stade de Reims", "Stade Rennais FC", "Toulouse Football Club")

> eredivisie <- c("ADO Den Haag","Ajax", "AZ Alkmaar", "De Graafschap","Excelsior","FC Emmen","FC Groningen",

+ "FC Utrecht", "Feyenoord","Fortuna Sittard", "Heracles Almelo","NAC Breda",

+ "PEC Zwolle", "PSV","SC Heerenveen","Vitesse","VVV-Venlo","Willem II")

> liganos <- c("Os Belenenses", "Boavista FC", "CD Feirense", "CD Tondela", "CD Aves", "FC Porto",

+ "CD Nacional", "GD Chaves", "Clube Sport Marítimo", "Moreirense FC", "Portimonense SC", "Rio Ave FC",

+ "Santa Clara", "SC Braga", "SL Benfica", "Sporting CP", "Vitória Guimarães", "Vitória de Setúbal")

> df%<>%mutate(

+ League = case\_when(

+ Club %in% bundesliga ~ "Bundesliga",

+ Club %in% premierLeague ~ "Premier League",

+ Club %in% laliga ~ "La Liga",

+ Club %in% seriea ~ "Serie A",

+ Club %in% superlig ~ "Süper Lig",

+ Club %in% ligue1 ~ "Ligue 1",

+ Club %in% liganos ~ "Liga Nos",

+ Club %in% eredivisie ~ "Eredivisie"

+ ),

+ Country = case\_when(

+ League == "Bundesliga" ~ "Germany",

+ League == "Premier League" ~ "UK",

+ League == "La Liga" ~ "Spain",

+ League == "Serie A" ~ "Italy",

+ League == "Süper Lig" ~ "Turkey",

+ League == "Ligue 1" ~ "France",

+ League == "Liga Nos" ~ "Portugal",

+ League == "Eredivisie" ~ "Netherlands"

+ )

+ ) %>% filter(!is.na(League)) %>% mutate\_if(is.factor, as.character)

> rm(bundesliga, premierLeague, laliga, seriea, superlig, ligue1, eredivisie, liganos)

> #String Manipulation

> head(df$Value)

[1] "â‚¬110.5M" "â‚¬77M" "â‚¬118.5M" "â‚¬72M" "â‚¬102M" "â‚¬93M"

> df$Values <- str\_remove\_all(df$Value, "€") #Player values

> df$Values <- str\_replace\_all(df$Values, "K", "000")

> df$Values <- str\_remove\_all(df$Values, "M")

> df$Values <- as.numeric(df$Values)

> head(df$Values)

[1] 110.5 77.0 118.5 72.0 102.0 93.0

> df$Wages <- str\_remove\_all(df$Wage, "€") #Player wages

> df$Wages <- str\_replace\_all(df$Wages, "K", "000")

> df$Wages <- as.numeric(df$Wages)

> head(df$Wages)

[1] 565000 405000 290000 260000 355000 340000

> data\_1 <- df%>%mutate(Values = if\_else(df$Values < 1000, Values \* 1000000, Values)) #Million Tranformation

> #Create Position class

> unique(data\_1$Position)

[1] "RF" "ST" "LW" "GK" "RCM" "LF" "RS" "RCB" "LCM" "LDM" "CDM" "LS" "LCB" "RM" "CAM" "LM" "LB" "CB" "RDM" "RW" "RB" "CM" "RAM" "CF"

[25] "LAM" "RWB" "LWB" ""

> defence <- c("CB", "RB", "LB", "LWB", "RWB", "LCB", "RCB")

> midfielder <- c("CM", "CDM","CAM","LM","RM", "LAM", "RAM", "LCM", "RCM", "LDM", "RDM")

> data\_2 <- data\_1

> data\_2 %<>% mutate(Class = if\_else(Position%in%"GK", "Goal Keeper",

+ if\_else(Position%in%defence, "Defender",

+ if\_else(Position%in%midfielder, "Midfielder", "Forward"))))

> rm(defence, midfielder)

> head(data\_2$Class)

[1] "Forward" "Forward" "Forward" "Goal Keeper" "Midfielder" "Forward"

> #Height & Weight

> data\_3 <- data\_2

> data\_3 %<>% mutate(Height = round((as.numeric(str\_sub(Height, start=1, end=1))\*30.48) + (as.numeric(str\_sub(Height, start=3, end=5))\*2.54)),

+ Weight = round(as.numeric(str\_sub(Weight, start=1, end=3)) / 2.204623))

> head(data\_3)

ï.. ID Name Age Photo Nationality Flag Overall Potential

1 0 158023 L. Messi 31 https://cdn.sofifa.org/players/4/19/158023.png Argentina https://cdn.sofifa.org/flags/52.png 94 94

2 1 20801 Cristiano Ronaldo 33 https://cdn.sofifa.org/players/4/19/20801.png Portugal https://cdn.sofifa.org/flags/38.png 94 94

3 2 190871 Neymar Jr 26 https://cdn.sofifa.org/players/4/19/190871.png Brazil https://cdn.sofifa.org/flags/54.png 92 93

4 3 193080 De Gea 27 https://cdn.sofifa.org/players/4/19/193080.png Spain https://cdn.sofifa.org/flags/45.png 91 93

5 4 192985 K. De Bruyne 27 https://cdn.sofifa.org/players/4/19/192985.png Belgium https://cdn.sofifa.org/flags/7.png 91 92

6 5 183277 E. Hazard 27 https://cdn.sofifa.org/players/4/19/183277.png Belgium https://cdn.sofifa.org/flags/7.png 91 91

Club Club.Logo Value Wage Special Preferred.Foot International.Reputation Weak.Foot

1 FC Barcelona https://cdn.sofifa.org/teams/2/light/241.png â‚¬110.5M â‚¬565K 2202 Left 5 4

2 Juventus https://cdn.sofifa.org/teams/2/light/45.png â‚¬77M â‚¬405K 2228 Right 5 4

3 Paris Saint-Germain https://cdn.sofifa.org/teams/2/light/73.png â‚¬118.5M â‚¬290K 2143 Right 5 5

4 Manchester United https://cdn.sofifa.org/teams/2/light/11.png â‚¬72M â‚¬260K 1471 Right 4 3

5 Manchester City https://cdn.sofifa.org/teams/2/light/10.png â‚¬102M â‚¬355K 2281 Right 4 5

6 Chelsea https://cdn.sofifa.org/teams/2/light/5.png â‚¬93M â‚¬340K 2142 Right 4 4

Skill.Moves Work.Rate Body.Type Real.Face Position Jersey.Number Joined Loaned.From Contract.Valid.Until Height Weight LS ST RS LW

1 4 Medium/ Medium Messi Yes RF 10 Jul 1, 2004 2021 170 72 88+2 88+2 88+2 92+2

2 5 High/ Low C. Ronaldo Yes ST 7 Jul 10, 2018 2022 188 83 91+3 91+3 91+3 89+3

3 5 High/ Medium Neymar Yes LW 10 Aug 3, 2017 2022 175 68 84+3 84+3 84+3 89+3

4 1 Medium/ Medium Lean Yes GK 1 Jul 1, 2011 2020 193 76

5 4 High/ High Normal Yes RCM 7 Aug 30, 2015 2023 180 70 82+3 82+3 82+3 87+3

6 4 High/ Medium Normal Yes LF 10 Jul 1, 2012 2020 173 74 83+3 83+3 83+3 89+3

LF CF RF RW LAM CAM RAM LM LCM CM RCM RM LWB LDM CDM RDM RWB LB LCB CB RCB RB Crossing Finishing HeadingAccuracy

1 93+2 93+2 93+2 92+2 93+2 93+2 93+2 91+2 84+2 84+2 84+2 91+2 64+2 61+2 61+2 61+2 64+2 59+2 47+2 47+2 47+2 59+2 84 95 70

2 90+3 90+3 90+3 89+3 88+3 88+3 88+3 88+3 81+3 81+3 81+3 88+3 65+3 61+3 61+3 61+3 65+3 61+3 53+3 53+3 53+3 61+3 84 94 89

3 89+3 89+3 89+3 89+3 89+3 89+3 89+3 88+3 81+3 81+3 81+3 88+3 65+3 60+3 60+3 60+3 65+3 60+3 47+3 47+3 47+3 60+3 79 87 62

4 17 13 21

5 87+3 87+3 87+3 87+3 88+3 88+3 88+3 88+3 87+3 87+3 87+3 88+3 77+3 77+3 77+3 77+3 77+3 73+3 66+3 66+3 66+3 73+3 93 82 55

6 88+3 88+3 88+3 89+3 89+3 89+3 89+3 89+3 82+3 82+3 82+3 89+3 66+3 63+3 63+3 63+3 66+3 60+3 49+3 49+3 49+3 60+3 81 84 61

ShortPassing Volleys Dribbling Curve FKAccuracy LongPassing BallControl Acceleration SprintSpeed Agility Reactions Balance ShotPower Jumping Stamina

1 90 86 97 93 94 87 96 91 86 91 95 95 85 68 72

2 81 87 88 81 76 77 94 89 91 87 96 70 95 95 88

3 84 84 96 88 87 78 95 94 90 96 94 84 80 61 81

4 50 13 18 21 19 51 42 57 58 60 90 43 31 67 43

5 92 82 86 85 83 91 91 78 76 79 91 77 91 63 90

6 89 80 95 83 79 83 94 94 88 95 90 94 82 56 83

Strength LongShots Aggression Interceptions Positioning Vision Penalties Composure Marking StandingTackle SlidingTackle GKDiving GKHandling GKKicking

1 59 94 48 22 94 94 75 96 33 28 26 6 11 15

2 79 93 63 29 95 82 85 95 28 31 23 7 11 15

3 49 82 56 36 89 87 81 94 27 24 33 9 9 15

4 64 12 38 30 12 68 40 68 15 21 13 90 85 87

5 75 91 76 61 87 94 79 88 68 58 51 15 13 5

6 66 80 54 41 87 89 86 91 34 27 22 11 12 6

GKPositioning GKReflexes Release.Clause League Country Values Wages Class

1 14 8 â‚¬226.5M La Liga Spain 110500000 565000 Forward

2 14 11 â‚¬127.1M Serie A Italy 77000000 405000 Forward

3 15 11 â‚¬228.1M Ligue 1 France 118500000 290000 Forward

4 88 94 â‚¬138.6M Premier League UK 72000000 260000 Goal Keeper

5 10 13 â‚¬196.4M Premier League UK 102000000 355000 Midfielder

6 8 8 â‚¬172.1M Premier League UK 93000000 340000 Forward

> #Correction of Preferred Foot variable

> data\_4 <- data\_3

> data\_4 %<>% filter(Preferred.Foot%in%c("Left", "Right"))

> data\_4$Preferred.Foot <- as.factor(as.character(data\_4$Preferred.Foot))

> unique(data\_4$Preferred.Foot)

[1] Left Right

Levels: Left Right

> #Rename some variables

> data\_5 <- data\_4

> data\_5 %<>% rename(

+ "Heading.Accuracy" = HeadingAccuracy,

+ "Short.Passing" = ShortPassing,

+ "FK.Accuracy" = FKAccuracy,

+ "Long.Passing" = LongPassing,

+ "Ball.Control" = BallControl,

+ "Sprint.Speed" = SprintSpeed,

+ "Shot.Power" = ShotPower,

+ "Long.Shots"= LongShots,

+ "Standing.Tackle"= StandingTackle,

+ "Sliding.Tackle"= SlidingTackle,

+ "GK.Diving"= GKDiving,

+ "GK.Handling"= GKHandling,

+ "GK.Kicking"= GKKicking,

+ "GK.Positioning"= GKPositioning,

+ "GK.Reflexes"= GKReflexes

+ )

> #Remove unnecessary values

> data\_6 <- data\_5

> data\_6 %<>% select(-ID, -Body.Type, -Real.Face, -Joined, -Loaned.From, -Release.Clause, -Photo, -Flag, -Special, -Work.Rate)

> data\_manipulated <- data\_6

>

> #Dealing with Missing Values

> colSums(is.na(data\_manipulated))

ï.. Name Age Nationality Overall Potential

0 0 0 0 0 0

Club Club.Logo Value Wage Preferred.Foot International.Reputation

0 0 0 0 0 0

Weak.Foot Skill.Moves Position Jersey.Number Contract.Valid.Until Height

0 0 0 0 0 0

Weight LS ST RS LW LF

0 0 0 0 0 0

CF RF RW LAM CAM RAM

0 0 0 0 0 0

LM LCM CM RCM RM LWB

0 0 0 0 0 0

LDM CDM RDM RWB LB LCB

0 0 0 0 0 0

CB RCB RB Crossing Finishing Heading.Accuracy

0 0 0 0 0 0

Short.Passing Volleys Dribbling Curve FK.Accuracy Long.Passing

0 0 0 0 0 0

Ball.Control Acceleration Sprint.Speed Agility Reactions Balance

0 0 0 0 0 0

Shot.Power Jumping Stamina Strength Long.Shots Aggression

0 0 0 0 0 0

Interceptions Positioning Vision Penalties Composure Marking

0 0 0 0 0 0

Standing.Tackle Sliding.Tackle GK.Diving GK.Handling GK.Kicking GK.Positioning

0 0 0 0 0 0

GK.Reflexes League Country Values Wages Class

0 0 0 0 0 0

>

> #Visualization

> #Distribution & Avg. of Players in each League

> summ <- data\_manipulated %>% group\_by(League) %>% summarise(age=mean(Age), .groups='drop')

> summ

# A tibble: 8 x 2

League age

<chr> <dbl>

1 Bundesliga 24.2

2 Eredivisie 23.3

3 La Liga 24.8

4 Liga Nos 25.5

5 Ligue 1 24.3

6 Premier League 24.6

7 Serie A 25.7

8 Süper Lig 26.5

> options(repr.plot.width = 12, repr.plot.height = 8)

> ggplot()+

+ geom\_histogram(data\_manipulated, mapping = aes(Age, fill = League),bins=10)+

+ geom\_vline(summ, mapping = aes(xintercept = age), color = "red", size = 1.5)+

+ geom\_text(summ, mapping = aes(x = age+3, y = 65, label = round(age,digits = 2)))+

+ facet\_wrap(League~.)+

+ theme\_minimal()+

+ theme(legend.position = "bottom")+

+ labs(y = "Frequency", title = "Distribution & The Average Age of The Players in each League", caption = "@EA Sports - FIFA 19")

> #Distribution of Total Market value in each League

> data\_manipulated %>%

+ group\_by(League) %>%

+ summarise(Total.Value = sum(as.numeric(Values), na.rm = TRUE),.groups = 'drop') %>%

+ ggplot(aes(reorder(League, Total.Value), Total.Value, fill = Total.Value))+

+ geom\_col(show.legend = FALSE)+

+ coord\_flip()+

+ theme\_minimal()+

+ labs(x = NULL, y = "Market Values of rhe Leagues")+

+ scale\_fill\_gradient(low = "khaki", high = "seagreen")+

+ theme(axis.line.y = element\_line(colour = "darkslategray"),

+ axis.ticks.x = element\_line(colour = "darkslategray"))+

+ scale\_y\_continuous(labels = c("0 €", "2 Billion €", "4 Billion €", "6 Billion €"))

> #Interactive World Map & No. of Players

> options(repr.plot.width = 12, repr.plot.height = 8)

> world\_map <- map\_data("world")

> numofplayers <- world\_map %>%

+ mutate(region = as.character(region)) %>%

+ left\_join((data\_manipulated %>% mutate(Nationality = as.character(Nationality),

+ Nationality = if\_else(Nationality %in% "England",

+ "UK", Nationality)) %>%

+ #filter(League == "Bundesliga") %>%

+ count(Nationality, name = "Number of Player") %>%

+ rename(region = Nationality) %>%

+ mutate(region = as.character(region))), by = "region")

> ggplot(numofplayers, aes(long, lat, group = group))+

+ geom\_polygon(aes(fill = `Number of Player` ), color = "white", show.legend = FALSE)+

+ scale\_fill\_viridis\_c(option = "C")+

+ theme\_void()+

+ labs(fill = "Number of Player",

+ title = "Number of Player in FIFA 19")

> #Comparison of 2 players

> # Selection of the players

> players <- data\_manipulated %>%

+ filter(Name %in% c("Cristiano Ronaldo", "L. Messi")) %>%

+ # Unite Name & Club variables

+ mutate(Name = paste0(Name, ", ", Club)) %>%

+ # Selection abilities of the players

+ select(Name,Crossing:Sliding.Tackle) %>%

+ # Correction of the punctuation

+ rename\_all(funs(gsub("[[:punct:]]", " ", .))) %>%

+ # Tranform from Variable to Observation

+ gather(Skill, Exp, Crossing:`Sliding Tackle`, -Name)

> head(players)

Name Skill Exp

1 L. Messi, FC Barcelona Crossing 84

2 Cristiano Ronaldo, Juventus Crossing 84

3 L. Messi, FC Barcelona Finishing 95

4 Cristiano Ronaldo, Juventus Finishing 94

5 L. Messi, FC Barcelona Heading Accuracy 70

6 Cristiano Ronaldo, Juventus Heading Accuracy 89

> options(repr.plot.width = 15, repr.plot.height = 8)

> ggplot(players, aes(Skill, Exp, fill = Name))+

+ geom\_col(show.legend = FALSE)+

+ coord\_flip()+

+ facet\_wrap(Name~.)+

+ scale\_fill\_manual(values = c("black", "navy"))+

+ theme\_minimal()

> options(repr.plot.width = 15, repr.plot.height = 8)

> ggplot(players, aes(Skill, Exp, fill = Name))+

+ geom\_col(position = "fill")+

+ coord\_flip()+

+ scale\_fill\_manual(values = c("black", "red"))+

+ theme\_minimal()+

+ geom\_hline(yintercept = 0.5, color = "white", size = 1, linetype = 2)+

+ theme(legend.position = "top", axis.text.x=element\_blank())+

+ labs(title = "Messi VS Ronaldo")

> #BMI - Body Mass Index

> #1. Below the Ideal Weight: < 18.49

> #2. Ideal Weight: 18.5 - 24.99

> #3. Over the Ideal Weight: 25 - 29.99

> #4. Much Over The Ideal Weight: > 30

> unique(data\_manipulated$Club)

[1] "FC Barcelona" "Juventus" "Paris Saint-Germain" "Manchester United" "Manchester City"

[6] "Chelsea" "Real Madrid" "Tottenham Hotspur" "Liverpool" "Napoli"

[11] "Arsenal" "Milan" "Inter" "Lazio" "Borussia Dortmund"

[16] "Olympique Lyonnais" "Roma" "Valencia CF" "FC Porto" "FC Schalke 04"

[21] "Sporting CP" "Real Betis" "Olympique de Marseille" "RC Celta" "Bayer 04 Leverkusen"

[26] "Real Sociedad" "Villarreal CF" "Sevilla FC" "SL Benfica" "AS Monaco"

[31] "Leicester City" "Atalanta" "RB Leipzig" "Ajax" "Everton"

[36] "West Ham United" "TSG 1899 Hoffenheim" "OGC Nice" "Wolverhampton Wanderers" "Hertha BSC"

[41] "SV Werder Bremen" "Athletic Club de Bilbao" "Torino" "Crystal Palace" "VfL Wolfsburg"

[46] "Sassuolo" "PSV" "Levante UD" "Fulham" "Watford"

[51] "Montpellier HSC" "Galatasaray SK" "SD Eibar" "Sampdoria" "VfB Stuttgart"

[56] "SC Braga" "Eintracht Frankfurt" "Girona FC" "Burnley" "Southampton"

[61] "Getafe CF" "Chievo Verona" "Genoa" "RCD Espanyol" "Cagliari"

[66] "1. FSV Mainz 05" "Bournemouth" "FC Augsburg" "Fiorentina" "FC Nantes"

[71] "Feyenoord" "Brighton & Hove Albion" "SC Freiburg" "Stade Rennais FC" "Trabzonspor"

[76] "SPAL" "Portimonense SC" "Newcastle United" "Frosinone" "Hannover 96"

[81] "Stade Malherbe Caen" "Toulouse Football Club" "Huddersfield Town" "CD Tondela" "Rio Ave FC"

[86] "FC Girondins de Bordeaux" "Parma" "RC Strasbourg Alsace" "Bologna" "Amiens SC"

[91] "Udinese" "Real Valladolid CF" "Rayo Vallecano" "En Avant de Guingamp" "Akhisar Belediyespor"

[96] "LOSC Lille" "BB Erzurumspor" "FC Groningen" "Angers SCO" "Antalyaspor"

[101] "Empoli" "VVV-Venlo" "Alanyaspor" "Cardiff City" "Dijon FCO"

[106] "AZ Alkmaar" "Willem II" "Boavista FC" "Atiker Konyaspor" "GD Chaves"

[111] "Stade de Reims" "ADO Den Haag" "SD Huesca" "Vitesse" "Kayserispor"

[116] "Yeni Malatyaspor" "Bursaspor" "Heracles Almelo" "NAC Breda" "Moreirense FC"

[121] "FC Utrecht" "SC Heerenveen" "Sivasspor" "CD Feirense" "CD Aves"

[126] "CD Nacional" "Santa Clara" "Fortuna Sittard" "PEC Zwolle" "Excelsior"

[131] "Os Belenenses" "FC Emmen" "De Graafschap"

> # Calculate BMI

> bmi <- data\_manipulated %>%

+ filter(Club == "FC Barcelona") %>%

+ mutate(BMI = round(Weight/(Height/100)^2, digits = 4)) %>%

+ arrange(-BMI)%>%

+ select(Name, Age, Position, Class, Height, Weight, BMI)

> options(repr.plot.width = 12, repr.plot.height = 8)

> # Head & Tail Observations

> bmi2 <- rbind(

+ bmi %>% head(5) %>% mutate(BMI = BMI \* -1),

+ bmi %>% tail(5)) %>% mutate(Type = if\_else(BMI < 0, "Head", "Tail"))

> # BMI Visual

> bmi2 %>%

+ ggplot(aes(fct\_reorder(paste(Name,",", Position), desc(BMI)), BMI))+

+ geom\_col(aes(fill = Type))+

+ geom\_text(aes(y = c(rep(-2,5), rep(2,5)),label = round(abs(BMI),digits = 2)),

+ color = "white", fontface = "bold", size = 4)+

+ coord\_flip()+

+ theme\_minimal()+

+ theme(axis.text.x = element\_blank(),

+ legend.position = "top",

+ panel.background = element\_rect(fill = "lightgray"),

+ panel.grid.minor = element\_blank(),

+ axis.text = element\_text(color = "slategray", face = "bold.italic",size = 12),

+ title = element\_text(color = "slategray", face = "bold.italic",size = 20),

+ legend.box.background = element\_rect(linetype = 2))+

+ labs(x = NULL, y = NULL, fill = NULL, title = "BMI Index")+

+ scale\_fill\_manual(values = c("steelblue", "khaki"))

>

> #Scale the Data

> numeric\_feature <- Filter(is.numeric, data\_manipulated)

> data\_standardized <- data.frame(scale(numeric\_feature))

> data\_standardized

ï.. Age Overall Potential International.Reputation Weak.Foot Skill.Moves Jersey.Number Height Weight Crossing Finishing

1 -1.087785 1.3717005 3.191279 3.050070 5.712935 1.39966159 1.6103701 -0.63100398 -1.8365790 -0.553752087 1.4919060 2.1948857

2 -1.087585 1.8120458 3.191279 3.050070 5.712935 1.39966159 2.7646376 -0.79521543 0.9083646 0.988584356 1.4919060 2.1471341

3 -1.087386 0.2708374 2.909515 2.875068 5.712935 2.81949121 2.7646376 -0.63100398 -1.0740947 -1.114601703 1.2407621 1.8128726

4 -1.087186 0.4910100 2.768633 2.875068 4.152847 -0.02016803 -1.8524324 -1.12363833 1.6708490 0.007097529 -1.8734215 -1.7207485

5 -1.086986 0.4910100 2.768633 2.700065 4.152847 2.81949121 1.6103701 -0.79521543 -0.3116103 -0.834176895 1.9439649 1.5741144

6 -1.086787 0.4910100 2.768633 2.525063 4.152847 1.39966159 1.6103701 -0.63100398 -1.3790884 -0.273327279 1.3412197 1.6696177

7 -1.086587 1.5918731 2.768633 2.525063 4.152847 1.39966159 1.6103701 -0.63100398 -1.3790884 -1.395026511 1.5923635 1.0965981

8 -1.086388 1.3717005 2.768633 2.525063 5.712935 1.39966159 0.4561026 -0.68574113 0.1458803 1.409221568 1.1403046 2.0993824

9 -1.086188 1.5918731 2.768633 2.525063 4.152847 -0.02016803 0.4561026 -0.35731823 0.1458803 0.848371952 0.5877882 0.5235784

10 -1.085590 0.7111826 2.627750 2.350060 4.152847 2.81949121 0.4561026 -0.74047828 0.1458803 0.007097529 1.6928211 1.2876046

11 -1.085190 1.5918731 2.627750 2.350060 4.152847 -1.43999766 1.6103701 -0.02889533 -1.3790884 -1.254814107 1.4919060 1.2876046

12 -1.084991 0.4910100 2.486868 2.350060 2.592759 -0.02016803 -0.6981649 -0.46679253 -2.1415728 -0.553752087 0.6882457 0.7623366

13 -1.084791 -0.1695079 2.486868 3.050070 2.592759 -0.02016803 1.6103701 -0.02889533 -0.6166041 -0.133114875 1.3914484 1.6696177

14 -1.084592 -0.1695079 2.486868 2.525063 2.592759 1.39966159 0.4561026 -0.68574113 0.9083646 1.829858780 1.0398471 2.1471341

15 -1.084193 0.2708374 2.486868 2.700065 2.592759 1.39966159 -1.8524324 0.02584182 0.9083646 1.269009164 -1.9738790 -1.6729968

16 -1.083993 0.2708374 2.486868 2.350060 4.152847 -1.43999766 -1.8524324 -1.12363833 2.4333333 2.811345608 -2.0241078 -1.6729968

17 -1.083794 0.9313553 2.486868 2.175057 4.152847 -0.02016803 0.4561026 -0.90468973 0.9083646 0.007097529 0.3868731 0.8578399

18 -1.083594 1.3717005 2.486868 2.175057 4.152847 1.39966159 0.4561026 -0.02889533 0.4508740 0.147309933 0.7887032 1.9083759

19 -1.083195 1.1515279 2.486868 2.175057 4.152847 1.39966159 1.6103701 -0.63100398 -1.3790884 -0.834176895 0.7887032 2.0993824

20 -1.082995 1.8120458 2.486868 2.175057 4.152847 -0.02016803 -0.6981649 -1.01416403 0.9083646 1.269009164 0.1859580 -0.7657157

21 -1.082796 -1.2703711 2.345986 3.225073 2.592759 1.39966159 2.7646376 -0.63100398 -0.6166041 -0.413539683 1.1403046 1.8606242

Heading.Accuracy Short.Passing Volleys Dribbling Curve FK.Accuracy Long.Passing Ball.Control Acceleration Sprint.Speed Agility Reactions

1 0.75369099 1.6848656 1.9863077 1.7997488 2.0295349 2.5052292 1.83445120 1.8047771 1.7115729 1.3810617 1.79984320 2.985502

2 1.76105880 1.1055559 2.0378096 1.3536297 1.4302396 1.5539810 1.21248899 1.6924545 1.5763900 1.7225829 1.52352339 3.093794

3 0.32953612 1.2986591 1.8833039 1.7501800 1.7798285 2.1352993 1.27468521 1.7486158 1.9143474 1.6542787 2.14524296 2.877210

4 -1.84425756 -0.8898441 -1.7733304 -2.1161850 -1.5662367 -1.4583048 -0.40461276 -1.2279342 -0.5865377 -0.5314571 -0.34163533 2.444041

5 -0.04159938 1.8136010 1.7803002 1.2544922 1.6300047 1.9239108 2.08323609 1.5239705 0.8328836 0.6980193 0.97088377 2.552333

6 0.27651677 1.6204978 1.6772964 1.7006112 1.5301222 1.7125224 1.58566632 1.6924545 1.9143474 1.5176702 2.07616301 2.444041

7 -0.04159938 1.8779688 1.4712888 1.4527673 1.6300047 1.6596753 1.89664743 1.6362932 0.9680665 0.4248023 1.93800310 2.444041

8 1.12482650 1.1699236 2.0893115 1.3040610 1.6799460 1.9767580 0.40393811 1.4678092 1.3736155 0.6297150 1.17812362 2.660625

9 1.86709751 0.9124526 0.9562699 0.1144102 1.0806507 1.3425925 1.21248899 1.1308413 0.6977006 0.6297150 0.90180381 1.902580

10 -0.09461874 1.8136010 1.7803002 1.0066483 1.6799460 1.9767580 2.20762853 1.4678092 -0.1133973 -0.2582401 0.34916419 2.335749

11 -0.09461874 1.8779688 1.7803002 1.4031985 1.4801809 1.6068281 1.83445120 1.6924545 0.2921516 -0.1216317 1.86892315 2.444041

12 -0.09461874 1.4273946 0.4412510 0.9075107 -0.1678811 0.1271088 1.46127388 0.9061960 1.1032495 0.8346277 1.17812362 2.768917

13 0.64765227 1.4917623 2.0893115 1.5519049 1.7798285 2.1881464 1.08809655 1.5801318 1.4412070 1.1761490 1.79984320 2.010872

14 1.54898136 1.0411881 1.8833039 0.9570795 1.2804158 1.1312041 1.52347010 1.1308413 0.1569687 0.4248023 0.41824414 2.552333

15 -2.37445114 -1.7909925 -1.7218285 -2.1657538 -1.7160605 -1.8282346 -0.96437876 -2.5758059 -1.8707760 -1.0778910 -1.93047424 1.902580

16 -2.26841243 -1.9840958 -1.8248323 -2.3640289 -1.6661193 -1.4054577 -1.39975230 -2.2949993 -1.3300441 -0.9412826 -0.27255538 1.794288

17 0.64765227 1.6204978 -0.1767717 0.9570795 0.6811205 1.1312041 1.52347010 1.3554865 -1.0596782 -0.9412826 0.07284438 2.119164

18 1.76105880 0.9124526 2.1923153 0.9570795 1.2304745 1.5539810 -0.34241654 1.0185186 0.6301091 0.6980193 0.83272386 2.552333

19 1.12482650 1.1055559 1.9348058 1.4031985 1.4801809 1.3954397 0.40393811 1.4116479 1.5087985 0.9712362 1.45444343 2.444041

20 1.44294265 -0.3105345 -0.1252698 -0.1334337 0.3814729 -0.8241394 0.09295701 -0.3855144 -0.1809888 0.6297150 -0.75611505 1.577704

21 1.12482650 1.1699236 1.5742926 1.4527673 1.2304745 0.8669685 0.96370411 1.5239705 2.0495304 2.0641041 1.86892315 2.119164

Balance Shot.Power Jumping Stamina Strength Long.Shots Aggression Interceptions Positioning Vision Penalties Composure

1 2.1378487 1.34352854 0.15177264 0.48906217 -0.60256102 2.0376206 -0.64395656 -1.26756793 1.8930605 2.4020311 1.41774311 2.7751992

2 0.3973190 1.89288042 2.42074430 1.48199590 1.00233410 1.9893135 0.18980770 -0.95952933 1.9401677 1.6035537 2.02215398 2.6874373

3 1.3720156 1.06885260 -0.43647927 1.04758739 -1.40500859 1.4579349 -0.19928229 -0.65149073 1.6575244 1.9362526 1.78038963 2.5996753

4 -1.4824530 -1.62297158 0.06773665 -1.31063020 -0.20133724 -1.9235649 -1.19979940 -0.91552382 -1.9697314 0.6719968 -0.69769495 0.3178650

5 0.8846673 1.67313967 -0.26840730 1.60611261 0.68135508 1.8926992 0.91240339 0.44864713 1.5633100 2.4020311 1.65950746 2.0731037

6 2.0682275 1.17872298 -0.85665921 1.17170411 -0.04084773 1.3613207 -0.31045086 -0.43146316 1.5633100 2.0693322 2.08259507 2.3363895

7 2.0682275 1.01391742 0.15177264 1.54405425 -0.68280578 1.4579349 0.13422341 1.41676844 1.1864522 2.2689515 1.84083072 1.7220560

8 1.3023945 1.39846373 0.23580863 1.60611261 1.32331312 1.6028563 1.52383051 -0.43146316 1.7988461 1.7366333 2.02215398 1.8098179

9 0.1188343 1.01391742 2.25267233 1.23376247 1.32331312 0.3468707 1.57941480 1.72480704 0.2914151 0.3392979 1.41774311 1.5465321

10 0.4669402 1.45339892 -3.04159488 0.67523725 0.52086556 1.9410063 0.02305485 1.37276293 1.1864522 1.8697129 1.29686093 1.8098179

11 1.7897428 0.62937110 -0.18437131 0.86141232 -1.16427432 1.1197850 -0.14369801 -0.03541353 1.6575244 2.2689515 1.41774311 2.5119134

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13 1.4416368 1.17872298 0.74002455 0.98552903 -0.12109249 1.7477778 -0.64395656 -0.82751279 1.4219883 1.9362526 2.08259507 1.7220560

14 0.4669402 1.50833410 0.99213251 1.54405425 1.40355788 1.6028563 0.91240339 -0.69549624 1.8459533 1.4704742 2.32435941 2.1608657

15 -1.4824530 -2.11738827 1.07616850 -1.80709707 1.00233410 -2.0201791 -0.92187798 -1.26756793 -2.0168386 0.7385366 -1.60431126 0.4056270

16 -1.3432106 -1.34829564 0.15177264 -1.62092199 0.28013129 -1.6820292 -2.03356367 -1.57560653 -1.9226242 -0.9249579 -1.48342908 0.1423412

17 -0.8558623 0.02508404 -0.01629934 1.35787918 0.84184459 0.1053350 1.41266195 1.59279050 1.0922378 1.9362526 0.51112680 2.2486276

18 -0.3685140 1.45339892 1.83249239 1.73022933 0.92208934 1.3130135 1.35707766 -0.12342456 1.8459533 1.2708548 2.02215398 1.5465321

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20 -0.6469987 0.95898223 1.91652838 0.05465367 1.80478166 -0.1362007 1.80175193 1.63679602 -1.2160159 -0.5257193 -0.09328407 1.7220560

21 1.3023945 1.01391742 0.74002455 1.17170411 0.36037605 1.2647064 0.13422341 -0.56347970 1.6104172 1.6035537 1.11553767 1.8975799

Marking Standing.Tackle Sliding.Tackle GK.Diving GK.Handling GK.Kicking GK.Positioning GK.Reflexes Values Wages

1 -0.81382432 -0.99693438 -0.98817606 -0.5749064 -0.3216783 -0.08855293 -0.1573438 -0.4700254 10.587303 13.398194

2 -1.04145761 -0.87043634 -1.11591110 -0.5236341 -0.3216783 -0.08855293 -0.1573438 -0.3181741 7.179220 9.419694

3 -1.08698427 -1.16559844 -0.69012766 -0.4210895 -0.4295405 -0.08855293 -0.1039817 -0.3181741 11.401173 6.560146

4 -1.63330419 -1.29209648 -1.54169454 3.7319654 3.6692221 3.96449911 3.7914527 3.8830465 6.670551 5.814177

5 0.77960877 0.26804604 0.07628253 -0.1134558 -0.2138161 -0.65147682 -0.3707923 -0.2169398 9.722565 8.176412

6 -0.76829766 -1.03910039 -1.15848944 -0.3185450 -0.2677472 -0.59518444 -0.4775165 -0.4700254 8.806961 7.803428

7 0.41539550 1.02703429 1.01300610 -0.2160004 -0.4295405 -0.53889205 -0.1573438 -0.4194083 6.161882 9.792678

8 0.50644882 -0.28011214 -0.47723594 0.5018116 0.4333569 0.81212530 0.8565364 0.9978709 7.484422 10.662975

9 1.64461531 1.70169052 1.77941629 -0.3185450 -0.4834716 -0.42630727 -0.5308786 -0.3181741 4.534142 8.798053

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12 1.78119529 1.65952450 1.52394623 -0.1134558 -0.2677472 -0.37001488 -0.5308786 -0.3687912 5.754947 4.943880

13 -1.26909091 -1.33426249 -1.24364613 -0.6261787 -0.6991959 -0.70776921 -0.6376029 -0.4700254 8.400026 4.446568

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15 -1.17803759 -1.62942459 -1.66942957 3.5781486 3.6692221 4.02079150 3.6313664 3.6805780 5.246278 5.316865

16 -1.40567089 -1.41859452 -1.41395950 3.4756040 3.9928086 3.12011327 3.6847285 3.5793438 4.788476 5.316865

17 1.78119529 1.44869443 1.31105451 -0.6261787 -0.4834716 -0.20113771 -0.4241544 -0.2169398 4.585009 7.181787

18 0.05118222 -0.28011214 -0.43465759 -0.2672727 -0.6452648 -0.20113771 -0.2107059 -0.3687912 5.449746 4.322240

19 -0.95040430 -1.33426249 -1.58427288 -0.2160004 -0.1059540 -0.59518444 -0.3174302 -0.1663227 5.907548 6.808803

20 1.91777527 1.74385653 1.73683795 -0.7287232 -0.7531270 -0.82035399 -0.6909650 -0.7231110 2.092531 4.695224

21 -0.76829766 -0.74393830 -0.73270600 -0.2160004 -0.6452648 -0.53889205 -0.3174302 -0.5712596 7.586156 1.835677

[ reached 'max' / getOption("max.print") -- omitted 3851 rows ]

>

> #PCA

> data\_pca <- prcomp(data\_standardized,

+ center = TRUE,

+ scale. = TRUE)

> data\_with\_pca <- data.frame(as.matrix(data\_standardized) %\*% as.matrix(data\_pca$rotation[,0:5]))

> data\_with\_pca

PC1 PC2 PC3 PC4 PC5

1 -10.37151575 6.147904405 -11.26033150 2.694502132 -4.928103442

2 -9.32280116 7.023755019 -8.71100439 -0.823766672 -4.905720323

3 -9.50109278 4.311339068 -10.07240029 2.610463230 -4.461507817

4 6.83389697 8.455722811 -8.84177747 3.953419923 -3.060405336

5 -9.55848687 6.260124969 -7.12074247 2.023594038 -3.297437015

6 -9.02375298 4.004977409 -8.71030720 1.937465119 -3.905128241

7 -9.32657398 5.366431585 -6.18869269 3.920881421 -1.844468465

8 -7.86225118 7.820741740 -8.37111550 0.501872271 -3.762076060

9 -6.83254899 8.064057028 -2.12749246 1.704756898 -3.321272987

10 -7.98123670 6.164900996 -5.48511996 1.436842158 -1.359437987

11 -7.90941206 3.767611688 -6.48132487 2.449858047 -0.955387126

12 -6.69552177 5.679469373 -2.22525960 4.389718501 -2.395145571

13 -8.14738458 2.658595397 -7.52079879 0.461325534 -4.070270075

14 -7.23863956 5.741238435 -5.46658281 -1.655646889 -3.835411715

15 8.61543543 8.194210071 -7.64228019 2.708232248 -2.782813134

16 8.83262967 8.216708563 -7.62863384 2.019892341 -3.186838472

17 -5.74761186 7.674318988 -2.17072314 1.438785031 -1.559918304

18 -7.00138687 5.290122902 -4.95551272 -1.254892507 -2.847438842

19 -7.90106917 3.632098909 -7.97139007 0.327308944 -3.154246652

20 -2.88050721 7.812684734 0.91877550 0.800366037 -2.510303612

21 -7.87903905 2.341672381 -6.17997792 1.083637791 -4.698997893

22 -7.59797444 3.447927522 -6.32085082 2.110154503 -3.267704431

23 -5.63760709 7.704304261 -1.54281815 0.983022425 -2.757910194

24 -7.30352684 0.165506837 -7.04281905 3.229873194 -1.344711208

25 -7.54452125 3.917724495 -5.62500256 2.314954454 -2.531499224

26 -7.91301086 3.351778981 -6.30750679 1.267511721 -1.667931676

27 -8.67043820 3.048490511 -6.79359229 2.728746781 -2.263668283

28 -6.77924418 3.908153790 -6.28341647 -0.877015342 -3.704124445

29 -8.58134737 5.394455681 -3.14783142 2.372496625 -1.953650040

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34 9.76169569 7.113480468 -6.00238195 1.623403585 -1.201571444

35 9.16869610 6.788223449 -5.90932264 1.075077005 0.866455095

36 -5.36185278 6.179497150 -1.18701539 1.801498966 -3.146254399

37 -5.34657663 3.330685481 -5.26265145 -1.095345290 -4.233995088

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39 -8.45561707 5.930819616 -3.61479784 -0.786537674 -3.050203917

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41 -5.59079438 5.404032152 -4.91806174 -2.917634844 -4.238210723

42 -5.42583288 3.519560832 -4.46477238 -2.019234715 -3.102148691

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44 -7.23319247 0.320528678 -6.39557833 2.411241178 -0.295575240

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67 -6.32398652 4.230098128 -1.35440803 1.573566622 0.491440020

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87 -5.88105555 4.573884841 -0.61152490 1.885967827 -0.689921322

88 -2.32062163 5.420733421 1.19096883 0.956549148 -0.775801164

89 -6.18524582 3.517738370 -5.72000824 -2.050588170 -2.144818172

90 -2.97529808 7.093269755 0.46117410 -0.543501199 -0.749190774

91 -1.77959492 5.046960023 1.61391201 1.532591268 -3.439003080

92 -6.51140100 3.026541156 -0.92331127 1.626555349 -0.469376874

93 -2.77204597 5.611907354 0.96531979 0.575193332 -1.901875577

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118 -5.24904591 5.100394124 -1.56723521 -1.988645995 -1.405808322

119 -6.15410063 1.298819439 -4.96152051 1.472833386 -0.154340253

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129 -6.67556074 -0.185794255 -5.18578109 2.137490758 0.492367462

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134 -6.07167847 1.335615237 -3.01899484 2.828440791 -0.155212095

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163 -6.57987539 1.680906174 -3.84684457 0.756362632 -0.296772863

164 -5.77653510 4.198135603 -0.53339035 -0.670063397 -0.449343601

165 9.70898930 5.551109516 -5.37584994 0.973772161 0.431060945

166 0.87467182 6.394248355 3.04818568 0.350790541 -1.720539764

167 -5.59939126 3.792900884 -0.56765588 -0.356514281 0.784835701

168 -1.99294672 4.156396176 -1.82545658 -5.640792197 -1.206479201

169 -5.22986096 2.004545550 -4.03143172 -3.978993993 -1.554755271

170 -3.93905737 4.744762057 0.60882576 0.275335637 0.028918710

171 -4.43252404 5.123008793 -0.21276670 -0.740701614 0.088658016

172 10.79888908 5.980078038 -4.14700471 -0.142950634 -0.851075197

173 -6.22054185 0.452663529 -5.40475718 1.490091821 1.063636460

174 8.86565093 5.358357902 -5.61854243 1.696076684 -0.444922496

175 -4.24040615 4.791664812 0.44060104 0.475485674 -0.245658807

176 -5.34027063 3.681545987 -0.30401206 1.306025903 0.633693336

177 9.87004843 4.911621705 -5.27995892 2.052158679 0.439377304

178 -5.53827721 3.273395965 -3.41528382 -0.188879335 1.551232489

179 -5.60493714 4.497651746 -1.26462895 0.095583461 -0.307431228

180 10.46575732 4.541294539 -4.79664380 1.141226322 0.739433746

181 -4.70282114 4.692179870 0.28679326 -0.374933829 1.117065844

182 9.69353238 5.256969943 -5.25919188 1.593784380 0.289814271

183 11.86242576 3.489347541 -4.46047050 0.379691508 -0.325723310

184 -2.61334789 4.533978888 1.24107869 0.070861468 -2.327164810

185 -5.95363989 1.939275011 -1.88863324 2.315259024 -1.070591705

186 9.52939902 5.077438528 -5.36210003 1.562821471 -2.670836815

187 -5.37082953 -0.545922658 -3.51203507 0.496152687 -1.377357836

188 -5.88786065 1.413966538 -0.77190325 3.654207275 -0.117664626

189 -5.88837899 -0.113028372 -5.56219794 0.451260625 -1.723486839

190 9.13979207 3.045554068 -5.01566417 2.541262560 -0.237730350

191 -1.52275474 4.594083578 1.58939603 1.889454944 -2.971348502

192 -5.44127241 0.081902014 -4.33043911 -1.405224994 -0.611373743

193 -4.40365818 1.879376591 -0.04746764 3.206442356 -1.137219003

194 -3.23491137 3.141521529 0.58292019 0.628533342 1.297698559

195 -6.05823696 1.107523191 -3.74220896 0.510692427 -0.728671690

196 -4.37286937 0.597723989 -4.57553171 -0.586264248 -1.844843506

197 -0.69625693 4.873669828 2.15437315 0.908099134 -2.695713272

198 -4.67532887 0.127451845 -4.19558092 1.438900737 -0.763592356

199 -5.97201332 2.528707982 -1.19157092 2.160513105 -1.260079501

200 -0.98597530 5.012320293 2.04446248 1.612200555 -2.798951863

[ reached 'max' / getOption("max.print") -- omitted 3672 rows ]

> #Plot method

> summary(data\_pca)

Importance of components:

PC1 PC2 PC3 PC4 PC5 PC6 PC7 PC8 PC9 PC10 PC11 PC12 PC13 PC14 PC15 PC16

Standard deviation 4.6273 2.4769 2.2962 1.51763 1.24600 1.15910 0.98973 0.90924 0.89752 0.75703 0.69782 0.59185 0.55554 0.52326 0.51767 0.48539

Proportion of Variance 0.4655 0.1334 0.1146 0.05007 0.03375 0.02921 0.02129 0.01797 0.01751 0.01246 0.01059 0.00761 0.00671 0.00595 0.00583 0.00512

Cumulative Proportion 0.4655 0.5988 0.7135 0.76354 0.79729 0.82649 0.84779 0.86576 0.88327 0.89573 0.90632 0.91393 0.92064 0.92659 0.93242 0.93754

PC17 PC18 PC19 PC20 PC21 PC22 PC23 PC24 PC25 PC26 PC27 PC28 PC29 PC30 PC31 PC32

Standard deviation 0.47184 0.45347 0.44193 0.43133 0.42248 0.41894 0.39579 0.38046 0.36147 0.34418 0.34199 0.32386 0.32319 0.31275 0.29004 0.2877

Proportion of Variance 0.00484 0.00447 0.00425 0.00404 0.00388 0.00382 0.00341 0.00315 0.00284 0.00258 0.00254 0.00228 0.00227 0.00213 0.00183 0.0018

Cumulative Proportion 0.94238 0.94685 0.95110 0.95514 0.95902 0.96284 0.96624 0.96939 0.97223 0.97481 0.97735 0.97963 0.98190 0.98403 0.98585 0.9877

PC33 PC34 PC35 PC36 PC37 PC38 PC39 PC40 PC41 PC42 PC43 PC44 PC45 PC46

Standard deviation 0.27297 0.26632 0.24813 0.24176 0.2251 0.22147 0.21331 0.18057 0.16434 0.15907 0.15542 0.14476 0.1364 0.09284

Proportion of Variance 0.00162 0.00154 0.00134 0.00127 0.0011 0.00107 0.00099 0.00071 0.00059 0.00055 0.00053 0.00046 0.0004 0.00019

Cumulative Proportion 0.98927 0.99082 0.99215 0.99342 0.9945 0.99559 0.99658 0.99729 0.99788 0.99843 0.99895 0.99941 0.9998 1.00000

> #Selecting 5 principal components

> data\_final <- data\_with\_pca[,0:5]

> data\_final

PC1 PC2 PC3 PC4 PC5

1 -10.37151575 6.147904405 -11.26033150 2.694502132 -4.928103442

2 -9.32280116 7.023755019 -8.71100439 -0.823766672 -4.905720323

3 -9.50109278 4.311339068 -10.07240029 2.610463230 -4.461507817

4 6.83389697 8.455722811 -8.84177747 3.953419923 -3.060405336

5 -9.55848687 6.260124969 -7.12074247 2.023594038 -3.297437015

6 -9.02375298 4.004977409 -8.71030720 1.937465119 -3.905128241

7 -9.32657398 5.366431585 -6.18869269 3.920881421 -1.844468465

8 -7.86225118 7.820741740 -8.37111550 0.501872271 -3.762076060

9 -6.83254899 8.064057028 -2.12749246 1.704756898 -3.321272987

10 -7.98123670 6.164900996 -5.48511996 1.436842158 -1.359437987

11 -7.90941206 3.767611688 -6.48132487 2.449858047 -0.955387126

12 -6.69552177 5.679469373 -2.22525960 4.389718501 -2.395145571

13 -8.14738458 2.658595397 -7.52079879 0.461325534 -4.070270075

14 -7.23863956 5.741238435 -5.46658281 -1.655646889 -3.835411715

15 8.61543543 8.194210071 -7.64228019 2.708232248 -2.782813134

16 8.83262967 8.216708563 -7.62863384 2.019892341 -3.186838472

17 -5.74761186 7.674318988 -2.17072314 1.438785031 -1.559918304

18 -7.00138687 5.290122902 -4.95551272 -1.254892507 -2.847438842

19 -7.90106917 3.632098909 -7.97139007 0.327308944 -3.154246652

20 -2.88050721 7.812684734 0.91877550 0.800366037 -2.510303612

21 -7.87903905 2.341672381 -6.17997792 1.083637791 -4.698997893

22 -7.59797444 3.447927522 -6.32085082 2.110154503 -3.267704431

23 -5.63760709 7.704304261 -1.54281815 0.983022425 -2.757910194

24 -7.30352684 0.165506837 -7.04281905 3.229873194 -1.344711208

25 -7.54452125 3.917724495 -5.62500256 2.314954454 -2.531499224

26 -7.91301086 3.351778981 -6.30750679 1.267511721 -1.667931676

27 -8.67043820 3.048490511 -6.79359229 2.728746781 -2.263668283

28 -6.77924418 3.908153790 -6.28341647 -0.877015342 -3.704124445

29 -8.58134737 5.394455681 -3.14783142 2.372496625 -1.953650040

30 -8.45382093 5.610786617 -5.51442048 0.004237262 -3.705242879

31 8.39426870 6.275757086 -6.57220369 3.993451848 -1.507620428

32 -5.82029725 4.709312073 -6.31627213 -2.379783090 -3.392407411

33 -4.82767352 6.416828135 -0.40355284 1.152700985 -0.808863843

34 9.76169569 7.113480468 -6.00238195 1.623403585 -1.201571444

35 9.16869610 6.788223449 -5.90932264 1.075077005 0.866455095

36 -5.36185278 6.179497150 -1.18701539 1.801498966 -3.146254399

37 -5.34657663 3.330685481 -5.26265145 -1.095345290 -4.233995088

38 -0.42228789 7.525480477 1.84608495 1.432185488 -4.301792172

39 -8.45561707 5.930819616 -3.61479784 -0.786537674 -3.050203917

40 8.44203959 6.419059596 -6.99271503 3.308168450 -1.107791233

41 -5.59079438 5.404032152 -4.91806174 -2.917634844 -4.238210723

42 -5.42583288 3.519560832 -4.46477238 -2.019234715 -3.102148691

43 -7.07993673 3.606149828 -2.61278787 4.000139265 -1.860449240

44 -7.23319247 0.320528678 -6.39557833 2.411241178 -0.295575240

45 -4.86393820 6.379614358 -0.18583341 0.182731419 -0.889099308

46 -6.99573634 4.162026893 -3.25405978 0.128127271 -0.463393361

47 -7.10081926 4.641966567 -3.85737389 0.467137223 0.046537258

48 -3.42327910 7.884245543 -0.58667518 -0.355754603 -1.538442822

49 -6.75071608 1.893867983 -5.59430777 0.398633552 -3.941995359

50 -6.71480660 1.113405142 -5.50364133 2.869417145 -1.721849975

51 7.40932363 5.541663521 -6.75491828 2.941167498 -1.782396988

52 -7.08907548 2.241446212 -5.53498181 1.535049607 -2.688824047

53 -3.95888158 7.260487142 -0.07121571 -0.118767665 -2.750296492

54 -6.39393317 1.258137973 -5.98525225 3.300522392 -2.556830503

55 -7.55788958 3.873957914 -4.17180810 0.461759105 -2.278613479

56 -3.09926219 6.998800817 -0.14400207 1.692435089 -4.076786154

57 -7.06644109 3.116886664 -3.03097015 4.839082031 -0.113710733

58 -6.49247010 4.553569467 -1.14978149 1.652579471 -1.817648084

59 -7.38584878 1.333061312 -5.78986761 1.815875334 -1.531840303

60 -7.36834590 2.148144940 -5.83328266 0.195924981 -0.521142915

61 -5.43837352 5.028779078 -0.57140717 2.540756710 -1.147356517

62 -4.24795602 6.549345505 0.53317522 -0.391479897 -1.129717944

63 -4.05409459 6.607423804 -0.08012774 1.035762789 -0.956056536

64 -7.16828693 3.797154566 -3.06801540 1.583039465 0.238781641

65 -1.82830420 7.236377527 1.32253456 0.364601961 -2.798353204

66 -5.57803816 2.177947828 -6.47171151 -0.145548356 -0.671572470

67 -6.32398652 4.230098128 -1.35440803 1.573566622 0.491440020

68 -1.60539020 5.412632958 1.43045822 1.332976239 -3.563651244

69 -6.48928816 4.310538445 -1.40202586 -0.504340869 -1.990657430

70 -6.56821677 2.424875216 -5.76058063 0.861499367 -2.649628190

71 -6.77362275 1.664070824 -5.43206522 0.190668299 -1.642539826

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73 -6.85834298 0.731748269 -6.23110109 1.313866702 -1.302430487

74 -6.81153622 2.270483919 -5.15842291 -0.089928587 -2.248923757

75 -0.04726220 6.549712514 2.22614118 3.043544795 -4.183220141

76 -2.92108957 5.929768405 0.63072491 0.812114823 -1.647124931

77 -5.84150648 2.748257549 -2.20467275 -0.460173419 1.766772364

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83 -3.99052631 4.255935959 -3.62507673 -3.397386796 -0.934592904

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87 -5.88105555 4.573884841 -0.61152490 1.885967827 -0.689921322

88 -2.32062163 5.420733421 1.19096883 0.956549148 -0.775801164

89 -6.18524582 3.517738370 -5.72000824 -2.050588170 -2.144818172

90 -2.97529808 7.093269755 0.46117410 -0.543501199 -0.749190774

91 -1.77959492 5.046960023 1.61391201 1.532591268 -3.439003080

92 -6.51140100 3.026541156 -0.92331127 1.626555349 -0.469376874

93 -2.77204597 5.611907354 0.96531979 0.575193332 -1.901875577

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95 -6.15686914 2.102686648 -4.77790599 -0.081254522 -3.365220191

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119 -6.15410063 1.298819439 -4.96152051 1.472833386 -0.154340253

120 9.10328803 4.768764862 -5.47706445 2.438351177 -0.463823384

121 -6.42193910 1.936702133 -2.26149644 1.260092051 1.725056875

122 -6.58260582 4.443607787 -0.85224785 -0.715325618 -0.156875721

123 -6.03641026 1.023697601 -4.67972820 -0.592096056 0.903695115

124 -5.78208987 1.452589339 -4.26768236 -2.140920468 1.357303904

125 -1.63998216 5.911909268 1.46884581 0.720003249 -2.355244402

126 -5.62768713 2.653438879 -3.86897644 -1.574166061 -0.518642126

127 8.56351878 4.865859260 -5.79877264 1.931745160 0.024089458

128 -1.29465849 5.764763957 1.82990712 0.464778705 -0.384945155

129 -6.67556074 -0.185794255 -5.18578109 2.137490758 0.492367462

130 -1.50999645 5.684037856 1.82860477 0.478129484 -0.248987057

131 -6.32522021 0.287014591 -6.00945242 1.906436244 -2.413297506

132 -6.27613860 1.006272219 -4.65741039 0.600757103 -3.326401692

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135 -0.03793034 6.216104037 2.11457146 0.114810851 -3.367765384

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137 -5.73485750 3.721751214 -0.96017605 -0.113218604 -1.496228868

138 -6.27959565 0.008133336 -4.37052775 0.186258137 -0.849687838

139 -6.29346554 0.861261141 -3.27411259 1.218491542 0.691958349

140 -6.16504839 1.217172472 -4.11341187 1.751917472 -0.594518151

141 -4.47714527 1.086448555 -2.90991221 -1.270402913 -1.581353857

142 -0.99437255 5.511010194 2.29831177 0.149101490 -1.542814274

143 -6.59088920 2.256216882 -2.61756734 2.129247860 -1.169581082

144 9.73058232 4.388857422 -5.58255546 2.233633670 -0.699778781

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164 -5.77653510 4.198135603 -0.53339035 -0.670063397 -0.449343601

165 9.70898930 5.551109516 -5.37584994 0.973772161 0.431060945

166 0.87467182 6.394248355 3.04818568 0.350790541 -1.720539764

167 -5.59939126 3.792900884 -0.56765588 -0.356514281 0.784835701

168 -1.99294672 4.156396176 -1.82545658 -5.640792197 -1.206479201

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170 -3.93905737 4.744762057 0.60882576 0.275335637 0.028918710

171 -4.43252404 5.123008793 -0.21276670 -0.740701614 0.088658016

172 10.79888908 5.980078038 -4.14700471 -0.142950634 -0.851075197

173 -6.22054185 0.452663529 -5.40475718 1.490091821 1.063636460

174 8.86565093 5.358357902 -5.61854243 1.696076684 -0.444922496

175 -4.24040615 4.791664812 0.44060104 0.475485674 -0.245658807

176 -5.34027063 3.681545987 -0.30401206 1.306025903 0.633693336

177 9.87004843 4.911621705 -5.27995892 2.052158679 0.439377304

178 -5.53827721 3.273395965 -3.41528382 -0.188879335 1.551232489

179 -5.60493714 4.497651746 -1.26462895 0.095583461 -0.307431228

180 10.46575732 4.541294539 -4.79664380 1.141226322 0.739433746

181 -4.70282114 4.692179870 0.28679326 -0.374933829 1.117065844

182 9.69353238 5.256969943 -5.25919188 1.593784380 0.289814271

183 11.86242576 3.489347541 -4.46047050 0.379691508 -0.325723310

184 -2.61334789 4.533978888 1.24107869 0.070861468 -2.327164810

185 -5.95363989 1.939275011 -1.88863324 2.315259024 -1.070591705

186 9.52939902 5.077438528 -5.36210003 1.562821471 -2.670836815

187 -5.37082953 -0.545922658 -3.51203507 0.496152687 -1.377357836

188 -5.88786065 1.413966538 -0.77190325 3.654207275 -0.117664626

189 -5.88837899 -0.113028372 -5.56219794 0.451260625 -1.723486839

190 9.13979207 3.045554068 -5.01566417 2.541262560 -0.237730350

191 -1.52275474 4.594083578 1.58939603 1.889454944 -2.971348502

192 -5.44127241 0.081902014 -4.33043911 -1.405224994 -0.611373743

193 -4.40365818 1.879376591 -0.04746764 3.206442356 -1.137219003

194 -3.23491137 3.141521529 0.58292019 0.628533342 1.297698559

195 -6.05823696 1.107523191 -3.74220896 0.510692427 -0.728671690

196 -4.37286937 0.597723989 -4.57553171 -0.586264248 -1.844843506

197 -0.69625693 4.873669828 2.15437315 0.908099134 -2.695713272

198 -4.67532887 0.127451845 -4.19558092 1.438900737 -0.763592356

199 -5.97201332 2.528707982 -1.19157092 2.160513105 -1.260079501

200 -0.98597530 5.012320293 2.04446248 1.612200555 -2.798951863

[ reached 'max' / getOption("max.print") -- omitted 3672 rows ]

>

> #KMeans

> set.seed(109)

> # Initialize total within sum of squares error: wss

> wss <- 0

> # For 1 to 30 cluster centers

> for (j in 1:15) {

+ km.out <- kmeans(data\_final, centers = j, nstart = 20)

+ # Save total within sum of squares to wss variable

+ wss[j] <- km.out$tot.withinss

+ }

> # create a DF to use in a ggplot visualisation

> wss\_df <- data.frame(num\_cluster = 1:15, wgss = wss)

> # plot to determine optimal k

> ggplot(data = wss\_df, aes(x=num\_cluster, y= wgss)) +

+ geom\_line(color = "lightgrey", size = 2) +

+ geom\_point(color = "green", size = 4) +

+ theme\_dark() +

+ geom\_curve(x=15, xend=8, y=300000, yend= 290500, arrow = arrow(length = unit(0.2,"cm")), size =1, colour = "purple")

> # Set k equal to the number of clusters corresponding to the elbow location

> k <- 4

> # Create a k-means model on wisc.data: wisc.km

> k\_means <- kmeans(data\_final, centers = k, nstart = 20)

> # add the cluster group back to the original DF for all players other than GK and Unknown

> cluster\_data <- data\_standardized %>%

+ mutate(Cluster = k\_means$cluster)

> cluster\_data

ï.. Age Overall Potential International.Reputation Weak.Foot Skill.Moves Jersey.Number Height Weight Crossing Finishing

1 -1.087785 1.3717005 3.191279 3.050070 5.712935 1.39966159 1.6103701 -0.63100398 -1.8365790 -0.553752087 1.4919060 2.1948857

2 -1.087585 1.8120458 3.191279 3.050070 5.712935 1.39966159 2.7646376 -0.79521543 0.9083646 0.988584356 1.4919060 2.1471341

3 -1.087386 0.2708374 2.909515 2.875068 5.712935 2.81949121 2.7646376 -0.63100398 -1.0740947 -1.114601703 1.2407621 1.8128726

4 -1.087186 0.4910100 2.768633 2.875068 4.152847 -0.02016803 -1.8524324 -1.12363833 1.6708490 0.007097529 -1.8734215 -1.7207485

5 -1.086986 0.4910100 2.768633 2.700065 4.152847 2.81949121 1.6103701 -0.79521543 -0.3116103 -0.834176895 1.9439649 1.5741144

6 -1.086787 0.4910100 2.768633 2.525063 4.152847 1.39966159 1.6103701 -0.63100398 -1.3790884 -0.273327279 1.3412197 1.6696177

7 -1.086587 1.5918731 2.768633 2.525063 4.152847 1.39966159 1.6103701 -0.63100398 -1.3790884 -1.395026511 1.5923635 1.0965981

8 -1.086388 1.3717005 2.768633 2.525063 5.712935 1.39966159 0.4561026 -0.68574113 0.1458803 1.409221568 1.1403046 2.0993824

9 -1.086188 1.5918731 2.768633 2.525063 4.152847 -0.02016803 0.4561026 -0.35731823 0.1458803 0.848371952 0.5877882 0.5235784

10 -1.085590 0.7111826 2.627750 2.350060 4.152847 2.81949121 0.4561026 -0.74047828 0.1458803 0.007097529 1.6928211 1.2876046

11 -1.085190 1.5918731 2.627750 2.350060 4.152847 -1.43999766 1.6103701 -0.02889533 -1.3790884 -1.254814107 1.4919060 1.2876046

12 -1.084991 0.4910100 2.486868 2.350060 2.592759 -0.02016803 -0.6981649 -0.46679253 -2.1415728 -0.553752087 0.6882457 0.7623366

13 -1.084791 -0.1695079 2.486868 3.050070 2.592759 -0.02016803 1.6103701 -0.02889533 -0.6166041 -0.133114875 1.3914484 1.6696177

14 -1.084592 -0.1695079 2.486868 2.525063 2.592759 1.39966159 0.4561026 -0.68574113 0.9083646 1.829858780 1.0398471 2.1471341

15 -1.084193 0.2708374 2.486868 2.700065 2.592759 1.39966159 -1.8524324 0.02584182 0.9083646 1.269009164 -1.9738790 -1.6729968

16 -1.083993 0.2708374 2.486868 2.350060 4.152847 -1.43999766 -1.8524324 -1.12363833 2.4333333 2.811345608 -2.0241078 -1.6729968

17 -1.083794 0.9313553 2.486868 2.175057 4.152847 -0.02016803 0.4561026 -0.90468973 0.9083646 0.007097529 0.3868731 0.8578399

18 -1.083594 1.3717005 2.486868 2.175057 4.152847 1.39966159 0.4561026 -0.02889533 0.4508740 0.147309933 0.7887032 1.9083759

19 -1.083195 1.1515279 2.486868 2.175057 4.152847 1.39966159 1.6103701 -0.63100398 -1.3790884 -0.834176895 0.7887032 2.0993824

20 -1.082995 1.8120458 2.486868 2.175057 4.152847 -0.02016803 -0.6981649 -1.01416403 0.9083646 1.269009164 0.1859580 -0.7657157

21 -1.082796 -1.2703711 2.345986 3.225073 2.592759 1.39966159 2.7646376 -0.63100398 -0.6166041 -0.413539683 1.1403046 1.8606242

Heading.Accuracy Short.Passing Volleys Dribbling Curve FK.Accuracy Long.Passing Ball.Control Acceleration Sprint.Speed Agility Reactions Balance

1 0.75369099 1.6848656 1.9863077 1.7997488 2.0295349 2.5052292 1.83445120 1.8047771 1.7115729 1.3810617 1.79984320 2.985502 2.1378487

2 1.76105880 1.1055559 2.0378096 1.3536297 1.4302396 1.5539810 1.21248899 1.6924545 1.5763900 1.7225829 1.52352339 3.093794 0.3973190

3 0.32953612 1.2986591 1.8833039 1.7501800 1.7798285 2.1352993 1.27468521 1.7486158 1.9143474 1.6542787 2.14524296 2.877210 1.3720156

4 -1.84425756 -0.8898441 -1.7733304 -2.1161850 -1.5662367 -1.4583048 -0.40461276 -1.2279342 -0.5865377 -0.5314571 -0.34163533 2.444041 -1.4824530

5 -0.04159938 1.8136010 1.7803002 1.2544922 1.6300047 1.9239108 2.08323609 1.5239705 0.8328836 0.6980193 0.97088377 2.552333 0.8846673

6 0.27651677 1.6204978 1.6772964 1.7006112 1.5301222 1.7125224 1.58566632 1.6924545 1.9143474 1.5176702 2.07616301 2.444041 2.0682275

7 -0.04159938 1.8779688 1.4712888 1.4527673 1.6300047 1.6596753 1.89664743 1.6362932 0.9680665 0.4248023 1.93800310 2.444041 2.0682275

8 1.12482650 1.1699236 2.0893115 1.3040610 1.6799460 1.9767580 0.40393811 1.4678092 1.3736155 0.6297150 1.17812362 2.660625 1.3023945

9 1.86709751 0.9124526 0.9562699 0.1144102 1.0806507 1.3425925 1.21248899 1.1308413 0.6977006 0.6297150 0.90180381 1.902580 0.1188343

10 -0.09461874 1.8136010 1.7803002 1.0066483 1.6799460 1.9767580 2.20762853 1.4678092 -0.1133973 -0.2582401 0.34916419 2.335749 0.4669402

11 -0.09461874 1.8779688 1.7803002 1.4031985 1.4801809 1.6068281 1.83445120 1.6924545 0.2921516 -0.1216317 1.86892315 2.444041 1.7897428

12 -0.09461874 1.4273946 0.4412510 0.9075107 -0.1678811 0.1271088 1.46127388 0.9061960 1.1032495 0.8346277 1.17812362 2.768917 1.9289851

13 0.64765227 1.4917623 2.0893115 1.5519049 1.7798285 2.1881464 1.08809655 1.5801318 1.4412070 1.1761490 1.79984320 2.010872 1.4416368

14 1.54898136 1.0411881 1.8833039 0.9570795 1.2804158 1.1312041 1.52347010 1.1308413 0.1569687 0.4248023 0.41824414 2.552333 0.4669402

15 -2.37445114 -1.7909925 -1.7218285 -2.1657538 -1.7160605 -1.8282346 -0.96437876 -2.5758059 -1.8707760 -1.0778910 -1.93047424 1.902580 -1.4824530

16 -2.26841243 -1.9840958 -1.8248323 -2.3640289 -1.6661193 -1.4054577 -1.39975230 -2.2949993 -1.3300441 -0.9412826 -0.27255538 1.794288 -1.3432106

17 0.64765227 1.6204978 -0.1767717 0.9570795 0.6811205 1.1312041 1.52347010 1.3554865 -1.0596782 -0.9412826 0.07284438 2.119164 -0.8558623

18 1.76105880 0.9124526 2.1923153 0.9570795 1.2304745 1.5539810 -0.34241654 1.0185186 0.6301091 0.6980193 0.83272386 2.552333 -0.3685140

19 1.12482650 1.1055559 1.9348058 1.4031985 1.4801809 1.3954397 0.40393811 1.4116479 1.5087985 0.9712362 1.45444343 2.444041 1.8593639

20 1.44294265 -0.3105345 -0.1252698 -0.1334337 0.3814729 -0.8241394 0.09295701 -0.3855144 -0.1809888 0.6297150 -0.75611505 1.577704 -0.6469987

21 1.12482650 1.1699236 1.5742926 1.4527673 1.2304745 0.8669685 0.96370411 1.5239705 2.0495304 2.0641041 1.86892315 2.119164 1.3023945

Shot.Power Jumping Stamina Strength Long.Shots Aggression Interceptions Positioning Vision Penalties Composure Marking Standing.Tackle

1 1.34352854 0.15177264 0.48906217 -0.60256102 2.0376206 -0.64395656 -1.26756793 1.8930605 2.4020311 1.41774311 2.7751992 -0.81382432 -0.99693438

2 1.89288042 2.42074430 1.48199590 1.00233410 1.9893135 0.18980770 -0.95952933 1.9401677 1.6035537 2.02215398 2.6874373 -1.04145761 -0.87043634

3 1.06885260 -0.43647927 1.04758739 -1.40500859 1.4579349 -0.19928229 -0.65149073 1.6575244 1.9362526 1.78038963 2.5996753 -1.08698427 -1.16559844

4 -1.62297158 0.06773665 -1.31063020 -0.20133724 -1.9235649 -1.19979940 -0.91552382 -1.9697314 0.6719968 -0.69769495 0.3178650 -1.63330419 -1.29209648

5 1.67313967 -0.26840730 1.60611261 0.68135508 1.8926992 0.91240339 0.44864713 1.5633100 2.4020311 1.65950746 2.0731037 0.77960877 0.26804604

6 1.17872298 -0.85665921 1.17170411 -0.04084773 1.3613207 -0.31045086 -0.43146316 1.5633100 2.0693322 2.08259507 2.3363895 -0.76829766 -1.03910039

7 1.01391742 0.15177264 1.54405425 -0.68280578 1.4579349 0.13422341 1.41676844 1.1864522 2.2689515 1.84083072 1.7220560 0.41539550 1.02703429

8 1.39846373 0.23580863 1.60611261 1.32331312 1.6028563 1.52383051 -0.43146316 1.7988461 1.7366333 2.02215398 1.8098179 0.50644882 -0.28011214

9 1.01391742 2.25267233 1.23376247 1.32331312 0.3468707 1.57941480 1.72480704 0.2914151 0.3392979 1.41774311 1.5465321 1.64461531 1.70169052

10 1.45339892 -3.04159488 0.67523725 0.52086556 1.9410063 0.02305485 1.37276293 1.1864522 1.8697129 1.29686093 1.8098179 0.96171541 1.15353234

11 0.62937110 -0.18437131 0.86141232 -1.16427432 1.1197850 -0.14369801 -0.03541353 1.6575244 2.2689515 1.41774311 2.5119134 0.36986884 0.05721597

12 0.57443592 0.90809653 1.97846276 0.76159983 0.8299421 1.69058337 1.81281807 0.8095945 1.4039344 0.14848027 1.8098179 1.78119529 1.65952450

13 1.17872298 0.74002455 0.98552903 -0.12109249 1.7477778 -0.64395656 -0.82751279 1.4219883 1.9362526 2.08259507 1.7220560 -1.26909091 -1.33426249

14 1.50833410 0.99213251 1.54405425 1.40355788 1.6028563 0.91240339 -0.69549624 1.8459533 1.4704742 2.32435941 2.1608657 0.23328886 -0.65960627

15 -2.11738827 1.07616850 -1.80709707 1.00233410 -2.0201791 -0.92187798 -1.26756793 -2.0168386 0.7385366 -1.60431126 0.4056270 -1.17803759 -1.62942459

16 -1.34829564 0.15177264 -1.62092199 0.28013129 -1.6820292 -2.03356367 -1.57560653 -1.9226242 -0.9249579 -1.48342908 0.1423412 -1.40567089 -1.41859452

17 0.02508404 -0.01629934 1.35787918 0.84184459 0.1053350 1.41266195 1.59279050 1.0922378 1.9362526 0.51112680 2.2486276 1.78119529 1.44869443

18 1.45339892 1.83249239 1.73022933 0.92208934 1.3130135 1.35707766 -0.12342456 1.8459533 1.2708548 2.02215398 1.5465321 0.05118222 -0.28011214

19 1.50833410 1.24424048 0.73729560 0.52086556 1.5062421 0.30097627 -1.17955690 1.7988461 1.6700935 1.90127180 2.2486276 -0.95040430 -1.33426249

20 0.95898223 1.91652838 0.05465367 1.80478166 -0.1362007 1.80175193 1.63679602 -1.2160159 -0.5257193 -0.09328407 1.7220560 1.91777527 1.74385653

21 1.01391742 0.74002455 1.17170411 0.36037605 1.2647064 0.13422341 -0.56347970 1.6104172 1.6035537 1.11553767 1.8975799 -0.76829766 -0.74393830

Sliding.Tackle GK.Diving GK.Handling GK.Kicking GK.Positioning GK.Reflexes Values Wages Cluster

1 -0.98817606 -0.5749064 -0.3216783 -0.08855293 -0.1573438 -0.4700254 10.587303 13.398194 3

2 -1.11591110 -0.5236341 -0.3216783 -0.08855293 -0.1573438 -0.3181741 7.179220 9.419694 3

3 -0.69012766 -0.4210895 -0.4295405 -0.08855293 -0.1039817 -0.3181741 11.401173 6.560146 3

4 -1.54169454 3.7319654 3.6692221 3.96449911 3.7914527 3.8830465 6.670551 5.814177 2

5 0.07628253 -0.1134558 -0.2138161 -0.65147682 -0.3707923 -0.2169398 9.722565 8.176412 3

6 -1.15848944 -0.3185450 -0.2677472 -0.59518444 -0.4775165 -0.4700254 8.806961 7.803428 3

7 1.01300610 -0.2160004 -0.4295405 -0.53889205 -0.1573438 -0.4194083 6.161882 9.792678 3

8 -0.47723594 0.5018116 0.4333569 0.81212530 0.8565364 0.9978709 7.484422 10.662975 3

9 1.77941629 -0.3185450 -0.4834716 -0.42630727 -0.5308786 -0.3181741 4.534142 8.798053 3

10 0.84269272 -0.3698172 -0.3216783 -0.20113771 -0.5308786 -0.3687912 7.128354 8.176412 3

11 -0.86044103 -0.5749064 -0.1059540 -0.53889205 -0.5842407 -0.2675569 5.449746 6.435818 3

12 1.52394623 -0.1134558 -0.2677472 -0.37001488 -0.5308786 -0.3687912 5.754947 4.943880 3

13 -1.24364613 -0.6261787 -0.6991959 -0.70776921 -0.6376029 -0.4700254 8.400026 4.446568 3

14 -0.47723594 -0.4723618 -0.3756094 -0.31372249 -0.1573438 -0.3181741 7.840490 4.446568 3

15 -1.66942957 3.5781486 3.6692221 4.02079150 3.6313664 3.6805780 5.246278 5.316865 2

16 -1.41395950 3.4756040 3.9928086 3.12011327 3.6847285 3.5793438 4.788476 5.316865 2

17 1.31105451 -0.6261787 -0.4834716 -0.20113771 -0.4241544 -0.2169398 4.585009 7.181787 3

18 -0.43465759 -0.2672727 -0.6452648 -0.20113771 -0.2107059 -0.3687912 5.449746 4.322240 3

19 -1.58427288 -0.2160004 -0.1059540 -0.59518444 -0.3174302 -0.1663227 5.907548 6.808803 3

20 1.73683795 -0.7287232 -0.7531270 -0.82035399 -0.6909650 -0.7231110 2.092531 4.695224 3

21 -0.73270600 -0.2160004 -0.6452648 -0.53889205 -0.3174302 -0.5712596 7.586156 1.835677 3

[ reached 'max' / getOption("max.print") -- omitted 3851 rows ]

> #Conclusion : With the help of kmeans we clustered playes into 4 different categories

**Day 14 – R Programming**

**Telecommunication Customer Churn – R Classification Project**

> setwd("C:/zubeda/PGA02\_Zubu/R Programming/Models")

> library(caret)

> library(broom)

> library(dplyr)

> library(dummy)

> library(ggplot2)

> library(ROCit)

> library(purrr)

> #install.packages("CatEncoders")

> library(CatEncoders)

> library(Metrics)

> library(tidyverse)

> library(ggrepel)

> library(GGally)

> library(gridExtra)

> library(ipred)

>

> #Read the data

> raw\_data <- read.csv("churn.csv")

> head(raw\_data)

customerID gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity OnlineBackup DeviceProtection

1 7590-VHVEG Female 0 Yes No 1 No No phone service DSL No Yes No

2 5575-GNVDE Male 0 No No 34 Yes No DSL Yes No Yes

3 3668-QPYBK Male 0 No No 2 Yes No DSL Yes Yes No

4 7795-CFOCW Male 0 No No 45 No No phone service DSL Yes No Yes

5 9237-HQITU Female 0 No No 2 Yes No Fiber optic No No No

6 9305-CDSKC Female 0 No No 8 Yes Yes Fiber optic No No Yes

TechSupport StreamingTV StreamingMovies Contract PaperlessBilling PaymentMethod MonthlyCharges TotalCharges Churn

1 No No No Month-to-month Yes Electronic check 29.85 29.85 No

2 No No No One year No Mailed check 56.95 1889.50 No

3 No No No Month-to-month Yes Mailed check 53.85 108.15 Yes

4 Yes No No One year No Bank transfer (automatic) 42.30 1840.75 No

5 No No No Month-to-month Yes Electronic check 70.70 151.65 Yes

6 No Yes Yes Month-to-month Yes Electronic check 99.65 820.50 Yes

>

> #Understand & Prepare the data

> dim(raw\_data)

[1] 7043 21

> str(raw\_data)

'data.frame': 7043 obs. of 21 variables:

$ customerID : chr "7590-VHVEG" "5575-GNVDE" "3668-QPYBK" "7795-CFOCW" ...

$ gender : chr "Female" "Male" "Male" "Male" ...

$ SeniorCitizen : int 0 0 0 0 0 0 0 0 0 0 ...

$ Partner : chr "Yes" "No" "No" "No" ...

$ Dependents : chr "No" "No" "No" "No" ...

$ tenure : int 1 34 2 45 2 8 22 10 28 62 ...

$ PhoneService : chr "No" "Yes" "Yes" "No" ...

$ MultipleLines : chr "No phone service" "No" "No" "No phone service" ...

$ InternetService : chr "DSL" "DSL" "DSL" "DSL" ...

$ OnlineSecurity : chr "No" "Yes" "Yes" "Yes" ...

$ OnlineBackup : chr "Yes" "No" "Yes" "No" ...

$ DeviceProtection: chr "No" "Yes" "No" "Yes" ...

$ TechSupport : chr "No" "No" "No" "Yes" ...

$ StreamingTV : chr "No" "No" "No" "No" ...

$ StreamingMovies : chr "No" "No" "No" "No" ...

$ Contract : chr "Month-to-month" "One year" "Month-to-month" "One year" ...

$ PaperlessBilling: chr "Yes" "No" "Yes" "No" ...

$ PaymentMethod : chr "Electronic check" "Mailed check" "Mailed check" "Bank transfer (automatic)" ...

$ MonthlyCharges : num 29.9 57 53.9 42.3 70.7 ...

$ TotalCharges : num 29.9 1889.5 108.2 1840.8 151.7 ...

$ Churn : chr "No" "No" "Yes" "No" ...

> length(raw\_data)

[1] 21

> ncol(raw\_data)

[1] 21

> nrow(raw\_data)

[1] 7043

> summary(raw\_data)

customerID gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines

Length:7043 Length:7043 Min. :0.0000 Length:7043 Length:7043 Min. : 0.00 Length:7043 Length:7043

Class :character Class :character 1st Qu.:0.0000 Class :character Class :character 1st Qu.: 9.00 Class :character Class :character

Mode :character Mode :character Median :0.0000 Mode :character Mode :character Median :29.00 Mode :character Mode :character

Mean :0.1621 Mean :32.37

3rd Qu.:0.0000 3rd Qu.:55.00

Max. :1.0000 Max. :72.00

InternetService OnlineSecurity OnlineBackup DeviceProtection TechSupport StreamingTV StreamingMovies Contract

Length:7043 Length:7043 Length:7043 Length:7043 Length:7043 Length:7043 Length:7043 Length:7043

Class :character Class :character Class :character Class :character Class :character Class :character Class :character Class :character

Mode :character Mode :character Mode :character Mode :character Mode :character Mode :character Mode :character Mode :character

PaperlessBilling PaymentMethod MonthlyCharges TotalCharges Churn

Length:7043 Length:7043 Min. : 18.25 Min. : 18.8 Length:7043

Class :character Class :character 1st Qu.: 35.50 1st Qu.: 401.4 Class :character

Mode :character Mode :character Median : 70.35 Median :1397.5 Mode :character

Mean : 64.76 Mean :2283.3

3rd Qu.: 89.85 3rd Qu.:3794.7

Max. :118.75 Max. :8684.8

NA's :11

> #Label Encoding

> data <- raw\_data

> #Saving names of categorical variables

> factors <- names(which(sapply(data, is.factor)))

> for(i in factors) {

+ encode <- LabelEncoder.fit(data[, i])

+ data[, i] <- transform(encode, data[, i])

+ }

> head(data)

customerID gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity OnlineBackup DeviceProtection

1 7590-VHVEG Female 0 Yes No 1 No No phone service DSL No Yes No

2 5575-GNVDE Male 0 No No 34 Yes No DSL Yes No Yes

3 3668-QPYBK Male 0 No No 2 Yes No DSL Yes Yes No

4 7795-CFOCW Male 0 No No 45 No No phone service DSL Yes No Yes

5 9237-HQITU Female 0 No No 2 Yes No Fiber optic No No No

6 9305-CDSKC Female 0 No No 8 Yes Yes Fiber optic No No Yes

TechSupport StreamingTV StreamingMovies Contract PaperlessBilling PaymentMethod MonthlyCharges TotalCharges Churn

1 No No No Month-to-month Yes Electronic check 29.85 29.85 No

2 No No No One year No Mailed check 56.95 1889.50 No

3 No No No Month-to-month Yes Mailed check 53.85 108.15 Yes

4 Yes No No One year No Bank transfer (automatic) 42.30 1840.75 No

5 No No No Month-to-month Yes Electronic check 70.70 151.65 Yes

6 No Yes Yes Month-to-month Yes Electronic check 99.65 820.50 Yes

> data\_1 <- data[-c(1)] #Remove CustomerID feature as it is not relevant

> head(data\_1)

gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity OnlineBackup DeviceProtection TechSupport

1 Female 0 Yes No 1 No No phone service DSL No Yes No No

2 Male 0 No No 34 Yes No DSL Yes No Yes No

3 Male 0 No No 2 Yes No DSL Yes Yes No No

4 Male 0 No No 45 No No phone service DSL Yes No Yes Yes

5 Female 0 No No 2 Yes No Fiber optic No No No No

6 Female 0 No No 8 Yes Yes Fiber optic No No Yes No

StreamingTV StreamingMovies Contract PaperlessBilling PaymentMethod MonthlyCharges TotalCharges Churn

1 No No Month-to-month Yes Electronic check 29.85 29.85 No

2 No No One year No Mailed check 56.95 1889.50 No

3 No No Month-to-month Yes Mailed check 53.85 108.15 Yes

4 No No One year No Bank transfer (automatic) 42.30 1840.75 No

5 No No Month-to-month Yes Electronic check 70.70 151.65 Yes

6 Yes Yes Month-to-month Yes Electronic check 99.65 820.50 Yes

> glimpse(data\_1) #Similar to str

Rows: 7,043

Columns: 20

$ gender <chr> "Female", "Male", "Male", "Male", "Female", "Female", "Male", "Female", "Female", "Male", "Male", "Male", "Male", "Male", "Male", "~

$ SeniorCitizen <int> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,~

$ Partner <chr> "Yes", "No", "No", "No", "No", "No", "No", "No", "Yes", "No", "Yes", "No", "Yes", "No", "No", "Yes", "No", "No", "Yes", "No", "No",~

$ Dependents <chr> "No", "No", "No", "No", "No", "No", "Yes", "No", "No", "Yes", "Yes", "No", "No", "No", "No", "Yes", "No", "Yes", "Yes", "No", "No",~

$ tenure <int> 1, 34, 2, 45, 2, 8, 22, 10, 28, 62, 13, 16, 58, 49, 25, 69, 52, 71, 10, 21, 1, 12, 1, 58, 49, 30, 47, 1, 72, 17, 71, 2, 27, 1, 1, 7~

$ PhoneService <chr> "No", "Yes", "Yes", "No", "Yes", "Yes", "Yes", "No", "Yes", "Yes", "Yes", "Yes", "Yes", "Yes", "Yes", "Yes", "Yes", "Yes", "Yes", "~

$ MultipleLines <chr> "No phone service", "No", "No", "No phone service", "No", "Yes", "Yes", "No phone service", "Yes", "No", "No", "No", "Yes", "Yes", ~

$ InternetService <chr> "DSL", "DSL", "DSL", "DSL", "Fiber optic", "Fiber optic", "Fiber optic", "DSL", "Fiber optic", "DSL", "DSL", "No", "Fiber optic", "~

$ OnlineSecurity <chr> "No", "Yes", "Yes", "Yes", "No", "No", "No", "Yes", "No", "Yes", "Yes", "No internet service", "No", "No", "Yes", "Yes", "No intern~

$ OnlineBackup <chr> "Yes", "No", "Yes", "No", "No", "No", "Yes", "No", "No", "Yes", "No", "No internet service", "No", "Yes", "No", "Yes", "No internet~

$ DeviceProtection <chr> "No", "Yes", "No", "Yes", "No", "Yes", "No", "No", "Yes", "No", "No", "No internet service", "Yes", "Yes", "Yes", "Yes", "No intern~

$ TechSupport <chr> "No", "No", "No", "Yes", "No", "No", "No", "No", "Yes", "No", "No", "No internet service", "No", "No", "Yes", "Yes", "No internet s~

$ StreamingTV <chr> "No", "No", "No", "No", "No", "Yes", "Yes", "No", "Yes", "No", "No", "No internet service", "Yes", "Yes", "Yes", "Yes", "No interne~

$ StreamingMovies <chr> "No", "No", "No", "No", "No", "Yes", "No", "No", "Yes", "No", "No", "No internet service", "Yes", "Yes", "Yes", "Yes", "No internet~

$ Contract <chr> "Month-to-month", "One year", "Month-to-month", "One year", "Month-to-month", "Month-to-month", "Month-to-month", "Month-to-month",~

$ PaperlessBilling <chr> "Yes", "No", "Yes", "No", "Yes", "Yes", "Yes", "No", "Yes", "No", "Yes", "No", "No", "Yes", "Yes", "No", "No", "No", "No", "Yes", "~

$ PaymentMethod <chr> "Electronic check", "Mailed check", "Mailed check", "Bank transfer (automatic)", "Electronic check", "Electronic check", "Credit ca~

$ MonthlyCharges <dbl> 29.85, 56.95, 53.85, 42.30, 70.70, 99.65, 89.10, 29.75, 104.80, 56.15, 49.95, 18.95, 100.35, 103.70, 105.50, 113.25, 20.65, 106.70,~

$ TotalCharges <dbl> 29.85, 1889.50, 108.15, 1840.75, 151.65, 820.50, 1949.40, 301.90, 3046.05, 3487.95, 587.45, 326.80, 5681.10, 5036.30, 2686.05, 7895~

$ Churn <chr> "No", "No", "Yes", "No", "Yes", "Yes", "No", "No", "Yes", "No", "No", "No", "No", "Yes", "No", "No", "No", "No", "Yes", "No", "Yes"~

> #Missing data

> sum(is.na(data\_1))

[1] 11

> colSums(is.na(data\_1)) #To know missing values in all features

gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity

0 0 0 0 0 0 0 0 0

OnlineBackup DeviceProtection TechSupport StreamingTV StreamingMovies Contract PaperlessBilling PaymentMethod MonthlyCharges

0 0 0 0 0 0 0 0 0

TotalCharges Churn

11 0

> #Filling Missing NA values

> data\_2 <- data\_1 %>% mutate(TotalCharges = if\_else(is.na(TotalCharges) == TRUE, median(TotalCharges, na.rm=TRUE), TotalCharges))

> #na.rm = TRUE ignore missing values and calculate the mean, median...

> head(data\_2)

gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity OnlineBackup DeviceProtection TechSupport

1 Female 0 Yes No 1 No No phone service DSL No Yes No No

2 Male 0 No No 34 Yes No DSL Yes No Yes No

3 Male 0 No No 2 Yes No DSL Yes Yes No No

4 Male 0 No No 45 No No phone service DSL Yes No Yes Yes

5 Female 0 No No 2 Yes No Fiber optic No No No No

6 Female 0 No No 8 Yes Yes Fiber optic No No Yes No

StreamingTV StreamingMovies Contract PaperlessBilling PaymentMethod MonthlyCharges TotalCharges Churn

1 No No Month-to-month Yes Electronic check 29.85 29.85 No

2 No No One year No Mailed check 56.95 1889.50 No

3 No No Month-to-month Yes Mailed check 53.85 108.15 Yes

4 No No One year No Bank transfer (automatic) 42.30 1840.75 No

5 No No Month-to-month Yes Electronic check 70.70 151.65 Yes

6 Yes Yes Month-to-month Yes Electronic check 99.65 820.50 Yes

> sum(is.na(data\_2))

[1] 0

> #Remove outliers

> remove\_outliers <- function(x, na.rm=TRUE, ...) {

+ qnt <- quantile(x, probs=c(.10, .90), na.rm=na.rm, ...)

+ H <- 1.5 \* IQR(x, na.rm=na.rm)

+ y <- x

+ y[x < (qnt[1] - H)] <- NA

+ y[x > (qnt[3] + H)] <- NA

+ y

+ }

> data\_3 <- data\_2

> data\_3 <- cbind(data\_3[1], apply(data\_3[2], 2, remove\_outliers), data\_3[3:4], apply(data\_3[5], 2, remove\_outliers), data\_3[6:18], apply(data\_3[19], 2, remove\_outliers), data\_3[20])

> head(data\_3)

gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity OnlineBackup DeviceProtection TechSupport

1 Female 0 Yes No 1 No No phone service DSL No Yes No No

2 Male 0 No No 34 Yes No DSL Yes No Yes No

3 Male 0 No No 2 Yes No DSL Yes Yes No No

4 Male 0 No No 45 No No phone service DSL Yes No Yes Yes

5 Female 0 No No 2 Yes No Fiber optic No No No No

6 Female 0 No No 8 Yes Yes Fiber optic No No Yes No

StreamingTV StreamingMovies Contract PaperlessBilling PaymentMethod MonthlyCharges TotalCharges Churn

1 No No Month-to-month Yes Electronic check 29.85 29.85 No

2 No No One year No Mailed check 56.95 1889.50 No

3 No No Month-to-month Yes Mailed check 53.85 108.15 Yes

4 No No One year No Bank transfer (automatic) 42.30 1840.75 No

5 No No Month-to-month Yes Electronic check 70.70 151.65 Yes

6 Yes Yes Month-to-month Yes Electronic check 99.65 820.50 Yes

> sum(is.na(data\_3))

[1] 0

> #There are no outliers

> #Visualizing features

> #Explore target variable

> df <- data\_3

> df %>% group\_by(Churn) %>%

+ count() %>%

+ ggplot(aes(reorder(Churn, -n), n), fill=Churn) +

+ geom\_col(fill = c("seagreen", "steelblue")) +

+ geom\_text\_repel(aes(label = n), size = 9) +

+ coord\_flip() +

+ theme\_minimal() +

+ labs(x= NULL, y = "Frequency", title = "Dependent Variable - Churn")

> #Customer partner status

> ggplot(raw\_data, aes(Partner, fill=Churn)) +

+ geom\_bar() +

+ labs(title="Customer Partner Status", x="Does the Customer have a Partner?", y="Count")

> #Customer Dependents

> ggplot(raw\_data, aes(Dependents, fill=Churn)) +

+ geom\_bar() +

+ labs(title="Customer Dependents Status", x="Does the Customer have Dependents?", y="Count")

> #Customer Tenure

> ggplot(raw\_data, aes(tenure, fill = Churn)) +

+ geom\_histogram() +

+ labs(title = "Customer Tenure Histogram",

+ x = "Length of Customer Tenure",

+ y = "Count")

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> #Customer Internet Service status

> ggplot(raw\_data, aes(InternetService, fill = Churn)) +

+ geom\_bar() +

+ labs(title = "Customer Internet Service Status",

+ x = "Type of Internet Service Customer Has",

+ y = "Count")

> #Customer Contract Term

> ggplot(raw\_data, aes(Contract, fill = Churn)) +

+ geom\_bar() +

+ labs(title = "Popularity of Contract Types",

+ x = "Type of Contract Customer Has",

+ y = "Count")

> #Paperless Billing Status

> ggplot(raw\_data, aes(PaperlessBilling, fill = Churn)) +

+ geom\_bar() +

+ labs(title = "Paperless Billing Status",

+ x = "Does the Customer Use Paperless Billing?",

+ y = "Count")

> #Customer payment method

> ggplot(raw\_data, aes(PaymentMethod, fill = Churn)) +

+ geom\_bar() +

+ labs(title = "Payment Method",

+ x = "What Payment Method does the Customer Use?",

+ y = "Count")

> #Customer Monthly Charges

> ggplot(raw\_data, aes(MonthlyCharges, fill = Churn)) +

+ geom\_histogram() +

+ labs(title = "Monthly Charges Histogram",

+ x = "Monthly Charge to Customer",

+ y = "Count")

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> Churn\_df <- raw\_data

> Internet\_Addons\_df <- data.frame('Online Security'= Churn\_df$OnlineSecurity, 'Online Backup'= Churn\_df$OnlineBackup,

+ 'Device Protection'= Churn\_df$DeviceProtection, 'Tech Support'= Churn\_df$TechSupport,

+ 'Streaming TV'= Churn\_df$StreamingTV, 'Streaming Movies'= Churn\_df$StreamingMovies)

> perc <- function(x) {

+ l = length(x)

+ v = length(grep("Yes", x))

+ v / l \* 100

+ }

> Churn\_df <- raw\_data

> Internet\_Addons\_df <- data.frame('Online Security'= Churn\_df$OnlineSecurity, 'Online Backup'= Churn\_df$OnlineBackup,

+ 'Device Protection'= Churn\_df$DeviceProtection, 'Tech Support'= Churn\_df$TechSupport,

+ 'Streaming TV'= Churn\_df$StreamingTV, 'Streaming Movies'= Churn\_df$StreamingMovies)

> perc <- function(x) {

+ l = length(x)

+ v = length(grep("Yes", x))

+ v / l \* 100

+ }

> #Percentage of yes

> #grep() returns the indices of vector elements that contains the character

> #Monthly charges based on Internet service

> ggplot(Churn\_df, aes(MonthlyCharges, fill = InternetService)) +

+ geom\_histogram() +

+ labs(title = "Monthly Charges Histogram By Internet Service Option",

+ x = "Monthly Charge to Customer",

+ y = "Count")

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> #Payment Method based on Senior citizenship

> ggplot(Churn\_df, aes(SeniorCitizen, fill = PaymentMethod)) +

+ geom\_bar(position = 'fill') +

+ labs(title = "Payment Method of Seniors vs. Everyone Else",

+ x = "Is the Customer a Senior Citizen?",

+ y = "Fraction")

> #Payment Method based on Internet Service

> ggplot(Churn\_df, aes(InternetService, fill = PaymentMethod)) +

+ geom\_bar(position = 'fill') +

+ labs(title = "Payment Method by Internet Service",

+ x = "Which Internet Service does the Customer Have?",

+ y = "Fraction")

> #Partner based on Dependents

> ggplot(Churn\_df, aes(Partner, fill = Dependents)) +

+ geom\_bar(position = 'fill') +

+ labs(title = "Customer Dependents Status",

+ x = "Does the Customer have a Partner?",

+ y = "Fraction")

> #Bivariate analysis

> telco <- raw\_data

> ggplot(telco, aes(y= tenure, x = "", fill = Churn)) +

+ geom\_boxplot()+

+ theme\_bw()+

+ xlab(" ")

> ggplot(telco, aes(y= MonthlyCharges, x = "", fill = Churn)) +

+ geom\_boxplot()+

+ theme\_bw()+

+ xlab(" ")

> ggplot(telco, aes(y= TotalCharges, x = "", fill = Churn)) +

+ geom\_boxplot()+

+ theme\_bw()+

+ xlab(" ")

Warning message:

Removed 11 rows containing non-finite values (stat\_boxplot).

> grid.arrange(

+

+ ggplot(df,aes(x = MonthlyCharges, color = Churn))+

+ geom\_freqpoly(size=2)+

+ theme\_minimal(),

+

+ ggplot(df,aes(x = TotalCharges, color = Churn))+

+ geom\_freqpoly(size=2)+

+ theme\_minimal(),

+

+ ggplot(df,aes(x = tenure, color = Churn))+

+ geom\_freqpoly(size=2)+

+ theme\_minimal()

+

+ )

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

`stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

> #Correlation

> data\_numeric <- Filter(is.numeric, data\_3)

> data\_numeric

SeniorCitizen tenure MonthlyCharges TotalCharges

1 0 1 29.85 29.85

2 0 34 56.95 1889.50

3 0 2 53.85 108.15

4 0 45 42.30 1840.75

5 0 2 70.70 151.65

6 0 8 99.65 820.50

7 0 22 89.10 1949.40

8 0 10 29.75 301.90

9 0 28 104.80 3046.05

10 0 62 56.15 3487.95

11 0 13 49.95 587.45

12 0 16 18.95 326.80

13 0 58 100.35 5681.10

14 0 49 103.70 5036.30

15 0 25 105.50 2686.05

16 0 69 113.25 7895.15

17 0 52 20.65 1022.95

18 0 71 106.70 7382.25

19 0 10 55.20 528.35

20 0 21 90.05 1862.90

21 1 1 39.65 39.65

22 0 12 19.80 202.25

23 0 1 20.15 20.15

24 0 58 59.90 3505.10

25 0 49 59.60 2970.30

26 0 30 55.30 1530.60

27 0 47 99.35 4749.15

28 0 1 30.20 30.20

29 0 72 90.25 6369.45

30 0 17 64.70 1093.10

31 1 71 96.35 6766.95

32 1 2 95.50 181.65

33 0 27 66.15 1874.45

34 0 1 20.20 20.20

35 1 1 45.25 45.25

36 0 72 99.90 7251.70

37 0 5 69.70 316.90

38 0 46 74.80 3548.30

39 0 34 106.35 3549.25

40 0 11 97.85 1105.40

41 0 10 49.55 475.70

42 0 70 69.20 4872.35

43 0 17 20.75 418.25

44 0 63 79.85 4861.45

45 0 13 76.20 981.45

46 0 49 84.50 3906.70

47 0 2 49.25 97.00

48 0 2 80.65 144.15

49 0 52 79.75 4217.80

50 0 69 64.15 4254.10

51 1 43 90.25 3838.75

52 0 15 99.10 1426.40

53 1 25 69.50 1752.65

54 1 8 80.65 633.30

55 1 60 74.85 4456.35

56 1 18 95.45 1752.55

57 0 63 99.65 6311.20

58 1 66 108.45 7076.35

59 0 34 24.95 894.30

60 0 72 107.50 7853.70

61 0 47 100.50 4707.10

62 0 60 89.90 5450.70

63 0 72 42.10 2962.00

64 0 18 54.40 957.10

65 0 9 94.40 857.25

66 0 3 75.30 244.10

67 0 47 78.90 3650.35

68 0 31 79.20 2497.20

69 0 50 20.15 930.90

70 0 10 79.85 887.35

71 0 1 49.05 49.05

72 0 52 20.40 1090.65

73 1 64 111.60 7099.00

74 0 62 24.25 1424.60

75 0 3 64.50 177.40

76 1 56 110.50 6139.50

77 0 46 55.65 2688.85

78 0 8 54.65 482.25

79 1 30 74.75 2111.30

80 0 45 25.90 1216.60

81 0 1 79.35 79.35

82 0 11 50.55 565.35

83 0 7 75.15 496.90

84 0 42 103.80 4327.50

85 0 49 20.15 973.35

86 0 9 99.30 918.75

87 0 35 62.15 2215.45

88 0 48 20.65 1057.00

89 0 46 19.95 927.10

90 0 29 33.75 1009.25

91 0 30 82.05 2570.20

92 1 1 74.70 74.70

93 0 66 84.00 5714.25

94 0 65 111.05 7107.00

95 0 72 100.90 7459.05

96 0 12 78.95 927.35

97 0 71 66.85 4748.70

98 0 5 21.05 113.85

99 0 52 21.00 1107.20

100 1 25 98.50 2514.50

101 0 1 20.20 20.20

102 0 1 19.45 19.45

103 0 38 95.00 3605.60

104 1 66 45.55 3027.25

105 0 68 110.00 7611.85

106 0 5 24.30 100.20

107 0 72 104.15 7303.05

108 0 32 30.15 927.65

109 0 43 94.35 3921.30

110 0 72 19.40 1363.25

111 0 55 96.75 5238.90

112 0 52 57.95 3042.25

113 0 43 91.65 3954.10

114 1 37 76.50 2868.15

115 0 64 54.60 3423.50

116 0 3 89.85 248.40

117 0 36 31.05 1126.35

118 0 10 100.25 1064.65

119 0 41 20.65 835.15

120 0 27 85.20 2151.60

121 0 56 99.80 5515.45

122 0 6 20.70 112.75

123 0 3 74.40 229.55

124 0 7 50.70 350.35

125 0 4 20.85 62.90

126 0 33 88.95 3027.65

127 1 27 78.05 2135.50

128 0 72 23.55 1723.95

129 0 1 19.75 19.75

130 1 71 56.45 3985.35

131 0 13 85.95 1215.65

132 0 25 58.60 1502.65

133 0 67 50.55 3260.10

134 0 1 35.45 35.45

135 0 2 44.35 81.25

136 0 43 25.70 1188.20

137 0 23 75.00 1778.50

138 0 64 20.20 1277.75

139 0 57 19.60 1170.55

140 1 1 70.45 70.45

141 1 72 88.05 6425.65

142 0 8 71.15 563.65

143 0 61 101.05 5971.25

144 0 64 84.30 5289.05

145 1 71 23.95 1756.20

146 0 65 99.05 6416.70

147 0 3 19.60 61.35

148 0 1 45.65 45.65

149 0 30 64.50 1929.95

150 0 15 69.50 1071.40

151 0 8 68.55 564.35

152 0 7 95.00 655.50

153 0 70 108.15 7930.55

154 0 62 86.10 5215.25

155 0 6 19.70 113.50

156 0 14 80.90 1152.80

157 0 22 84.15 1821.95

158 0 22 20.15 419.90

159 0 16 64.25 1024.00

160 0 10 25.70 251.60

161 0 13 56.00 764.55

162 0 20 82.40 1592.35

163 0 2 69.70 135.20

164 0 53 73.90 3958.25

165 0 11 20.60 233.90

166 0 69 19.90 1363.45

167 0 4 70.90 273.00

168 0 72 89.05 6254.45

169 1 58 45.30 2651.20

170 0 16 20.40 321.40

171 0 43 84.25 3539.25

172 0 2 104.40 242.80

173 0 14 81.95 1181.75

174 0 53 94.85 5000.20

175 0 32 20.55 654.55

176 0 34 24.70 780.20

177 1 15 74.45 1145.70

178 1 7 76.45 503.60

179 0 15 105.35 1559.25

180 0 61 20.55 1252.00

181 0 1 29.95 29.95

182 0 1 45.30 45.30

183 0 8 84.50 662.65

184 0 33 74.75 2453.30

185 0 13 79.25 1111.65

186 0 1 24.80 24.80

187 0 20 51.80 1023.85

188 0 3 30.40 82.15

189 0 13 19.65 244.80

190 0 40 56.60 2379.10

191 0 43 71.90 3173.35

192 0 6 91.00 531.00

193 0 69 19.75 1375.40

194 0 72 109.70 8129.30

195 0 59 19.30 1192.70

196 0 20 96.55 1901.65

197 0 24 24.10 587.40

198 0 59 111.35 6519.75

199 0 72 112.25 8041.65

200 0 1 20.75 20.75

201 0 27 101.90 2681.15

202 0 14 80.05 1112.30

203 0 71 105.55 7405.50

204 0 13 78.30 1033.95

205 0 44 68.85 2958.95

206 0 33 79.95 2684.85

207 0 72 55.45 4179.20

208 0 1 79.90 79.90

209 0 19 106.60 1934.45

210 0 64 102.45 6654.10

211 0 2 46.00 84.50

212 0 1 25.25 25.25

213 0 61 19.75 1124.20

214 0 29 20.00 540.05

215 1 23 86.80 1975.85

216 0 57 58.75 3437.45

217 0 72 45.25 3139.80

218 0 66 56.60 3789.20

219 0 65 84.20 5324.50

220 0 8 80.00 624.60

221 0 4 70.15 268.35

222 0 71 24.75 1836.90

223 0 1 20.20 20.20

224 0 4 50.05 179.35

225 0 12 19.35 219.35

226 0 24 50.60 1288.75

227 0 31 81.15 2545.75

228 0 1 55.20 55.20

229 0 30 89.90 2723.15

230 0 47 85.30 4107.25

231 0 54 108.00 5760.65

232 0 50 93.50 4747.50

233 0 1 84.60 84.60

234 0 72 20.25 1566.90

235 0 29 25.15 702.00

236 0 2 54.40 114.10

237 0 10 29.60 299.05

238 0 18 73.15 1305.95

239 1 11 95.00 1120.30

240 0 16 19.75 284.35

241 0 72 86.60 6350.50

242 0 72 109.20 7878.30

243 0 41 74.70 3187.65

244 1 65 94.40 6126.15

245 1 13 54.80 731.30

246 1 4 75.35 273.40

247 0 41 65.00 2531.80

248 1 15 74.40 1074.30

249 0 1 48.55 48.55

250 0 42 99.00 4298.45

[ reached 'max' / getOption("max.print") -- omitted 6793 rows ]

> library(reshape2)

> cormat <- round(cor(data\_numeric), 2)

> melted\_cormat <- melt(cormat) #dataframe is converted into long format & stretches the data frame

> head(melted\_cormat)

Var1 Var2 value

1 SeniorCitizen SeniorCitizen 1.00

2 tenure SeniorCitizen 0.02

3 MonthlyCharges SeniorCitizen 0.22

4 TotalCharges SeniorCitizen 0.10

5 SeniorCitizen tenure 0.02

6 tenure tenure 1.00

> #Heatmap

> ggplot(data = melted\_cormat, aes(x=Var1, y=Var2, fill=value),method = "number" , iscorr = False) +

+ geom\_tile() + theme(

+ axis.title.x = element\_blank(),

+ axis.title.y = element\_blank(),

+ panel.grid.major = element\_blank(),

+ panel.border = element\_blank(),

+ panel.background = element\_blank(),

+ axis.ticks = element\_blank(),

+ legend.direction = "horizontal")+

+ guides(fill = guide\_colorbar(barwidth = 7, barheight = 1,

+ title.position = "top", title.hjust = 0.5))

> library(corrplot)

> cex.before <- par("cex")

> par(cex = 0.7)

> corrplot(cor(data\_numeric), method = "color" , is.corr = FALSE ,addCoef.col="grey", order = "AOE",number.cex= 7/ncol(data\_3))

> par(cex = cex.before)

> table(data\_3$Churn)

No Yes

5174 1869

> data\_3$Churn <- ifelse(data\_3$Churn == 'Yes', 1, 0)

> head(data\_3)

gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity

1 Female 0 Yes No 1 No No phone service DSL No

2 Male 0 No No 34 Yes No DSL Yes

3 Male 0 No No 2 Yes No DSL Yes

4 Male 0 No No 45 No No phone service DSL Yes

5 Female 0 No No 2 Yes No Fiber optic No

6 Female 0 No No 8 Yes Yes Fiber optic No

OnlineBackup DeviceProtection TechSupport StreamingTV StreamingMovies Contract PaperlessBilling

1 Yes No No No No Month-to-month Yes

2 No Yes No No No One year No

3 Yes No No No No Month-to-month Yes

4 No Yes Yes No No One year No

5 No No No No No Month-to-month Yes

6 No Yes No Yes Yes Month-to-month Yes

PaymentMethod MonthlyCharges TotalCharges Churn

1 Electronic check 29.85 29.85 0

2 Mailed check 56.95 1889.50 0

3 Mailed check 53.85 108.15 1

4 Bank transfer (automatic) 42.30 1840.75 0

5 Electronic check 70.70 151.65 1

6 Electronic check 99.65 820.50 1

> #Feature Selection

> library(randomForest)

> fit\_rf <- randomForest(Churn ~ ., data=data\_3)

Warning message:

In randomForest.default(m, y, ...) :

The response has five or fewer unique values. Are you sure you want to do regression?

> importance(fit\_rf) #Generate feature importance

IncNodePurity

gender 27.085887

SeniorCitizen 22.701345

Partner 22.911961

Dependents 20.549237

tenure 183.223022

PhoneService 4.922793

MultipleLines 23.152161

InternetService 31.617128

OnlineSecurity 67.327481

OnlineBackup 28.063159

DeviceProtection 23.508311

TechSupport 54.106863

StreamingTV 16.854828

StreamingMovies 17.656631

Contract 120.686429

PaperlessBilling 26.847737

PaymentMethod 51.305822

MonthlyCharges 213.112811

TotalCharges 219.146335

> varImp(fit\_rf)

Overall

gender 27.085887

SeniorCitizen 22.701345

Partner 22.911961

Dependents 20.549237

tenure 183.223022

PhoneService 4.922793

MultipleLines 23.152161

InternetService 31.617128

OnlineSecurity 67.327481

OnlineBackup 28.063159

DeviceProtection 23.508311

TechSupport 54.106863

StreamingTV 16.854828

StreamingMovies 17.656631

Contract 120.686429

PaperlessBilling 26.847737

PaymentMethod 51.305822

MonthlyCharges 213.112811

TotalCharges 219.146335

> #Plot of importance scores by random forest

> varImpPlot(fit\_rf)

> data\_selected <- subset(data\_3, select=-c(PhoneService, Churn, StreamingTV)) #Selected Feature variables

> head(data\_selected)

gender SeniorCitizen Partner Dependents tenure MultipleLines InternetService OnlineSecurity OnlineBackup

1 Female 0 Yes No 1 No phone service DSL No Yes

2 Male 0 No No 34 No DSL Yes No

3 Male 0 No No 2 No DSL Yes Yes

4 Male 0 No No 45 No phone service DSL Yes No

5 Female 0 No No 2 No Fiber optic No No

6 Female 0 No No 8 Yes Fiber optic No No

DeviceProtection TechSupport StreamingMovies Contract PaperlessBilling PaymentMethod

1 No No No Month-to-month Yes Electronic check

2 Yes No No One year No Mailed check

3 No No No Month-to-month Yes Mailed check

4 Yes Yes No One year No Bank transfer (automatic)

5 No No No Month-to-month Yes Electronic check

6 Yes No Yes Month-to-month Yes Electronic check

MonthlyCharges TotalCharges

1 29.85 29.85

2 56.95 1889.50

3 53.85 108.15

4 42.30 1840.75

5 70.70 151.65

6 99.65 820.50

> table(data\_3$Contract)

Month-to-month One year Two year

3875 1473 1695

> data\_3$Churn <- ifelse(data\_3$Churn == 'Yes', 1, 0)

> head(data\_3)

gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity

1 Female 0 Yes No 1 No No phone service DSL No

2 Male 0 No No 34 Yes No DSL Yes

3 Male 0 No No 2 Yes No DSL Yes

4 Male 0 No No 45 No No phone service DSL Yes

5 Female 0 No No 2 Yes No Fiber optic No

6 Female 0 No No 8 Yes Yes Fiber optic No

OnlineBackup DeviceProtection TechSupport StreamingTV StreamingMovies Contract PaperlessBilling

1 Yes No No No No Month-to-month Yes

2 No Yes No No No One year No

3 Yes No No No No Month-to-month Yes

4 No Yes Yes No No One year No

5 No No No No No Month-to-month Yes

6 No Yes No Yes Yes Month-to-month Yes

PaymentMethod MonthlyCharges TotalCharges Churn

1 Electronic check 29.85 29.85 0

2 Mailed check 56.95 1889.50 0

3 Mailed check 53.85 108.15 1

4 Bank transfer (automatic) 42.30 1840.75 0

5 Electronic check 70.70 151.65 1

6 Electronic check 99.65 820.50 1

> #Feature Selection

> library(randomForest)

> fit\_rf <- randomForest(Churn ~ ., data=data\_3)

> importance(fit\_rf) #Generate feature importance

IncNodePurity

gender 27.085887

SeniorCitizen 22.701345

Partner 22.911961

Dependents 20.549237

tenure 183.223022

PhoneService 4.922793

MultipleLines 23.152161

InternetService 31.617128

OnlineSecurity 67.327481

OnlineBackup 28.063159

DeviceProtection 23.508311

TechSupport 54.106863

StreamingTV 16.854828

StreamingMovies 17.656631

Contract 120.686429

PaperlessBilling 26.847737

PaymentMethod 51.305822

MonthlyCharges 213.112811

TotalCharges 219.146335

> varImp(fit\_rf)

Overall

gender 27.085887

SeniorCitizen 22.701345

Partner 22.911961

Dependents 20.549237

tenure 183.223022

PhoneService 4.922793

MultipleLines 23.152161

InternetService 31.617128

OnlineSecurity 67.327481

OnlineBackup 28.063159

DeviceProtection 23.508311

TechSupport 54.106863

StreamingTV 16.854828

StreamingMovies 17.656631

Contract 120.686429

PaperlessBilling 26.847737

PaymentMethod 51.305822

MonthlyCharges 213.112811

TotalCharges 219.146335

> #Plot of importance scores by random forest

> varImpPlot(fit\_rf)

> data\_selected <- subset(data\_3, select=-c(PhoneService, Churn, StreamingTV)) #Selected Feature variables

> head(data\_selected)

gender SeniorCitizen Partner Dependents tenure MultipleLines InternetService OnlineSecurity OnlineBackup

1 Female 0 Yes No 1 No phone service DSL No Yes

2 Male 0 No No 34 No DSL Yes No

3 Male 0 No No 2 No DSL Yes Yes

4 Male 0 No No 45 No phone service DSL Yes No

5 Female 0 No No 2 No Fiber optic No No

6 Female 0 No No 8 Yes Fiber optic No No

DeviceProtection TechSupport StreamingMovies Contract PaperlessBilling PaymentMethod

1 No No No Month-to-month Yes Electronic check

2 Yes No No One year No Mailed check

3 No No No Month-to-month Yes Mailed check

4 Yes Yes No One year No Bank transfer (automatic)

5 No No No Month-to-month Yes Electronic check

6 Yes No Yes Month-to-month Yes Electronic check

MonthlyCharges TotalCharges

1 29.85 29.85

2 56.95 1889.50

3 53.85 108.15

4 42.30 1840.75

5 70.70 151.65

6 99.65 820.50

> table(data\_3$Contract)

Month-to-month One year Two year

3875 1473 1695

> data\_3$gender <- ifelse(data\_3$gender == "Male", 1, 0)

> data$Partner <- ifelse(data\_3$Partner =="Yes", 1, 0)

> data\_3$Dependents <- ifelse(data\_3$Dependents == "Yes", 1, 0)

> data\_3$PhoneService <- ifelse(data\_3$PhoneService == "Yes", 1, 0)

> data\_13 <- select(data\_3, select=-c('Churn')) #Create dummy variables

> dmy <- dummyVars("~.", data=data\_13, fullRank=T)

> dat\_transformed <- data.frame(predict(dmy, newdata=data\_13))

> glimpse(dat\_transformed)

Rows: 7,043

Columns: 30

$ gender <dbl> 0, 1, 1, 1, 0, 0, 1, 0, 0, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 1, ~

$ SeniorCitizen <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, ~

$ PartnerYes <dbl> 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, ~

$ Dependents <dbl> 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, ~

$ tenure <dbl> 1, 34, 2, 45, 2, 8, 22, 10, 28, 62, 13, 16, 58, 49, 25, 69, 52,~

$ PhoneService <dbl> 0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, ~

$ MultipleLinesNo.phone.service <dbl> 1, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, ~

$ MultipleLinesYes <dbl> 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 0, ~

$ InternetServiceFiber.optic <dbl> 0, 0, 0, 0, 1, 1, 1, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, ~

$ InternetServiceNo <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ OnlineSecurityNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ OnlineSecurityYes <dbl> 0, 1, 1, 1, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, ~

$ OnlineBackupNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ OnlineBackupYes <dbl> 1, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, ~

$ DeviceProtectionNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ DeviceProtectionYes <dbl> 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, ~

$ TechSupportNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ TechSupportYes <dbl> 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, ~

$ StreamingTVNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ StreamingTVYes <dbl> 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 0, 0, ~

$ StreamingMoviesNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ StreamingMoviesYes <dbl> 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 1, ~

$ ContractOne.year <dbl> 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ ContractTwo.year <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, ~

$ PaperlessBillingYes <dbl> 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, ~

$ PaymentMethodCredit.card..automatic. <dbl> 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, ~

$ PaymentMethodElectronic.check <dbl> 1, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, ~

$ PaymentMethodMailed.check <dbl> 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ MonthlyCharges <dbl> 29.85, 56.95, 53.85, 42.30, 70.70, 99.65, 89.10, 29.75, 104.80,~

$ TotalCharges <dbl> 29.85, 1889.50, 108.15, 1840.75, 151.65, 820.50, 1949.40, 301.9~

> data23 <- data\_3

> data\_31 <- dat\_transformed

> data\_31$Churn <- data\_3$Churn

> data\_3 <- data\_31

> data3 <- subset(data\_3, select=-c(Churn))

> base\_data <- data.frame(scale(data3))

> base\_data$Churn <- data\_3$Churn

> head(base\_data)

gender SeniorCitizen PartnerYes Dependents tenure PhoneService MultipleLinesNo.phone.service MultipleLinesYes InternetServiceFiber.optic InternetServiceNo

1 -1.0094870 -0.4398853 1.0344568 -0.6539655 -1.27735389 -3.0537936 3.0537936 -0.8541155 -0.8855969 -0.52589

2 0.9904615 -0.4398853 -0.9665537 -0.6539655 0.06632271 0.3274151 -0.3274151 -0.8541155 -0.8855969 -0.52589

3 0.9904615 -0.4398853 -0.9665537 -0.6539655 -1.23663642 0.3274151 -0.3274151 -0.8541155 -0.8855969 -0.52589

4 0.9904615 -0.4398853 -0.9665537 -0.6539655 0.51421491 -3.0537936 3.0537936 -0.8541155 -0.8855969 -0.52589

5 -1.0094870 -0.4398853 -0.9665537 -0.6539655 -1.23663642 0.3274151 -0.3274151 -0.8541155 1.1290216 -0.52589

6 -1.0094870 -0.4398853 -0.9665537 -0.6539655 -0.99233158 0.3274151 -0.3274151 1.1706356 1.1290216 -0.52589

OnlineSecurityNo.internet.service OnlineSecurityYes OnlineBackupNo.internet.service OnlineBackupYes DeviceProtectionNo.internet.service DeviceProtectionYes

1 -0.52589 -0.633888 -0.52589 1.3781427 -0.52589 -0.7239161

2 -0.52589 1.577342 -0.52589 -0.7255112 -0.52589 1.3811794

3 -0.52589 1.577342 -0.52589 1.3781427 -0.52589 -0.7239161

4 -0.52589 1.577342 -0.52589 -0.7255112 -0.52589 1.3811794

5 -0.52589 -0.633888 -0.52589 -0.7255112 -0.52589 -0.7239161

6 -0.52589 -0.633888 -0.52589 -0.7255112 -0.52589 1.3811794

TechSupportNo.internet.service TechSupportYes StreamingTVNo.internet.service StreamingTVYes StreamingMoviesNo.internet.service StreamingMoviesYes ContractOne.year

1 -0.52589 -0.6393932 -0.52589 -0.7900756 -0.52589 -0.7960136 -0.5142129

2 -0.52589 -0.6393932 -0.52589 -0.7900756 -0.52589 -0.7960136 1.9444438

3 -0.52589 -0.6393932 -0.52589 -0.7900756 -0.52589 -0.7960136 -0.5142129

4 -0.52589 1.5637607 -0.52589 -0.7900756 -0.52589 -0.7960136 1.9444438

5 -0.52589 -0.6393932 -0.52589 -0.7900756 -0.52589 -0.7960136 -0.5142129

6 -0.52589 -0.6393932 -0.52589 1.2655219 -0.52589 1.2560815 -0.5142129

ContractTwo.year PaperlessBillingYes PaymentMethodCredit.card..automatic. PaymentMethodElectronic.check PaymentMethodMailed.check MonthlyCharges TotalCharges Churn

1 -0.5629351 0.8297386 -0.5250101 1.4063185 -0.5447682 -1.1602405 -0.9941713 0

2 -0.5629351 -1.2050277 -0.5250101 -0.7109755 1.8353823 -0.2596105 -0.1732318 0

3 -0.5629351 0.8297386 -0.5250101 -0.7109755 1.8353823 -0.3626346 -0.9596059 1

4 -0.5629351 -1.2050277 -0.5250101 -0.7109755 -0.5447682 -0.7464825 -0.1947524 0

5 -0.5629351 0.8297386 -0.5250101 1.4063185 -0.5447682 0.1973512 -0.9404029 1

6 -0.5629351 0.8297386 -0.5250101 1.4063185 -0.5447682 1.1594634 -0.6451402 1

> #Standardizing Data

> dmy <- dummyVars("~.", data=data\_selected, fullRank=T) #Fullrank means no deletion of cols when creating dummy

> data\_selected <- data.frame(predict(dmy, newdata=data\_selected))

> glimpse(data\_selected)

Rows: 7,043

Columns: 27

$ genderMale <dbl> 0, 1, 1, 1, 0, 0, 1, 0, 0, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 1, 0, 1, 0, ~

$ SeniorCitizen <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, ~

$ PartnerYes <dbl> 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 0, 0, 1, 0, 0, 0, 0, ~

$ DependentsYes <dbl> 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, ~

$ tenure <dbl> 1, 34, 2, 45, 2, 8, 22, 10, 28, 62, 13, 16, 58, 49, 25, 69, 52, 71, 10, 21, 1, 12, 1, 58, 49, 30, 47, 1, 72, 17, 71, 2, ~

$ MultipleLinesNo.phone.service <dbl> 1, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ~

$ MultipleLinesYes <dbl> 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 1, ~

$ InternetServiceFiber.optic <dbl> 0, 0, 0, 0, 1, 1, 1, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, ~

$ InternetServiceNo <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, ~

$ OnlineSecurityNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, ~

$ OnlineSecurityYes <dbl> 0, 1, 1, 1, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, ~

$ OnlineBackupNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, ~

$ OnlineBackupYes <dbl> 1, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, ~

$ DeviceProtectionNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, ~

$ DeviceProtectionYes <dbl> 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, ~

$ TechSupportNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, ~

$ TechSupportYes <dbl> 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, ~

$ StreamingMoviesNo.internet.service <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, ~

$ StreamingMoviesYes <dbl> 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, ~

$ ContractOne.year <dbl> 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, ~

$ ContractTwo.year <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, ~

$ PaperlessBillingYes <dbl> 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, 1, ~

$ PaymentMethodCredit.card..automatic. <dbl> 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, ~

$ PaymentMethodElectronic.check <dbl> 1, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, ~

$ PaymentMethodMailed.check <dbl> 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, ~

$ MonthlyCharges <dbl> 29.85, 56.95, 53.85, 42.30, 70.70, 99.65, 89.10, 29.75, 104.80, 56.15, 49.95, 18.95, 100.35, 103.70, 105.50, 113.25, 20.~

$ TotalCharges <dbl> 29.85, 1889.50, 108.15, 1840.75, 151.65, 820.50, 1949.40, 301.90, 3046.05, 3487.95, 587.45, 326.80, 5681.10, 5036.30, 26~

> data\_standardized <- data.frame(scale(data\_selected))

> data\_standardized$Churn <- data\_3$Churn

> head(data\_standardized)

genderMale SeniorCitizen PartnerYes DependentsYes tenure MultipleLinesNo.phone.service MultipleLinesYes InternetServiceFiber.optic InternetServiceNo

1 -1.0094870 -0.4398853 1.0344568 -0.6539655 -1.27735389 3.0537936 -0.8541155 -0.8855969 -0.52589

2 0.9904615 -0.4398853 -0.9665537 -0.6539655 0.06632271 -0.3274151 -0.8541155 -0.8855969 -0.52589

3 0.9904615 -0.4398853 -0.9665537 -0.6539655 -1.23663642 -0.3274151 -0.8541155 -0.8855969 -0.52589

4 0.9904615 -0.4398853 -0.9665537 -0.6539655 0.51421491 3.0537936 -0.8541155 -0.8855969 -0.52589

5 -1.0094870 -0.4398853 -0.9665537 -0.6539655 -1.23663642 -0.3274151 -0.8541155 1.1290216 -0.52589

6 -1.0094870 -0.4398853 -0.9665537 -0.6539655 -0.99233158 -0.3274151 1.1706356 1.1290216 -0.52589

OnlineSecurityNo.internet.service OnlineSecurityYes OnlineBackupNo.internet.service OnlineBackupYes DeviceProtectionNo.internet.service DeviceProtectionYes

1 -0.52589 -0.633888 -0.52589 1.3781427 -0.52589 -0.7239161

2 -0.52589 1.577342 -0.52589 -0.7255112 -0.52589 1.3811794

3 -0.52589 1.577342 -0.52589 1.3781427 -0.52589 -0.7239161

4 -0.52589 1.577342 -0.52589 -0.7255112 -0.52589 1.3811794

5 -0.52589 -0.633888 -0.52589 -0.7255112 -0.52589 -0.7239161

6 -0.52589 -0.633888 -0.52589 -0.7255112 -0.52589 1.3811794

TechSupportNo.internet.service TechSupportYes StreamingMoviesNo.internet.service StreamingMoviesYes ContractOne.year ContractTwo.year PaperlessBillingYes

1 -0.52589 -0.6393932 -0.52589 -0.7960136 -0.5142129 -0.5629351 0.8297386

2 -0.52589 -0.6393932 -0.52589 -0.7960136 1.9444438 -0.5629351 -1.2050277

3 -0.52589 -0.6393932 -0.52589 -0.7960136 -0.5142129 -0.5629351 0.8297386

4 -0.52589 1.5637607 -0.52589 -0.7960136 1.9444438 -0.5629351 -1.2050277

5 -0.52589 -0.6393932 -0.52589 -0.7960136 -0.5142129 -0.5629351 0.8297386

6 -0.52589 -0.6393932 -0.52589 1.2560815 -0.5142129 -0.5629351 0.8297386

PaymentMethodCredit.card..automatic. PaymentMethodElectronic.check PaymentMethodMailed.check MonthlyCharges TotalCharges Churn

1 -0.5250101 1.4063185 -0.5447682 -1.1602405 -0.9941713 0

2 -0.5250101 -0.7109755 1.8353823 -0.2596105 -0.1732318 0

3 -0.5250101 -0.7109755 1.8353823 -0.3626346 -0.9596059 1

4 -0.5250101 -0.7109755 -0.5447682 -0.7464825 -0.1947524 0

5 -0.5250101 1.4063185 -0.5447682 0.1973512 -0.9404029 1

6 -0.5250101 1.4063185 -0.5447682 1.1594634 -0.6451402 1

> #Dimensionality Reduction

> data\_pca\_base <- subset(data\_standardized, select=-c(Churn))

> data\_pca <- prcomp(data\_pca\_base, center=TRUE, scale=TRUE)

> data\_with\_pca <- data.frame(as.matrix(data\_pca\_base)%\*%as.matrix(data\_pca$rotation[, 0:5]))

> data\_with\_pca$Churn <- data\_standardized$Churn

> head(data\_with\_pca)

PC1 PC2 PC3 PC4 PC5 Churn

1 -0.2955152 -2.38936470 2.1069586 1.5071681 -0.04385458 0

2 -0.1865087 -0.48647364 2.2286736 -2.0684808 1.11714981 0

3 -0.1336722 -1.83232797 1.9757102 -0.4827656 -0.25266282 1

4 -0.8044556 0.07787432 3.8398054 -1.7869959 0.27802735 0

5 -0.6240889 -3.22297858 -0.5877619 0.5054564 -0.29754996 1

6 -2.0039049 -1.98468530 -1.7407665 0.1597332 -0.30202864 1

>

> #Base Models

> dt <- sort(sample(nrow(base\_data), nrow(base\_data) \* .8))

> train <- base\_data[dt, ]

> test <- base\_data[-dt, ]

> dim(train)

[1] 5634 31

> dim(test)

[1] 1409 31

> actual <- test$Churn

> #actual <- if\_else(actual == 1, 0, 1)

> head(actual)

[1] 1 0 1 1 1 0

> table(train$Churn)

0 1

4141 1493

> #Logistic Regression

> lg\_1 <- glm(factor(Churn) ~ ., data=train, family="binomial")

> summary(lg\_1)

Call:

glm(formula = factor(Churn) ~ ., family = "binomial", data = train)

Deviance Residuals:

Min 1Q Median 3Q Max

-1.8934 -0.6804 -0.2835 0.7244 3.4006

Coefficients: (7 not defined because of singularities)

Estimate Std. Error z value Pr(>|z|)

(Intercept) -1.73189 0.06156 -28.132 < 2e-16 \*\*\*

gender -0.02583 0.03633 -0.711 0.477054

SeniorCitizen 0.09531 0.03516 2.711 0.006705 \*\*

PartnerYes -0.02211 0.04365 -0.506 0.612558

Dependents -0.06084 0.04626 -1.315 0.188462

tenure -1.37216 0.16843 -8.147 3.74e-16 \*\*\*

PhoneService 0.13374 0.21585 0.620 0.535508

MultipleLinesNo.phone.service NA NA NA NA

MultipleLinesYes 0.23319 0.09793 2.381 0.017259 \*

InternetServiceFiber.optic 1.06800 0.44619 2.394 0.016684 \*

InternetServiceNo -0.86077 0.37389 -2.302 0.021322 \*

OnlineSecurityNo.internet.service NA NA NA NA

OnlineSecurityYes -0.03262 0.09142 -0.357 0.721214

OnlineBackupNo.internet.service NA NA NA NA

OnlineBackupYes 0.04434 0.09381 0.473 0.636486

DeviceProtectionNo.internet.service NA NA NA NA

DeviceProtectionYes 0.10755 0.09441 1.139 0.254645

TechSupportNo.internet.service NA NA NA NA

TechSupportYes -0.02656 0.09208 -0.288 0.773023

StreamingTVNo.internet.service NA NA NA NA

StreamingTVYes 0.35753 0.17843 2.004 0.045096 \*

StreamingMoviesNo.internet.service NA NA NA NA

StreamingMoviesYes 0.36020 0.17902 2.012 0.044216 \*

ContractOne.year -0.26479 0.04863 -5.444 5.20e-08 \*\*\*

ContractTwo.year -0.60728 0.08581 -7.077 1.47e-12 \*\*\*

PaperlessBillingYes 0.20588 0.04107 5.013 5.35e-07 \*\*\*

PaymentMethodCredit.card..automatic. -0.04250 0.05230 -0.813 0.416432

PaymentMethodElectronic.check 0.13856 0.04980 2.782 0.005396 \*\*

PaymentMethodMailed.check -0.01966 0.05414 -0.363 0.716511

MonthlyCharges -1.62317 1.07551 -1.509 0.131246

TotalCharges 0.61360 0.17719 3.463 0.000534 \*\*\*

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 6515.4 on 5633 degrees of freedom

Residual deviance: 4645.2 on 5610 degrees of freedom

AIC: 4693.2

Number of Fisher Scoring iterations: 6

> #Make Predictions

> prediction\_lg\_1 <- predict(lg\_1, data.frame(test))

> prediction\_lg\_1 <- if\_else(prediction\_lg\_1 >= 0.5, 1, 0)

> prediction\_lg\_1

[1] 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0

[81] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

[161] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

[241] 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

[321] 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

[401] 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1

[481] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0

[561] 0 1 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

[641] 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1

[721] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0

[801] 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0

[881] 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0

[961] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

> #Performance Measure

> table(prediction\_lg\_1)

prediction\_lg\_1

0 1

1235 174

> factor(test$Churn)

[1] 1 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 1 1 0 0 0 0 1 0 0

[81] 0 0 1 0 0 1 0 0 0 0 0 0 1 1 0 1 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0

[161] 0 1 0 0 0 1 0 1 0 0 1 0 0 0 0 1 1 0 0 0 1 1 0 0 1 0 0 0 1 1 1 0 0 0 0 0 1 0 0 0 0 1 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0

[241] 1 0 0 0 0 0 0 0 1 1 1 0 1 0 0 0 0 0 0 1 0 0 0 1 1 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 0 1 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0

[321] 0 1 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 1 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1

[401] 1 1 1 1 0 0 1 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1

[481] 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0

[561] 0 1 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 1 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 1 1 0 0 1 1 0 1 0 0 0 0 0

[641] 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0 0 0 1 0 1 0 0 1 1 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 1

[721] 1 0 1 0 0 1 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 0 1 0 0 0 0 1 1 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 1

[801] 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0

[881] 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 1

[961] 0 0 1 1 1 1 0 1 1 0 0 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> factor(prediction\_lg\_1)

[1] 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0

[81] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

[161] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

[241] 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

[321] 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

[401] 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1

[481] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0

[561] 0 1 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

[641] 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1

[721] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0

[801] 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0

[881] 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0

[961] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> confusionMatrix(data=factor(prediction\_lg\_1), reference=factor(test$Churn), positive="1")

Confusion Matrix and Statistics

Reference

Prediction 0 1

0 985 250

1 48 126

Accuracy : 0.7885

95% CI : (0.7662, 0.8096)

No Information Rate : 0.7331

P-Value [Acc > NIR] : 8.865e-07

Kappa : 0.3481

Mcnemar's Test P-Value : < 2.2e-16

Sensitivity : 0.33511

Specificity : 0.95353

Pos Pred Value : 0.72414

Neg Pred Value : 0.79757

Prevalence : 0.26686

Detection Rate : 0.08943

Detection Prevalence : 0.12349

Balanced Accuracy : 0.64432

'Positive' Class : 1

> accuracy\_score\_lg\_1 <- accuracy(actual, prediction\_lg\_1)

> precision\_score\_lg\_1 <- precision(actual, prediction\_lg\_1)

> accuracy\_score\_lg\_1

[1] 0.7885025

> precision\_score\_lg\_1

[1] 0.7241379

> #ROC Curve

> library(plyr)

> ROCit\_base <- rocit(score=prediction\_lg\_1, class=actual)

> plot(ROCit\_base)

> recall\_score\_lg\_1 <- recall(actual, prediction\_lg\_1)

> auc\_score\_lg\_1 <- auc(actual, prediction\_lg\_1)

> Model <- c("Accuracy", "Precision", "Recall", "AUC Score")

> Logistic\_Regression <- c(accuracy\_score\_lg\_1 , precision\_score\_lg\_1 ,recall\_score\_lg\_1 , auc\_score\_lg\_1)

> Base\_Models = data.frame(Model,Logistic\_Regression)

> Base\_Models

Model Logistic\_Regression

1 Accuracy 0.7885025

2 Precision 0.7241379

3 Recall 0.3351064

4 AUC Score 0.6443199

> #Decision Tree

> library(rpart)

> library(rpart.plot)

> mtree\_1 <- rpart(factor(Churn) ~ ., data=train, method="class", control=rpart.control(minsplit=20, minbucket=7, maxdepth=8, usesurrogate=2, xval=10))

> summary(mtree\_1)

Call:

rpart(formula = factor(Churn) ~ ., data = train, method = "class",

control = rpart.control(minsplit = 20, minbucket = 7, maxdepth = 8,

usesurrogate = 2, xval = 10))

n= 5634

CP nsplit rel error xerror xstd

1 0.1091762 0 1.0000000 1.0000000 0.02218780

2 0.0100000 2 0.7816477 0.7843269 0.02039969

Variable importance

tenure TotalCharges InternetServiceFiber.optic MonthlyCharges PaymentMethodElectronic.check

28 24 17 16 5

MultipleLinesYes InternetServiceNo PaymentMethodMailed.check

5 4 1

Node number 1: 5634 observations, complexity param=0.1091762

predicted class=0 expected loss=0.2649982 P(node) =1

class counts: 4141 1493

probabilities: 0.735 0.265

left son=2 (3620 obs) right son=3 (2014 obs)

Primary splits:

tenure < -0.6462331 to the right, improve=246.4129, (0 missing)

InternetServiceFiber.optic < 0.1217124 to the left, improve=209.5511, (0 missing)

ContractTwo.year < 0.6066082 to the right, improve=199.8588, (0 missing)

PaymentMethodElectronic.check < 0.3476715 to the left, improve=198.1002, (0 missing)

InternetServiceNo < 0.6876891 to the right, improve=112.9543, (0 missing)

Surrogate splits:

TotalCharges < -0.6387723 to the right, agree=0.892, adj=0.697, (0 split)

PaymentMethodMailed.check < 0.645307 to the left, agree=0.650, adj=0.022, (0 split)

PartnerYes < 0.03395155 to the right, agree=0.648, adj=0.016, (0 split)

MonthlyCharges < -1.519994 to the right, agree=0.644, adj=0.003, (0 split)

Node number 2: 3620 observations

predicted class=0 expected loss=0.1546961 P(node) =0.6425275

class counts: 3060 560

probabilities: 0.845 0.155

Node number 3: 2014 observations, complexity param=0.1091762

predicted class=0 expected loss=0.4632572 P(node) =0.3574725

class counts: 1081 933

probabilities: 0.537 0.463

left son=6 (1140 obs) right son=7 (874 obs)

Primary splits:

InternetServiceFiber.optic < 0.1217124 to the left, improve=153.9028, (0 missing)

MonthlyCharges < 0.1483317 to the left, improve=131.2311, (0 missing)

InternetServiceNo < 0.6876891 to the right, improve=105.0443, (0 missing)

OnlineSecurityNo.internet.service < 0.6876891 to the right, improve=105.0443, (0 missing)

OnlineBackupNo.internet.service < 0.6876891 to the right, improve=105.0443, (0 missing)

Surrogate splits:

MonthlyCharges < 0.1150981 to the left, agree=0.971, adj=0.934, (0 split)

PaymentMethodElectronic.check < 0.3476715 to the left, agree=0.702, adj=0.314, (0 split)

TotalCharges < -0.8083216 to the left, agree=0.685, adj=0.275, (0 split)

MultipleLinesYes < 0.15826 to the left, agree=0.682, adj=0.267, (0 split)

InternetServiceNo < 0.6876891 to the right, agree=0.664, adj=0.227, (0 split)

Node number 6: 1140 observations

predicted class=0 expected loss=0.2921053 P(node) =0.2023429

class counts: 807 333

probabilities: 0.708 0.292

Node number 7: 874 observations

predicted class=1 expected loss=0.3135011 P(node) =0.1551296

class counts: 274 600

probabilities: 0.314 0.686

> #Make Predictions

> prediction\_mtree\_1 <- predict(mtree\_1, data.frame(test), type="class")

> prediction\_mtree\_1

5 10 14 21 23 29 34 35 42 49 51 54 58 59 62 71 76 78 82 83 98 105 115 118 124 125 134 138 150 162 165 167 168

1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 0

173 177 184 187 200 202 208 215 220 221 222 224 225 228 229 241 252 255 260 262 263 281 292 293 295 300 304 306 309 311 313 330 331

0 1 0 0 0 1 1 0 1 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0

337 338 340 349 353 354 356 364 368 369 379 382 383 385 388 394 403 406 408 410 415 417 426 435 442 468 470 475 484 485 488 489 490

0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1

501 506 510 511 515 519 527 542 549 559 561 562 563 564 567 568 570 571 574 584 588 601 607 616 617 618 621 622 624 626 629 634 660

0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

661 665 674 681 685 689 692 696 699 709 720 722 723 726 733 750 757 758 760 761 767 772 773 775 776 781 785 789 790 809 820 823 824

0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

831 833 838 844 859 869 871 873 880 884 890 903 910 914 920 928 934 947 950 951 954 955 961 965 976 977 980 988 992 995 1003 1009 1011

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0

1035 1036 1038 1041 1042 1050 1053 1069 1075 1077 1081 1097 1098 1102 1104 1117 1119 1122 1126 1143 1149 1154 1157 1158 1160 1164 1168 1169 1170 1172 1176 1178 1180

0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 1 0 0 0 0 1 0 0

1181 1192 1207 1214 1217 1220 1233 1238 1241 1249 1257 1258 1261 1270 1273 1281 1293 1295 1309 1311 1318 1326 1327 1331 1332 1333 1334 1341 1342 1345 1348 1350 1355

0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0

1362 1380 1384 1392 1399 1400 1402 1404 1414 1415 1441 1448 1450 1451 1452 1465 1467 1468 1472 1473 1475 1483 1488 1489 1490 1493 1494 1495 1496 1497 1498 1499 1502

1 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 1 0

1504 1506 1508 1520 1522 1523 1528 1530 1538 1539 1543 1546 1549 1550 1558 1563 1567 1573 1574 1577 1584 1585 1587 1589 1593 1594 1598 1600 1601 1603 1605 1607 1608

0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1

1615 1620 1639 1642 1644 1645 1650 1654 1656 1664 1671 1673 1680 1682 1683 1696 1703 1704 1708 1714 1716 1718 1726 1735 1744 1747 1754 1762 1764 1767 1771 1783 1796

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0

1802 1812 1815 1824 1830 1832 1833 1835 1846 1854 1855 1864 1865 1876 1883 1888 1890 1892 1893 1903 1904 1907 1908 1912 1916 1922 1923 1928 1931 1933 1943 1945 1960

0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0

1962 1965 1993 2004 2005 2006 2009 2011 2012 2015 2017 2018 2019 2030 2035 2038 2044 2050 2054 2060 2070 2079 2080 2082 2090 2091 2092 2096 2099 2110 2115 2119 2121

0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0

2138 2151 2154 2161 2164 2166 2167 2170 2172 2174 2185 2186 2189 2191 2192 2194 2211 2213 2218 2222 2224 2226 2231 2235 2242 2248 2254 2257 2263 2268 2274 2277 2279

0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0

2287 2295 2304 2306 2308 2311 2319 2323 2324 2330 2332 2355 2358 2370 2388 2391 2401 2407 2413 2417 2420 2421 2422 2424 2426 2428 2434 2439 2440 2444 2446 2459 2460

0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0

2462 2468 2477 2478 2487 2494 2496 2498 2501 2508 2509 2514 2522 2523 2524 2532 2537 2539 2552 2558 2563 2565 2566 2568 2574 2583 2591 2593 2600 2602 2608 2610 2617

0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0

2625 2627 2630 2632 2645 2649 2650 2660 2666 2669 2676 2681 2692 2697 2710 2713 2716 2720 2722 2724 2727 2729 2730 2738 2740 2743 2745 2749 2751 2752 2755 2756 2761

0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0

2762 2766 2772 2774 2776 2780 2782 2787 2789 2790 2791 2794 2799 2807 2814 2815 2827 2828 2830 2842 2849 2856 2865 2874 2876 2877 2881 2889 2890 2897 2899 2907 2909

0 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0

2911 2917 2921 2926 2931 2932 2933 2935 2939 2940 2942 2944 2945 2953 2956 2958 2966 2967 2968 2971 2977 2979 2981 2996 2997 2998 2999 3001 3012 3014 3015 3017 3028

0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0

3029 3031 3036 3038 3041 3045 3049 3050 3053 3054 3060 3061 3074 3076 3078 3080 3090 3092 3094 3097 3103 3105 3106 3108 3109 3132 3141 3142 3150 3155 3160 3161 3165

0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 1 1 0 0

3166 3169 3176 3181 3182 3193 3194 3217 3219 3226 3227 3228 3234 3245 3248 3250 3256 3260 3271 3275 3276 3287 3289 3295 3299 3304 3305 3308 3319 3322 3325 3337 3349

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 1 0 0

3381 3402 3412 3413 3420 3425 3429 3430 3431 3436 3445 3446 3463 3464 3474 3484 3485 3487 3492 3500 3501 3502 3512 3519 3524 3527 3528 3533 3534 3545 3546 3547 3551

1 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

3552 3555 3567 3573 3576 3579 3585 3609 3613 3618 3624 3627 3629 3632 3640 3641 3652 3653 3654 3660 3664 3669 3672 3674 3676 3680 3682 3693 3697 3701 3705 3709 3712

1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0

3713 3716 3720 3729 3736 3739 3752 3758 3759 3764 3766 3786 3799 3800 3803 3805 3808 3814 3822 3823 3826 3831 3833 3838 3841 3843 3846 3854 3856 3859 3862 3874 3876

0 1 0 0 1 0 0 0 0 1 0 1 0 0 0 1 0 0 1 1 0 1 0 1 0 0 1 0 0 0 0 0 0

3879 3886 3891 3892 3895 3906 3910 3911 3928 3931 3937 3938 3940 3943 3944 3952 3957 3960 3969 3973 3975 3980 3994 4004 4006 4009 4010 4014 4015 4016 4019 4023 4040

0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

4042 4043 4046 4048 4055 4059 4062 4067 4084 4088 4090 4091 4097 4098 4103 4106 4112 4115 4119 4122 4124 4129 4133 4140 4147 4148 4149 4154 4173 4182 4185 4189 4193

0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0

4194 4197 4199 4216 4219 4226 4234 4242 4243 4244 4251 4262 4265 4272 4276 4293 4295 4305 4307 4327 4332 4340 4341 4343 4344 4346 4351 4356 4374 4377 4378 4387 4388

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0

4389 4393 4408 4411 4416 4418 4420 4421 4427 4429 4432 4433 4447 4449 4451 4459 4460 4471 4472 4473 4476 4480 4481 4484 4494 4499 4503 4505 4512 4517 4520 4526 4538

0 0 0 1 0 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

4539 4543 4551 4556 4560 4563 4566 4568 4572 4573 4581 4583 4585 4594 4599 4605 4608 4611 4619 4620 4623 4624 4625 4629 4638 4640 4653 4654 4657 4661 4676 4689 4703

1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0

4708 4719 4726 4737 4748 4752 4754 4758 4765 4767 4774 4776 4781 4783 4792 4793 4798 4800 4801 4810 4812 4819 4823 4824 4826 4827 4835 4836 4843 4852 4856 4857 4860

0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 0

4862 4865 4869 4881 4886 4903 4905 4915 4920 4921

0 0 0 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> #Performance Measure

> table(prediction\_mtree\_1)

prediction\_mtree\_1

0 1

1195 214

> factor(test$Churn)

[1] 1 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 1 1 0 0 0 0 1 0 0

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[401] 1 1 1 1 0 0 1 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1

[481] 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0

[561] 0 1 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 1 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 1 1 0 0 1 1 0 1 0 0 0 0 0

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[721] 1 0 1 0 0 1 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 0 1 0 0 0 0 1 1 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 1

[801] 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0

[881] 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 1

[961] 0 0 1 1 1 1 0 1 1 0 0 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> factor(prediction\_mtree\_1)

5 10 14 21 23 29 34 35 42 49 51 54 58 59 62 71 76 78 82 83 98 105 115 118 124 125 134 138 150 162 165 167 168

1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 0

173 177 184 187 200 202 208 215 220 221 222 224 225 228 229 241 252 255 260 262 263 281 292 293 295 300 304 306 309 311 313 330 331

0 1 0 0 0 1 1 0 1 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0

337 338 340 349 353 354 356 364 368 369 379 382 383 385 388 394 403 406 408 410 415 417 426 435 442 468 470 475 484 485 488 489 490

0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1

501 506 510 511 515 519 527 542 549 559 561 562 563 564 567 568 570 571 574 584 588 601 607 616 617 618 621 622 624 626 629 634 660

0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

661 665 674 681 685 689 692 696 699 709 720 722 723 726 733 750 757 758 760 761 767 772 773 775 776 781 785 789 790 809 820 823 824

0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

831 833 838 844 859 869 871 873 880 884 890 903 910 914 920 928 934 947 950 951 954 955 961 965 976 977 980 988 992 995 1003 1009 1011

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0

1035 1036 1038 1041 1042 1050 1053 1069 1075 1077 1081 1097 1098 1102 1104 1117 1119 1122 1126 1143 1149 1154 1157 1158 1160 1164 1168 1169 1170 1172 1176 1178 1180

0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 1 0 0 0 0 1 0 0

1181 1192 1207 1214 1217 1220 1233 1238 1241 1249 1257 1258 1261 1270 1273 1281 1293 1295 1309 1311 1318 1326 1327 1331 1332 1333 1334 1341 1342 1345 1348 1350 1355

0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0

1362 1380 1384 1392 1399 1400 1402 1404 1414 1415 1441 1448 1450 1451 1452 1465 1467 1468 1472 1473 1475 1483 1488 1489 1490 1493 1494 1495 1496 1497 1498 1499 1502

1 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 1 0

1504 1506 1508 1520 1522 1523 1528 1530 1538 1539 1543 1546 1549 1550 1558 1563 1567 1573 1574 1577 1584 1585 1587 1589 1593 1594 1598 1600 1601 1603 1605 1607 1608

0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1

1615 1620 1639 1642 1644 1645 1650 1654 1656 1664 1671 1673 1680 1682 1683 1696 1703 1704 1708 1714 1716 1718 1726 1735 1744 1747 1754 1762 1764 1767 1771 1783 1796

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0

1802 1812 1815 1824 1830 1832 1833 1835 1846 1854 1855 1864 1865 1876 1883 1888 1890 1892 1893 1903 1904 1907 1908 1912 1916 1922 1923 1928 1931 1933 1943 1945 1960

0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0

1962 1965 1993 2004 2005 2006 2009 2011 2012 2015 2017 2018 2019 2030 2035 2038 2044 2050 2054 2060 2070 2079 2080 2082 2090 2091 2092 2096 2099 2110 2115 2119 2121

0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0

2138 2151 2154 2161 2164 2166 2167 2170 2172 2174 2185 2186 2189 2191 2192 2194 2211 2213 2218 2222 2224 2226 2231 2235 2242 2248 2254 2257 2263 2268 2274 2277 2279

0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0

2287 2295 2304 2306 2308 2311 2319 2323 2324 2330 2332 2355 2358 2370 2388 2391 2401 2407 2413 2417 2420 2421 2422 2424 2426 2428 2434 2439 2440 2444 2446 2459 2460

0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0

2462 2468 2477 2478 2487 2494 2496 2498 2501 2508 2509 2514 2522 2523 2524 2532 2537 2539 2552 2558 2563 2565 2566 2568 2574 2583 2591 2593 2600 2602 2608 2610 2617

0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0

2625 2627 2630 2632 2645 2649 2650 2660 2666 2669 2676 2681 2692 2697 2710 2713 2716 2720 2722 2724 2727 2729 2730 2738 2740 2743 2745 2749 2751 2752 2755 2756 2761

0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0

2762 2766 2772 2774 2776 2780 2782 2787 2789 2790 2791 2794 2799 2807 2814 2815 2827 2828 2830 2842 2849 2856 2865 2874 2876 2877 2881 2889 2890 2897 2899 2907 2909

0 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0

2911 2917 2921 2926 2931 2932 2933 2935 2939 2940 2942 2944 2945 2953 2956 2958 2966 2967 2968 2971 2977 2979 2981 2996 2997 2998 2999 3001 3012 3014 3015 3017 3028

0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0

3029 3031 3036 3038 3041 3045 3049 3050 3053 3054 3060 3061 3074 3076 3078 3080 3090 3092 3094 3097 3103 3105 3106 3108 3109 3132 3141 3142 3150 3155 3160 3161 3165

0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 1 1 0 0

3166 3169 3176 3181 3182 3193 3194 3217 3219 3226 3227 3228 3234 3245 3248 3250 3256 3260 3271 3275 3276 3287 3289 3295 3299 3304 3305 3308 3319 3322 3325 3337 3349

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 1 0 0

3381 3402 3412 3413 3420 3425 3429 3430 3431 3436 3445 3446 3463 3464 3474 3484 3485 3487 3492 3500 3501 3502 3512 3519 3524 3527 3528 3533 3534 3545 3546 3547 3551

1 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

3552 3555 3567 3573 3576 3579 3585 3609 3613 3618 3624 3627 3629 3632 3640 3641 3652 3653 3654 3660 3664 3669 3672 3674 3676 3680 3682 3693 3697 3701 3705 3709 3712

1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0

3713 3716 3720 3729 3736 3739 3752 3758 3759 3764 3766 3786 3799 3800 3803 3805 3808 3814 3822 3823 3826 3831 3833 3838 3841 3843 3846 3854 3856 3859 3862 3874 3876

0 1 0 0 1 0 0 0 0 1 0 1 0 0 0 1 0 0 1 1 0 1 0 1 0 0 1 0 0 0 0 0 0

3879 3886 3891 3892 3895 3906 3910 3911 3928 3931 3937 3938 3940 3943 3944 3952 3957 3960 3969 3973 3975 3980 3994 4004 4006 4009 4010 4014 4015 4016 4019 4023 4040

0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

4042 4043 4046 4048 4055 4059 4062 4067 4084 4088 4090 4091 4097 4098 4103 4106 4112 4115 4119 4122 4124 4129 4133 4140 4147 4148 4149 4154 4173 4182 4185 4189 4193

0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0

4194 4197 4199 4216 4219 4226 4234 4242 4243 4244 4251 4262 4265 4272 4276 4293 4295 4305 4307 4327 4332 4340 4341 4343 4344 4346 4351 4356 4374 4377 4378 4387 4388

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0

4389 4393 4408 4411 4416 4418 4420 4421 4427 4429 4432 4433 4447 4449 4451 4459 4460 4471 4472 4473 4476 4480 4481 4484 4494 4499 4503 4505 4512 4517 4520 4526 4538

0 0 0 1 0 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

4539 4543 4551 4556 4560 4563 4566 4568 4572 4573 4581 4583 4585 4594 4599 4605 4608 4611 4619 4620 4623 4624 4625 4629 4638 4640 4653 4654 4657 4661 4676 4689 4703

1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0

4708 4719 4726 4737 4748 4752 4754 4758 4765 4767 4774 4776 4781 4783 4792 4793 4798 4800 4801 4810 4812 4819 4823 4824 4826 4827 4835 4836 4843 4852 4856 4857 4860

0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 0

4862 4865 4869 4881 4886 4903 4905 4915 4920 4921

0 0 0 0 0 0 0 0 0 0

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Levels: 0 1

> confusionMatrix(data=factor(prediction\_mtree\_1), reference=factor(test$Churn), positive="1")

Confusion Matrix and Statistics

Reference

Prediction 0 1

0 959 236

1 74 140

Accuracy : 0.78

95% CI : (0.7574, 0.8014)

No Information Rate : 0.7331

P-Value [Acc > NIR] : 2.903e-05

Kappa : 0.3484

Mcnemar's Test P-Value : < 2.2e-16

Sensitivity : 0.37234

Specificity : 0.92836

Pos Pred Value : 0.65421

Neg Pred Value : 0.80251

Prevalence : 0.26686

Detection Rate : 0.09936

Detection Prevalence : 0.15188

Balanced Accuracy : 0.65035

'Positive' Class : 1

> accuracy\_score\_mtree\_1 <- accuracy(actual, prediction\_mtree\_1)

> precision\_score\_mtree\_1 <- precision(actual, prediction\_mtree\_1)

> accuracy\_score\_mtree\_1

[1] 0.7799858

> precision\_score\_mtree\_1

[1] 0.6542056

> ROCit\_base <- rocit(score=as.numeric(prediction\_mtree\_1), class=actual)

> plot(ROCit\_base)

> auc\_score\_mtree\_1 <- auc(actual, prediction\_mtree\_1)

> recall\_score\_mtree\_1 <- recall(actual, as.numeric(prediction\_mtree\_1))

> auc\_score\_mtree\_1 <- auc(actual, prediction\_mtree\_1)

> Decision\_Tree <- c(accuracy\_score\_mtree\_1 , precision\_score\_mtree\_1 ,recall\_score\_mtree\_1 , auc\_score\_mtree\_1)

> Base\_Models$DecisionTree = data.frame(Decision\_Tree)

> Base\_Models

Model Logistic\_Regression Decision\_Tree

1 Accuracy 0.7885025 0.7799858

2 Precision 0.7241379 0.6542056

3 Recall 0.3351064 1.3723404

4 AUC Score 0.6443199 0.6503522

> #KNN

> library(class)

> prediction\_knn\_1 <- knn(train, test, cl=train$Churn, k=13)

> prediction\_knn\_1

[1] 1 0 1 1 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 1 0 0 1 0 0 1 0 0 1 0 1 0 0 1 0 0 0 1 1 0 1 1 0 1 0 1 0 0 1 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0

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[961] 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> #Performance Measure

> table(prediction\_knn\_1)

prediction\_knn\_1

0 1

1070 339

> factor(test$Churn)

[1] 1 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 1 1 0 0 0 0 1 0 0

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[321] 0 1 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 1 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1

[401] 1 1 1 1 0 0 1 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1

[481] 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0

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[641] 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0 0 0 1 0 1 0 0 1 1 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 1

[721] 1 0 1 0 0 1 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 0 1 0 0 0 0 1 1 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 1

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[881] 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 1

[961] 0 0 1 1 1 1 0 1 1 0 0 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> confusionMatrix(data=factor(prediction\_knn\_1), reference=factor(test$Churn), positive="1")

Confusion Matrix and Statistics

Reference

Prediction 0 1

0 968 102

1 65 274

Accuracy : 0.8815

95% CI : (0.8634, 0.8979)

No Information Rate : 0.7331

P-Value [Acc > NIR] : < 2e-16

Kappa : 0.6873

Mcnemar's Test P-Value : 0.00534

Sensitivity : 0.7287

Specificity : 0.9371

Pos Pred Value : 0.8083

Neg Pred Value : 0.9047

Prevalence : 0.2669

Detection Rate : 0.1945

Detection Prevalence : 0.2406

Balanced Accuracy : 0.8329

'Positive' Class : 1

> accuracy\_score\_knn\_1 <- accuracy(actual, prediction\_knn\_1)

> precision\_score\_knn\_1 <- precision(actual, prediction\_knn\_1)

> accuracy\_score\_knn\_1

[1] 0.8814762

> precision\_score\_knn\_1

[1] 0.8082596

> #ROC Curve

> ROCit\_base <- rocit(score=as.numeric(prediction\_knn\_1), class=actual)

> plot(ROCit\_base)

> recall\_score\_knn\_1 <- recall(actual, as.numeric(prediction\_knn\_1))

> auc\_score\_knn\_1 <- auc(actual, prediction\_knn\_1)

> KNN <- c(accuracy\_score\_knn\_1 , precision\_score\_knn\_1 ,recall\_score\_knn\_1 , auc\_score\_knn\_1)

> Base\_Models$KNN = data.frame(KNN)

> Base\_Models

Model Logistic\_Regression Decision\_Tree SVM KNN

1 Accuracy 0.7885025 0.7799858 0.7913414 0.8814762

2 Precision 0.7241379 0.6542056 0.6314103 0.8082596

3 Recall 0.3351064 1.3723404 1.5239362 1.7287234

4 AUC Score 0.6443199 0.6503522 0.7063050 0.8328999

> #Random Forest

> rf\_1 = randomForest(x=train[-31], y=factor(train$Churn), ntree=500)

> summary(rf\_1)

Length Class Mode

call 4 -none- call

type 1 -none- character

predicted 5634 factor numeric

err.rate 1500 -none- numeric

confusion 6 -none- numeric

votes 11268 matrix numeric

oob.times 5634 -none- numeric

classes 2 -none- character

importance 30 -none- numeric

importanceSD 0 -none- NULL

localImportance 0 -none- NULL

proximity 0 -none- NULL

ntree 1 -none- numeric

mtry 1 -none- numeric

forest 14 -none- list

y 5634 factor numeric

test 0 -none- NULL

inbag 0 -none- NULL

> #Make Predictions

> prediction\_rf\_1 <- predict(rf\_1, data.frame(test), type="class")

> prediction\_rf\_1

5 10 14 21 23 29 34 35 42 49 51 54 58 59 62 71 76 78 82 83 98 105 115 118 124 125 134 138 150 162 165 167 168

1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 1 0

173 177 184 187 200 202 208 215 220 221 222 224 225 228 229 241 252 255 260 262 263 281 292 293 295 300 304 306 309 311 313 330 331

0 1 0 0 0 1 1 1 1 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0

337 338 340 349 353 354 356 364 368 369 379 382 383 385 388 394 403 406 408 410 415 417 426 435 442 468 470 475 484 485 488 489 490

0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1

501 506 510 511 515 519 527 542 549 559 561 562 563 564 567 568 570 571 574 584 588 601 607 616 617 618 621 622 624 626 629 634 660

0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

661 665 674 681 685 689 692 696 699 709 720 722 723 726 733 750 757 758 760 761 767 772 773 775 776 781 785 789 790 809 820 823 824

0 0 0 1 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0

831 833 838 844 859 869 871 873 880 884 890 903 910 914 920 928 934 947 950 951 954 955 961 965 976 977 980 988 992 995 1003 1009 1011

0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0

1035 1036 1038 1041 1042 1050 1053 1069 1075 1077 1081 1097 1098 1102 1104 1117 1119 1122 1126 1143 1149 1154 1157 1158 1160 1164 1168 1169 1170 1172 1176 1178 1180

0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 1 1 0 0 0 0 0 0 0

1181 1192 1207 1214 1217 1220 1233 1238 1241 1249 1257 1258 1261 1270 1273 1281 1293 1295 1309 1311 1318 1326 1327 1331 1332 1333 1334 1341 1342 1345 1348 1350 1355

0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 1

1362 1380 1384 1392 1399 1400 1402 1404 1414 1415 1441 1448 1450 1451 1452 1465 1467 1468 1472 1473 1475 1483 1488 1489 1490 1493 1494 1495 1496 1497 1498 1499 1502

1 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 1 0

1504 1506 1508 1520 1522 1523 1528 1530 1538 1539 1543 1546 1549 1550 1558 1563 1567 1573 1574 1577 1584 1585 1587 1589 1593 1594 1598 1600 1601 1603 1605 1607 1608

0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1

1615 1620 1639 1642 1644 1645 1650 1654 1656 1664 1671 1673 1680 1682 1683 1696 1703 1704 1708 1714 1716 1718 1726 1735 1744 1747 1754 1762 1764 1767 1771 1783 1796

0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 1 0 0 0 0 1 0 0 0 0

1802 1812 1815 1824 1830 1832 1833 1835 1846 1854 1855 1864 1865 1876 1883 1888 1890 1892 1893 1903 1904 1907 1908 1912 1916 1922 1923 1928 1931 1933 1943 1945 1960

0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0

1962 1965 1993 2004 2005 2006 2009 2011 2012 2015 2017 2018 2019 2030 2035 2038 2044 2050 2054 2060 2070 2079 2080 2082 2090 2091 2092 2096 2099 2110 2115 2119 2121

0 0 1 0 0 0 1 1 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 1 0

2138 2151 2154 2161 2164 2166 2167 2170 2172 2174 2185 2186 2189 2191 2192 2194 2211 2213 2218 2222 2224 2226 2231 2235 2242 2248 2254 2257 2263 2268 2274 2277 2279

0 1 1 0 1 0 0 0 1 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0

2287 2295 2304 2306 2308 2311 2319 2323 2324 2330 2332 2355 2358 2370 2388 2391 2401 2407 2413 2417 2420 2421 2422 2424 2426 2428 2434 2439 2440 2444 2446 2459 2460

0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0

2462 2468 2477 2478 2487 2494 2496 2498 2501 2508 2509 2514 2522 2523 2524 2532 2537 2539 2552 2558 2563 2565 2566 2568 2574 2583 2591 2593 2600 2602 2608 2610 2617

0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0

2625 2627 2630 2632 2645 2649 2650 2660 2666 2669 2676 2681 2692 2697 2710 2713 2716 2720 2722 2724 2727 2729 2730 2738 2740 2743 2745 2749 2751 2752 2755 2756 2761

0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0

2762 2766 2772 2774 2776 2780 2782 2787 2789 2790 2791 2794 2799 2807 2814 2815 2827 2828 2830 2842 2849 2856 2865 2874 2876 2877 2881 2889 2890 2897 2899 2907 2909

1 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 1 0 0 0 0 1

2911 2917 2921 2926 2931 2932 2933 2935 2939 2940 2942 2944 2945 2953 2956 2958 2966 2967 2968 2971 2977 2979 2981 2996 2997 2998 2999 3001 3012 3014 3015 3017 3028

0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 1 0 1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0

3029 3031 3036 3038 3041 3045 3049 3050 3053 3054 3060 3061 3074 3076 3078 3080 3090 3092 3094 3097 3103 3105 3106 3108 3109 3132 3141 3142 3150 3155 3160 3161 3165

0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 1 0 0

3166 3169 3176 3181 3182 3193 3194 3217 3219 3226 3227 3228 3234 3245 3248 3250 3256 3260 3271 3275 3276 3287 3289 3295 3299 3304 3305 3308 3319 3322 3325 3337 3349

0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 1 0 1 0 0 0 0 1 0 0

3381 3402 3412 3413 3420 3425 3429 3430 3431 3436 3445 3446 3463 3464 3474 3484 3485 3487 3492 3500 3501 3502 3512 3519 3524 3527 3528 3533 3534 3545 3546 3547 3551

1 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0

3552 3555 3567 3573 3576 3579 3585 3609 3613 3618 3624 3627 3629 3632 3640 3641 3652 3653 3654 3660 3664 3669 3672 3674 3676 3680 3682 3693 3697 3701 3705 3709 3712

1 1 0 1 0 0 1 0 1 1 1 0 0 1 0 1 0 1 0 0 1 0 1 1 0 0 1 0 0 0 0 0 0

3713 3716 3720 3729 3736 3739 3752 3758 3759 3764 3766 3786 3799 3800 3803 3805 3808 3814 3822 3823 3826 3831 3833 3838 3841 3843 3846 3854 3856 3859 3862 3874 3876

0 1 0 0 1 0 0 0 0 1 0 1 1 0 0 1 1 0 1 1 0 1 0 0 0 0 1 0 0 0 0 0 0

3879 3886 3891 3892 3895 3906 3910 3911 3928 3931 3937 3938 3940 3943 3944 3952 3957 3960 3969 3973 3975 3980 3994 4004 4006 4009 4010 4014 4015 4016 4019 4023 4040

0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

4042 4043 4046 4048 4055 4059 4062 4067 4084 4088 4090 4091 4097 4098 4103 4106 4112 4115 4119 4122 4124 4129 4133 4140 4147 4148 4149 4154 4173 4182 4185 4189 4193

0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 1 0

4194 4197 4199 4216 4219 4226 4234 4242 4243 4244 4251 4262 4265 4272 4276 4293 4295 4305 4307 4327 4332 4340 4341 4343 4344 4346 4351 4356 4374 4377 4378 4387 4388

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0

4389 4393 4408 4411 4416 4418 4420 4421 4427 4429 4432 4433 4447 4449 4451 4459 4460 4471 4472 4473 4476 4480 4481 4484 4494 4499 4503 4505 4512 4517 4520 4526 4538

0 0 0 1 0 1 0 0 0 1 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0

4539 4543 4551 4556 4560 4563 4566 4568 4572 4573 4581 4583 4585 4594 4599 4605 4608 4611 4619 4620 4623 4624 4625 4629 4638 4640 4653 4654 4657 4661 4676 4689 4703

1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 1 0 0 0 0 0 0 0

4708 4719 4726 4737 4748 4752 4754 4758 4765 4767 4774 4776 4781 4783 4792 4793 4798 4800 4801 4810 4812 4819 4823 4824 4826 4827 4835 4836 4843 4852 4856 4857 4860

0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 1 0 0 0

4862 4865 4869 4881 4886 4903 4905 4915 4920 4921

0 0 0 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> #Performance Measure

> table(prediction\_rf\_1)

prediction\_rf\_1

0 1

1119 290

> factor(test$Churn)

[1] 1 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 1 1 0 0 0 0 1 0 0

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[721] 1 0 1 0 0 1 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 0 1 0 0 0 0 1 1 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 1

[801] 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0

[881] 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 1 1 0 0 0 0 1

[961] 0 0 1 1 1 1 0 1 1 0 0 0 1 0 0 1 0 1 0 0 1 0 1 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 0 0

[ reached getOption("max.print") -- omitted 409 entries ]

Levels: 0 1

> confusionMatrix(data=factor(prediction\_rf\_1), reference=factor(test$Churn), positive="1")

Confusion Matrix and Statistics

Reference

Prediction 0 1

0 932 187

1 101 189

Accuracy : 0.7956

95% CI : (0.7736, 0.8164)

No Information Rate : 0.7331

P-Value [Acc > NIR] : 3.082e-08

Kappa : 0.4366

Mcnemar's Test P-Value : 5.481e-07

Sensitivity : 0.5027

Specificity : 0.9022

Pos Pred Value : 0.6517

Neg Pred Value : 0.8329

Prevalence : 0.2669

Detection Rate : 0.1341

Detection Prevalence : 0.2058

Balanced Accuracy : 0.7024

'Positive' Class : 1

> accuracy\_score\_rf\_1 <- accuracy(actual, prediction\_rf\_1)

> precision\_score\_rf\_1 <- precision(actual, prediction\_rf\_1)

> accuracy\_score\_rf\_1

[1] 0.7955997

> precision\_score\_rf\_1

[1] 0.6517241

> #ROC Curve

> ROCit\_base <- rocit(score=as.numeric(prediction\_rf\_1), class=actual)

> plot(ROCit\_base)

> recall\_score\_rf\_1 <- recall(actual, as.numeric(prediction\_rf\_1))

> auc\_score\_rf\_1 <- auc(actual, prediction\_rf\_1)

> Random\_Forest <- c(accuracy\_score\_rf\_1 , precision\_score\_rf\_1 ,recall\_score\_rf\_1 , auc\_score\_rf\_1)

> Base\_Models$RandomForest = data.frame(Random\_Forest)

> Base\_Models

Model Logistic\_Regression Decision\_Tree SVM KNN Random\_Forest

1 Accuracy 0.7885025 0.7799858 0.7913414 0.8814762 0.7955997

2 Precision 0.7241379 0.6542056 0.6314103 0.8082596 0.6517241

3 Recall 0.3351064 1.3723404 1.5239362 1.7287234 1.5026596

4 AUC Score 0.6443199 0.6503522 0.7063050 0.8328999 0.7024430