STAT5703 Data Mining I - Winter 2018

STEGANALYSIS

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Appendix

7. Applications

In this section we will show an example of Image **Steganography** and **Statistical Steganalysis**.

7.1 Calling Necessary Libraries

```
# 7. Applications
## 7.1 Calling Neccesary Libraries
l_packages = c("pixmap","factoextra","caret","ggplot2","ggpubr",
               "knitr","kableExtra","formatR", "xtable") # used to create the Report

for(p in l_packages){
  if (!require(p,character.only = TRUE)) install.packages(p)
  library(p,character.only = TRUE)
}
```

```
## Loading required package: pixmap
```

```
## Loading required package: factoextra
```

```
## Loading required package: ggplot2
```

```
## Welcome! Related Books: `Practical Guide To Cluster Analysis in R` at
https://goo.gl/13EFCZ
```

```
## Loading required package: caret
```

```
## Loading required package: lattice
```

```
## Loading required package: ggpubr
```

```
## Loading required package: magrittr

## Loading required package: kableExtra

## Loading required package: formatR

## Loading required package: xtable
```

7.2 Setting Up the Directory and Variables for Reproducibility

The **folder** variables need to be updated in order to reproduce the work.

```
## 7.2 Setting Up the Directory and Variables for Reproducibility
# Student and Assigment Information Variables
Student.Number <- "101066270"
ASorLAB <- "RESEARCH"
Student.info <- paste(Student.Number, ASorLAB, sep="-")
# Folder Variables
drive="C:"
path.upto <- paste("Users", "Enrique","Documents",
                   "Carleton", "Winter 2018", "STAT5703 Data Mining I", sep="/" )
code.dir <- paste(drive, path.upto, Student.info, "Code", sep="/")
data.dir <- paste(drive, path.upto, Student.info, "Data", sep="/")
img.src.dir <- paste(drive, path.upto, Student.info, "Data", "ImgSrc", sep="/")
img.stego.dir <- paste(drive, path.upto, Student.info, "Data", "Stego", sep="/")
work.dir <- paste(drive, path.upto, Student.info, "Work", sep="/")
report.dir <- paste(drive, path.upto, Student.info, "Report", sep="/")
setwd(work.dir)
getwd()

## [1] "C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703 Data Mining
I/101066270-RESEARCH/Work"

# For reproducibility
set.seed(12345)
```

7.3 Calling Necessary Functions

```
## 7.3 Calling Necessary Functions
source(paste(code.dir, paste(Student.info, "functions.r", sep=" "), sep="/"))

## [1] "successful!"

lsf.str()

## %w/o% : function (x, y)
## convert_to_main.r : function ()
## correct_kmeans_ids : function (class_ids, kmeans_ids)
## count_missclassifications : function (class_ids, kmeans_ids)
## count_rows : function (data, column, value)
## create_kmeans_clusters : function (data, method, k_max, type_data, var1, var2)
## elapsed_time : function (tic1, tic2)
## f.data.std : function (data)
## find_best_seed_kv2 : function (data, method, initial_seed, final_seed, k,
real_class)
## find_best_seedv2 : function (data, method, min_seed, max_seed, min_k, max_k,
real_class)
## find_unique_variables : function (data, single = FALSE)
## get.train : function (data.sz, train.sz)
## has_empty_cluster : function (data)
## panel.cor : function (x, y, digits = 2, prefix = "", cex.cor)
## panel.hist : function (x, ...)
## panel.smooth.asp : function (x, y, col = par("col"), bg = NA, pch = par("pch"),
cex = 1,
```

```
##     col.smooth = "red", span = 2/3, iter = 3, asp, ...)
## per_rows : function (data, column, value)
## plot_clusters : function (clusters_plots)
## print_kable : function (data, num_lines = 0, latex_options = 0, caption = NULL)
## print_kablev2 : function (data, num_lines = 0, latex_options = 0, caption = NULL)
## print_table : function (data, num_lines = 0, latex_options = 0, caption = NULL)
## Sphere.Data : function (data)
## std.to.orig : function (std.coef, mean.X, mean.Y, s.X, s.Y)
```

7.4 Image Steganography (*stegasaur*)

stegasaur is an R library (https://github.com/richfitz/stegasaur) that implements Steganography on different type of images based on **Least Significant Bit (LSB)** replacement embedding algorithm. In this section we will show an application using a cover **png** image and two different types of messages: a plain text and a R Object.

7.4.1 Installation

```
## 7.4 Image Steganography (*stegasaur*)
### 7.4.1 Installation
# First needs to be installed, is not available trough Studio so we need
# to installed manually
install.packages("devtools")
library(devtools)
install_github("richfitz/stegasaur")
```

7.4.2 Getting and Image (png) and Loading in R

```
### 7.4.2 Getting and Image (png) and Loading in R
# Download a png file, for example this
library(utils)
URL <- "https://pbs.twimg.com/profile_images/537625264277028864/14jJPXpX_400x400.png"
# and put it in the working dir, a called "canada_flag.png"
download.file(URL,"canada_flag.png", mode ="wb")
getwd()

## [1] "C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703 Data Mining
I/101066270-RESEARCH/Report"

library(png)
# Load the png image from working dir
img <- png::readPNG("canada_flag.png")

# Write and load the file to create a baseline
png::writePNG(img,"canada_flag.png")
img <- png::readPNG("canada_flag.png", info = TRUE)

# Details about the file
str(img)

##  num [1:256, 1:256, 1:4] 1 1 1 1 1 1 1 1 1 1 ...
##  - attr(*, "info")=Dotted pair list of 3
##   ..$ dim       : int [1:2] 256 256
##   ..$ bit.depth : int 8
##   ..$ color.type: chr "RGBA"
```

```
kable(file.info("canada_flag.png"))
```

	size	isdir	mode	mtime	ctime	atime	exe
canada_flag.png	11351	FALSE	666	2018-03-28 12:51:25	2018-03-20 09:06:01	2018-03-28 12:51:25	no

```
# 256 x 256, 4 bits

# Show the original file

plot(0, type='n', xlim=0:1, ylim=0:1, main="Original Image", axes = FALSE,
     xlab = "", ylab = "")
rasterImage(img,0,0,1,1)
```

7.4.3 Example with Plain Text

7.4.3.1 Encoding the Message

```
### 7.4.3 Example with Plain Text
#### 7.4.3.1 Encoding the Message
library(stegasaur)
(msg1 <- "This is a test of Steganography using K library stegasaur LSB")

## [1] "This is a test of Steganography using K library stegasaur LSB"

# Encode the text in the image using LSB
img2 <- stegasaur::lsb_encode(msg1, img)

# Write the new image to the working dir
png::writePNG(img2,"canada_flag2.png")
kable(file.info("canada_flag2.png"))
```

	size	isdir	mode	mtime	ctime	atime	exe
canada_flag2.pn	1153	FALS	666	2018-03-28	2018-03-20	2018-03-28	no

g	7	E		12:51:25	09:06:01	12:51:25	

```
# Load the file to plot
img2 <- png::readPNG("canada_flag2.png", info = TRUE)
# Details about the file
str(img2)

##  num [1:256, 1:256, 1:4] 1 0.996 1 1 1 ...
##  - attr(*, "info")=Dotted pair list of 3
##   ..$ dim       : int [1:2] 256 256
##   ..$ bit.depth : int 8
##   ..$ color.type: chr "RGBA"

# 256 x 256, 4 bits

# Show the New Image
plot(0, type='n', xlim=0:1, ylim=0:1, main="New Image", axes = FALSE,
     xlab = "", ylab = "")
rasterImage(img2,0,0,1,1)
```

7.4.3.2 Decoding the Message

```
#### 7.4.3.2 Decoding the Message
# Load the image with the message encoded
img2 <- png::readPNG("canada_flag2.png", info = TRUE)
kable(file.info("canada_flag2.png"))
```

	size	isdir	mode	mtime	ctime	atime	exe
canada_flag2.png	11537	FALSE	666	2018-03-28 12:51:25	2018-03-20 09:06:01	2018-03-28 12:51:26	no

```
dim(img2)

## [1] 256 256   4

# Decode the message
stegasaur::lsb_decode(img2)
```

```
## [1] "This is a test of Steganography using K library stegasaur LSB"
```

7.4.4 Example with an R Object

7.4.4.1 Encoding the Message

```
### 7.4.4 Example with an R Object
#### 7.4.4.1 Encoding the Message
library(stegasaur)
(msg2 <- data.frame(ID = c("101066270","1010XXXXXX","1010XXXXXX","101066XXXX"),
                    NAME = c("Enrique","Muneer","Alex","Michael")))

##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael

# Load the png image from working dir
img <- png::readPNG("canada_flag.png")

# Encode the text in the image using LSB
img3 <- stegasaur::lsb_encode(msg2, img)

# Write the new image to the working dir
png::writePNG(img3,"canada_flag3.png")

# Load the file to plot
img3 <- png::readPNG("canada_flag3.png")
# Details about the file
dim(img3)

## [1] 256 256   4

kable(file.info("canada_flag3.png"))
```

	size	isdir	mode	mtime	ctime	atime	exe
canada_flag3.png	12609	FALSE	666	2018-03-28 12:51:26	2018-03-20 19:02:08	2018-03-28 12:51:26	no

```
# 256 x 256, 4 bits

# Show the New Image
plot(0, type='n', xlim=0:1, ylim=0:1, main="New Image", axes = FALSE,
     xlab = "", ylab = "")
rasterImage(img3,0,0,1,1)
```

New Image

7.4.4.2 Decoding the Message

```
#### 7.4.4.2 Decoding the Message
# Load the image with the message encoded
img3 <- png::readPNG("canada_flag3.png")
dim(img3)

## [1] 256 256   4

# Decode the message
x <- stegasaur::lsb_decode(img3)
x

##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael

is.data.frame(x)

## [1] TRUE
```

We can notice that is possible encode different kind of object into the cover image.

7.4.5 Source Code

The source code of the functions are showed here.

LSB

```
### 7.4.5 Source Code
#### LSB
# Exported Functions
##' Takes an image matrix from something like \code{readPNG}.  Note
##' that this cannot be saved out as jpeg as the lossy compression
##' will drop the message
##'
```

```
##' @title Encode text into a lossless image
##' @param content Content to save into the image; can be a text
##' string or an arbitrary R object.
##' @param img An image matrix to save the message into
##' @param force_object Logical: Force saving a scalar text string as
##' an R object (will be slightly more space efficient).
##' @export
##' @author Rich FitzJohn
##' @importFrom png readPNG
##' @examples
##' img <- png::readPNG(system.file("img/Rlogo.png", package="png"))
##' txt <- "hello from stegasaur"
##' img2 <- lsb_encode(txt, img)
##' lsb_decode(img2)
lsb_encode <- function(content, img, force_object=FALSE) {
  text <- !force_object && is.character(content) && length(content) == 1L
  if (text) {
    content <- utf8ToInt(content)
  } else {
    content <- serialize(content, NULL)
  }

  img <- lsb_prepare(img)
  bits <- c(binvalue(length(content), LSB_BITSIZE_LEN),
            as.integer(text),
            binvalue(content, LSB_BITSIZE_CHAR))
  ret <- put_binary_value(bits, img)
  ret / 255
}

##' @export
##' @rdname lsb_encode
lsb_decode <- function(img) {
  img <- lsb_prepare(img)
  i <- seq_len(LSB_BITSIZE_LEN)
  len <- intvalue(img[i] %&% 1L, LSB_BITSIZE_LEN)
  is_text <- as.logical(img[LSB_BITSIZE_LEN + 1L] %&% 1L)

  bits <- img[seq_len(LSB_BITSIZE_CHAR * len) + LSB_BITSIZE_LEN + 1L] %&% 1L
  bytes <- intvalue(bits, LSB_BITSIZE_CHAR)

  if (is_text) {
    intToUtf8(bytes)
  } else {
    unserialize(as.raw(bytes))
  }
}

LSB_BITSIZE_LEN  <- 16L
LSB_BITSIZE_CHAR <- 8L # also for raw
INT_LEN <- length(intToBits(0L)) # 32L

binvalue <- function(val, bitsize) {
  b <- matrix(as.integer(intToBits(val)), INT_LEN)
```

```r
  i <- seq_len(bitsize)
  if (sum(b[-i, ])) {
    stop("Overflow detected")
  }
  c(b[i, ])
}

intvalue <- function(bits, bitsize) {
  m <- matrix(as.integer(bits), bitsize)
  m <- rbind(m, matrix(0L, INT_LEN - bitsize, ncol(m)))
  packBits(m, "integer")
}

put_binary_value <- function(bits, img) {
  if (length(bits) > length(img)) {
    stop("not enough space")
  }
  i <- seq_along(bits)
  j <- bits == 1L
  k <- !j
  img[i][j] <- img[i][j] %|% 1L
  img[i][k] <- img[i][k] %&% 254L
  img
}

lsb_prepare <- function(img) {
  if (is.double(img)) {
    img <- img * 255
    storage.mode(img) <- "integer"
  }
  img
}
```

Utility Functions

```r
#### Utility Functions
`%<<%` <- function(x, y) {
  bitops::bitShiftL(x, y)
}

`%>>%` <- function(x, y) {
  bitops::bitShiftR(x, y)
}

`%&%` <- function(x, y) {
  bitops::bitAnd(x, y)
}

`%|%` <- function(x, y) {
  bitops::bitOr(x, y)
}
```

7.5 Statistical Data Mining Image Steganalysis

We will implement three different Data Mining Image Steganalysis:

- Clustering based on K-means
- Support Vector Machine (SVM) Classification
- Neural Networks (NN) Classification

The main steps are:

- Find a dataset (images) that will be used as a cover images
- Create the stego images using a Steganography Algorithm
- Split the dataset into training and test
- Get the images features
- Do Classification / Clustering
- Compare Results

7.5.1 The Dataset

We will use 200 images of a typical database used for steganalysis related with the contest named **Break our Steganalysis System (BOSS)**. The database is named **BOSSbase v1.01** and could be download from this site:

http://dde.binghamton.edu/download/ImageDB/BOSSbase_1.01.zip

This dataset include 1000 images in **Netpbm Grayscale Image Format (PGM)** named ([1-1000].pgm).

7.5.2 Steganopraphy Algorithm / Creation of Stego Images

We will use the **stegosaur** library showed before that use the LSB Replacement Algorithm. For each image we will encode ramdonly a different object (a text or a R object) using the **stegasaur** library and save the image as stego.

```
## 7.5 Statistical Data Mining Image Steganalysis
### 7.5.2 Steganopraphy Algorithm / Creation of Stego Images
# For each image (\\Data\\ImgSrc\\[1-200].pgm) we will select randomly an object an
generate
# an Stego Image (\\Data\\Stego\\[1-200]-Stego.pgm)

file.name <- paste(work.dir, "stego_labels.Rds", sep="/")
file.name.et <- paste(work.dir, "stego_labels-et.Rds", sep="/")

if (file.exists(file.name)) {
  load(file.name,.GlobalEnv)
  load(file.name.et,.GlobalEnv)
} else {

  t1 <- proc.time()
```

```r
# Create a Set of Messages to Encode
stego.data <- list(msg1,msg2)
# The text message
object.size(msg1)
# The data.frame
object.size(msg2)
# To print only the ten first images
j <- 1
# To save the kind of stego in each Stego-image
stego.labels <- NULL

if (!dir.exists(img.stego.dir)) {
  dir.create(img.stego.dir)
}

par(mfrow=c(1,2))

print("Creating Stego Images ....")
for (i in 1:200) {

  msg_id <- sample(c("a","b"),1)

  msg <- ifelse(msg_id == "a", stego.data[1], stego.data[2])

  img <- read.pnm(paste0(img.src.dir,"\\",i,".pgm"))

  print(paste0("Loading Image: ",i,".pgm ..."))
  print("============================")

  if (j <= 10) {
    # Only show in the Report the first 10 Images
    plot(img, main = paste0("Original Image (Src)\n",i,".pgm"))
  }

  print("Encoding Message:")
  print(msg)
  print(paste0("Into image file:",i))

  img@grey <- stegasaur::lsb_encode(msg, img@grey)

  if (j <= 10) {
    # Only show in the Report the first 10 Images
    print("New Image:")
    plot(img, main = paste0("Encoded Image (Stego)\n",i,"-Stego.pgm"))
    print("Decoding Message:")
    (x <- stegasaur::lsb_decode(img@grey))
    print(x)
    j <- j+1
  }

  print(paste0("Saving Stego Image:", img.stego.dir,"/",i,"-Stego.pgm"))
  write.pnm(img,paste0(img.stego.dir,"\\",i,"-Stego",msg_id,".pgm"))
  stego.labels[i] <- paste0(i,"-Stego",msg_id)
}
```

```
  t2 <- proc.time()
  et <- elapsed_time(t1,t2)
  print(paste0("Stego Images Created ... time:",et))
  save(stego.labels, file = file.name)
  save(et, file = file.name.et)
}
```

```
## [1] "Creating Stego Images ...."
## [1] "Loading Image: 1.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:1"
## [1] "New Image:"
```

Original Image (Src)
1.pgm

Encoded Image (Stego)
1-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/1-Stego.pgm"
## [1] "Loading Image: 2.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
```

```
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:2"
## [1] "New Image:"
```

Original Image (Src)
2.pgm

Encoded Image (Stego)
2-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/2-Stego.pgm"
## [1] "Loading Image: 3.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:3"
## [1] "New Image:"
```

Original Image (Src)
3.pgm

Encoded Image (Stego)
3-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/3-Stego.pgm"
## [1] "Loading Image: 4.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:4"
## [1] "New Image:"
```

Original Image (Src)
4.pgm

Encoded Image (Stego)
4-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/4-Stego.pgm"
## [1] "Loading Image: 5.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:5"
## [1] "New Image:"
```

Original Image (Src)
5.pgm

Encoded Image (Stego)
5-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/5-Stego.pgm"
## [1] "Loading Image: 6.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:6"
## [1] "New Image:"
```

Original Image (Src)
6.pgm

Encoded Image (Stego)
6-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
```

```
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/6-Stego.pgm"
## [1] "Loading Image: 7.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:7"
## [1] "New Image:"
```

Original Image (Src)
7.pgm

Encoded Image (Stego)
7-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/7-Stego.pgm"
## [1] "Loading Image: 8.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:8"
## [1] "New Image:"
```

Original Image (Src)
8.pgm

Encoded Image (Stego)
8-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/8-Stego.pgm"
## [1] "Loading Image: 9.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:9"
## [1] "New Image:"
```

Original Image (Src)
9.pgm

Encoded Image (Stego)
9-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/9-Stego.pgm"
## [1] "Loading Image: 10.pgm ..."
## [1] "============================"

## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:10"
## [1] "New Image:"
```

Original Image (Src)
10.pgm

Encoded Image (Stego)
10-Stego.pgm

```
## [1] "Decoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/10-Stego.pgm"
## [1] "Loading Image: 11.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:11"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/11-Stego.pgm"
## [1] "Loading Image: 12.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:12"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/12-Stego.pgm"
## [1] "Loading Image: 13.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
```

```
## 4 101066XXXX Michael
##
## [1] "Into image file:13"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/13-Stego.pgm"
## [1] "Loading Image: 14.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:14"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/14-Stego.pgm"
## [1] "Loading Image: 15.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:15"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/15-Stego.pgm"
## [1] "Loading Image: 16.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:16"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/16-Stego.pgm"
## [1] "Loading Image: 17.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:17"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/17-Stego.pgm"
## [1] "Loading Image: 18.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:18"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/18-Stego.pgm"
## [1] "Loading Image: 19.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
```

```
##
## [1] "Into image file:19"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/19-Stego.pgm"
## [1] "Loading Image: 20.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:20"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/20-Stego.pgm"
## [1] "Loading Image: 21.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:21"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/21-Stego.pgm"
## [1] "Loading Image: 22.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:22"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/22-Stego.pgm"
## [1] "Loading Image: 23.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:23"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/23-Stego.pgm"
## [1] "Loading Image: 24.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
```

```
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:24"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/24-Stego.pgm"
## [1] "Loading Image: 25.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:25"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/25-Stego.pgm"
## [1] "Loading Image: 26.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:26"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/26-Stego.pgm"
## [1] "Loading Image: 27.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:27"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/27-Stego.pgm"
## [1] "Loading Image: 28.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:28"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/28-Stego.pgm"
## [1] "Loading Image: 29.pgm ..."
```

```
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:29"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/29-Stego.pgm"
## [1] "Loading Image: 30.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:30"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/30-Stego.pgm"
## [1] "Loading Image: 31.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:31"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/31-Stego.pgm"
## [1] "Loading Image: 32.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:32"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/32-Stego.pgm"
## [1] "Loading Image: 33.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:33"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/33-Stego.pgm"
## [1] "Loading Image: 34.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
```

```
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:34"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/34-Stego.pgm"
## [1] "Loading Image: 35.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:35"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/35-Stego.pgm"
## [1] "Loading Image: 36.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:36"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/36-Stego.pgm"
## [1] "Loading Image: 37.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:37"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/37-Stego.pgm"
## [1] "Loading Image: 38.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:38"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/38-Stego.pgm"
## [1] "Loading Image: 39.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
```

```
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:39"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/39-Stego.pgm"
## [1] "Loading Image: 40.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:40"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/40-Stego.pgm"
## [1] "Loading Image: 41.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:41"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/41-Stego.pgm"
## [1] "Loading Image: 42.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:42"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/42-Stego.pgm"
## [1] "Loading Image: 43.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:43"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/43-Stego.pgm"
## [1] "Loading Image: 44.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
```

```
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:44"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/44-Stego.pgm"
## [1] "Loading Image: 45.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:45"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/45-Stego.pgm"
## [1] "Loading Image: 46.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:46"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/46-Stego.pgm"
## [1] "Loading Image: 47.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:47"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/47-Stego.pgm"
## [1] "Loading Image: 48.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:48"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/48-Stego.pgm"
## [1] "Loading Image: 49.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:49"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/49-Stego.pgm"
```

```
## [1] "Loading Image: 50.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:50"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/50-Stego.pgm"
## [1] "Loading Image: 51.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:51"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/51-Stego.pgm"
## [1] "Loading Image: 52.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:52"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/52-Stego.pgm"
## [1] "Loading Image: 53.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:53"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/53-Stego.pgm"
## [1] "Loading Image: 54.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:54"
```

```
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/54-Stego.pgm"
## [1] "Loading Image: 55.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:55"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/55-Stego.pgm"
## [1] "Loading Image: 56.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:56"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/56-Stego.pgm"
## [1] "Loading Image: 57.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:57"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/57-Stego.pgm"
## [1] "Loading Image: 58.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:58"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/58-Stego.pgm"
## [1] "Loading Image: 59.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:59"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/59-Stego.pgm"
```

```
## [1] "Loading Image: 60.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:60"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/60-Stego.pgm"
## [1] "Loading Image: 61.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:61"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/61-Stego.pgm"
## [1] "Loading Image: 62.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:62"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/62-Stego.pgm"
## [1] "Loading Image: 63.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:63"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/63-Stego.pgm"
## [1] "Loading Image: 64.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:64"
```

```
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/64-Stego.pgm"
## [1] "Loading Image: 65.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:65"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/65-Stego.pgm"
## [1] "Loading Image: 66.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:66"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/66-Stego.pgm"
## [1] "Loading Image: 67.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:67"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/67-Stego.pgm"
## [1] "Loading Image: 68.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:68"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/68-Stego.pgm"
## [1] "Loading Image: 69.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
```

```
##
## [1] "Into image file:69"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/69-Stego.pgm"
## [1] "Loading Image: 70.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:70"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/70-Stego.pgm"
## [1] "Loading Image: 71.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:71"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/71-Stego.pgm"
## [1] "Loading Image: 72.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:72"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/72-Stego.pgm"
## [1] "Loading Image: 73.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:73"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/73-Stego.pgm"
## [1] "Loading Image: 74.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
```

```
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:74"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/74-Stego.pgm"
## [1] "Loading Image: 75.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:75"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/75-Stego.pgm"
## [1] "Loading Image: 76.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:76"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/76-Stego.pgm"
## [1] "Loading Image: 77.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:77"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/77-Stego.pgm"
## [1] "Loading Image: 78.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:78"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/78-Stego.pgm"
## [1] "Loading Image: 79.pgm ..."
```

```
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:79"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/79-Stego.pgm"
## [1] "Loading Image: 80.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:80"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/80-Stego.pgm"
## [1] "Loading Image: 81.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:81"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/81-Stego.pgm"
## [1] "Loading Image: 82.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:82"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/82-Stego.pgm"
## [1] "Loading Image: 83.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:83"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
```

```
Data Mining I/101066270-RESEARCH/Data/Stego/83-Stego.pgm"
## [1] "Loading Image: 84.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:84"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/84-Stego.pgm"
## [1] "Loading Image: 85.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:85"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/85-Stego.pgm"
## [1] "Loading Image: 86.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:86"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/86-Stego.pgm"
## [1] "Loading Image: 87.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:87"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/87-Stego.pgm"
## [1] "Loading Image: 88.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:88"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/88-Stego.pgm"
## [1] "Loading Image: 89.pgm ..."
```

```
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:89"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/89-Stego.pgm"
## [1] "Loading Image: 90.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:90"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/90-Stego.pgm"
## [1] "Loading Image: 91.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:91"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/91-Stego.pgm"
## [1] "Loading Image: 92.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:92"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/92-Stego.pgm"
## [1] "Loading Image: 93.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:93"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
```

```
Data Mining I/101066270-RESEARCH/Data/Stego/93-Stego.pgm"
## [1] "Loading Image: 94.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:94"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/94-Stego.pgm"
## [1] "Loading Image: 95.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:95"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/95-Stego.pgm"
## [1] "Loading Image: 96.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:96"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/96-Stego.pgm"
## [1] "Loading Image: 97.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:97"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/97-Stego.pgm"
## [1] "Loading Image: 98.pgm ..."
## [1] "============================"
```

```
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:98"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/98-Stego.pgm"
## [1] "Loading Image: 99.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:99"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/99-Stego.pgm"
## [1] "Loading Image: 100.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:100"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/100-Stego.pgm"
## [1] "Loading Image: 101.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:101"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/101-Stego.pgm"
## [1] "Loading Image: 102.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:102"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/102-Stego.pgm"
## [1] "Loading Image: 103.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
```

```
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:103"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/103-Stego.pgm"
## [1] "Loading Image: 104.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:104"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/104-Stego.pgm"
## [1] "Loading Image: 105.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:105"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/105-Stego.pgm"
## [1] "Loading Image: 106.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:106"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/106-Stego.pgm"
## [1] "Loading Image: 107.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
```

```
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:107"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/107-Stego.pgm"
## [1] "Loading Image: 108.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:108"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/108-Stego.pgm"
## [1] "Loading Image: 109.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:109"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/109-Stego.pgm"
## [1] "Loading Image: 110.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:110"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/110-Stego.pgm"
## [1] "Loading Image: 111.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:111"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/111-Stego.pgm"
## [1] "Loading Image: 112.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
```

```
##
## [1] "Into image file:112"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/112-Stego.pgm"
## [1] "Loading Image: 113.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:113"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/113-Stego.pgm"
## [1] "Loading Image: 114.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:114"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/114-Stego.pgm"
## [1] "Loading Image: 115.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:115"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/115-Stego.pgm"
## [1] "Loading Image: 116.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:116"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/116-Stego.pgm"
## [1] "Loading Image: 117.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
```

```
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:117"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/117-Stego.pgm"
## [1] "Loading Image: 118.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:118"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/118-Stego.pgm"
## [1] "Loading Image: 119.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:119"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/119-Stego.pgm"
## [1] "Loading Image: 120.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:120"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/120-Stego.pgm"
## [1] "Loading Image: 121.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:121"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/121-Stego.pgm"
## [1] "Loading Image: 122.pgm ..."
```

```
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:122"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/122-Stego.pgm"
## [1] "Loading Image: 123.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:123"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/123-Stego.pgm"
## [1] "Loading Image: 124.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:124"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/124-Stego.pgm"
## [1] "Loading Image: 125.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:125"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/125-Stego.pgm"
## [1] "Loading Image: 126.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
```

```
## 4 101066XXXX Michael
##
## [1] "Into image file:126"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/126-Stego.pgm"
## [1] "Loading Image: 127.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:127"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/127-Stego.pgm"
## [1] "Loading Image: 128.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:128"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/128-Stego.pgm"
## [1] "Loading Image: 129.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:129"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/129-Stego.pgm"
## [1] "Loading Image: 130.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:130"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/130-Stego.pgm"
## [1] "Loading Image: 131.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
```

```
## [1] "Into image file:131"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/131-Stego.pgm"
## [1] "Loading Image: 132.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:132"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/132-Stego.pgm"
## [1] "Loading Image: 133.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:133"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/133-Stego.pgm"
## [1] "Loading Image: 134.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:134"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/134-Stego.pgm"
## [1] "Loading Image: 135.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:135"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/135-Stego.pgm"
```

```
## [1] "Loading Image: 136.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:136"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/136-Stego.pgm"
## [1] "Loading Image: 137.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:137"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/137-Stego.pgm"
## [1] "Loading Image: 138.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:138"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/138-Stego.pgm"
## [1] "Loading Image: 139.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:139"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/139-Stego.pgm"
## [1] "Loading Image: 140.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:140"
```

```
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/140-Stego.pgm"
## [1] "Loading Image: 141.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:141"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/141-Stego.pgm"
## [1] "Loading Image: 142.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:142"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/142-Stego.pgm"
## [1] "Loading Image: 143.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:143"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/143-Stego.pgm"
## [1] "Loading Image: 144.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:144"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/144-Stego.pgm"
## [1] "Loading Image: 145.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
```

```
##
## [1] "Into image file:145"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/145-Stego.pgm"
## [1] "Loading Image: 146.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:146"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/146-Stego.pgm"
## [1] "Loading Image: 147.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:147"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/147-Stego.pgm"
## [1] "Loading Image: 148.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:148"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/148-Stego.pgm"
## [1] "Loading Image: 149.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:149"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/149-Stego.pgm"
## [1] "Loading Image: 150.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
```

```
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:150"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/150-Stego.pgm"
## [1] "Loading Image: 151.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:151"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/151-Stego.pgm"
## [1] "Loading Image: 152.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:152"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/152-Stego.pgm"
## [1] "Loading Image: 153.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:153"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/153-Stego.pgm"
## [1] "Loading Image: 154.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:154"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/154-Stego.pgm"
## [1] "Loading Image: 155.pgm ..."
```

```
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:155"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/155-Stego.pgm"
## [1] "Loading Image: 156.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:156"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/156-Stego.pgm"
## [1] "Loading Image: 157.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:157"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/157-Stego.pgm"
## [1] "Loading Image: 158.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:158"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/158-Stego.pgm"
## [1] "Loading Image: 159.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:159"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
```

```
Data Mining I/101066270-RESEARCH/Data/Stego/159-Stego.pgm"
## [1] "Loading Image: 160.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:160"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/160-Stego.pgm"
## [1] "Loading Image: 161.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:161"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/161-Stego.pgm"
## [1] "Loading Image: 162.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:162"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/162-Stego.pgm"
## [1] "Loading Image: 163.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:163"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/163-Stego.pgm"
## [1] "Loading Image: 164.pgm ..."
## [1] "============================"
```

```
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:164"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/164-Stego.pgm"
## [1] "Loading Image: 165.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:165"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/165-Stego.pgm"
## [1] "Loading Image: 166.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:166"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/166-Stego.pgm"
## [1] "Loading Image: 167.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:167"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/167-Stego.pgm"
## [1] "Loading Image: 168.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:168"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/168-Stego.pgm"
## [1] "Loading Image: 169.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
```

```
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:169"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/169-Stego.pgm"
## [1] "Loading Image: 170.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:170"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/170-Stego.pgm"
## [1] "Loading Image: 171.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:171"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/171-Stego.pgm"
## [1] "Loading Image: 172.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:172"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/172-Stego.pgm"
## [1] "Loading Image: 173.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:173"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/173-Stego.pgm"
## [1] "Loading Image: 174.pgm ..."
## [1] "============================"
```

```
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:174"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/174-Stego.pgm"
## [1] "Loading Image: 175.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:175"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/175-Stego.pgm"
## [1] "Loading Image: 176.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:176"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/176-Stego.pgm"
## [1] "Loading Image: 177.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:177"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/177-Stego.pgm"
## [1] "Loading Image: 178.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:178"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/178-Stego.pgm"
```

```
## [1] "Loading Image: 179.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:179"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/179-Stego.pgm"
## [1] "Loading Image: 180.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:180"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/180-Stego.pgm"
## [1] "Loading Image: 181.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:181"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/181-Stego.pgm"
## [1] "Loading Image: 182.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:182"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/182-Stego.pgm"
## [1] "Loading Image: 183.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:183"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/183-Stego.pgm"
## [1] "Loading Image: 184.pgm ..."
## [1] "============================"
```

```
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:184"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/184-Stego.pgm"
## [1] "Loading Image: 185.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:185"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/185-Stego.pgm"
## [1] "Loading Image: 186.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:186"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/186-Stego.pgm"
## [1] "Loading Image: 187.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:187"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/187-Stego.pgm"
## [1] "Loading Image: 188.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:188"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/188-Stego.pgm"
```

```
## [1] "Loading Image: 189.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:189"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/189-Stego.pgm"
## [1] "Loading Image: 190.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:190"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/190-Stego.pgm"
## [1] "Loading Image: 191.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:191"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/191-Stego.pgm"
## [1] "Loading Image: 192.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:192"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/192-Stego.pgm"
## [1] "Loading Image: 193.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:193"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/193-Stego.pgm"
## [1] "Loading Image: 194.pgm ..."
## [1] "============================"
```

```
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:194"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/194-Stego.pgm"
## [1] "Loading Image: 195.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:195"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/195-Stego.pgm"
## [1] "Loading Image: 196.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:196"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/196-Stego.pgm"
## [1] "Loading Image: 197.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:197"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/197-Stego.pgm"
## [1] "Loading Image: 198.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
##           ID    NAME
## 1  101066270 Enrique
## 2 1010XXXXXX  Muneer
## 3 1010XXXXXX    Alex
## 4 101066XXXX Michael
##
## [1] "Into image file:198"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/198-Stego.pgm"
## [1] "Loading Image: 199.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
```

```
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:199"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/199-Stego.pgm"
## [1] "Loading Image: 200.pgm ..."
## [1] "============================"
## [1] "Encoding Message:"
## [[1]]
## [1] "This is a test of Steganography using K library stegasaur LSB"
##
## [1] "Into image file:200"
## [1] "Saving Stego Image:C:/Users/Enrique/Documents/Carleton/Winter 2018/STAT5703
Data Mining I/101066270-RESEARCH/Data/Stego/200-Stego.pgm"
## [1] "Stego Images Created ... time:33"
```

7.5.3 Images Features

We will use the **Subtractive Pixel Adjacency Model SPAM features** defined in the paper (include a total of 686 variables), to get that we will use a Matlab code that is available on the following URL:

http://dde.binghamton.edu/download/feature_extractors/download/spam686.m

```
### 7.5.3 Images Features
function F = spam686(IMG)
% ------------------------------------------------------------------------
% Copyright (c) 2011 DDE Lab, Binghamton University, NY.
% All Rights Reserved.
% ------------------------------------------------------------------------
% Permission to use, copy, modify, and distribute this software for
% educational, research and non-profit purposes, without fee, and without a
% written agreement is hereby granted, provided that this copyright notice
% appears in all copies. The program is supplied "as is," without any
% accompanying services from DDE Lab. DDE Lab does not warrant the
% operation of the program will be uninterrupted or error-free. The
% end-user understands that the program was developed for research purposes
% and is advised not to rely exclusively on the program for any reason. In
% no event shall Binghamton University or DDE Lab be liable to any party
% for direct, indirect, special, incidental, or consequential damages,
% including lost profits, arising out of the use of this software. DDE Lab
% disclaims any warranties, and has no obligations to provide maintenance,
% support, updates, enhancements or modifications.
% ------------------------------------------------------------------------
% Contact: jan@kodovsky.com | fridrich@binghamton.edu | November 2011
%          http://dde.binghamton.edu/download/feature_extractors
% ------------------------------------------------------------------------
% Extracts spatial domain SPAM features, 2nd order, T=3. Dimensionality
% 686. See the original publication [1] for more details. In this
% implementation, we incorporated the following two modifications as
% compared to [1] (slightly better performance):
%  - marginalization of elements out of [-T,T] into borders (NOT throwing
%    them away)
%  - joint sample distribution (co-occurrence) instead of transition
```

```
%    probability matrix (different normalization)
% -------------------------------------------------------------------------
% Input: IMG ... input images (can be also JPEG image)
% Output: F .... resulting SPAM features
% -------------------------------------------------------------------------
% [1] T. Pevny, P. Bas, and J. Fridrich, Steganalysis by Subtractive Pixel
% Adjacency Matrix IEEE Trans. on Info. Forensics and Security, vol. 5(2),
% pp. 215-224, 2010.
% -------------------------------------------------------------------------

F = spam_extract_2(double(imread(IMG)),3);

function F = spam_extract_2(X,T)

% horizontal left-right
D = X(:,1:end-1) - X(:,2:end);
L = D(:,3:end); C = D(:,2:end-1); R = D(:,1:end-2);
Mh1 = GetM3(L,C,R,T);

% horizontal right-left
D = -D;
L = D(:,1:end-2); C = D(:,2:end-1); R = D(:,3:end);
Mh2 = GetM3(L,C,R,T);
% vertical bottom top
D = X(1:end-1,:) - X(2:end,:);
L = D(3:end,:); C = D(2:end-1,:); R = D(1:end-2,:);
Mv1 = GetM3(L,C,R,T);

% vertical top bottom
D = -D;
L = D(1:end-2,:); C = D(2:end-1,:); R = D(3:end,:);
Mv2 = GetM3(L,C,R,T);

% diagonal left-right
D = X(1:end-1,1:end-1) - X(2:end,2:end);
L = D(3:end,3:end); C = D(2:end-1,2:end-1); R = D(1:end-2,1:end-2);
Md1 = GetM3(L,C,R,T);

% diagonal right-left
D = -D;
L = D(1:end-2,1:end-2); C = D(2:end-1,2:end-1); R = D(3:end,3:end);
Md2 = GetM3(L,C,R,T);

% minor diagonal left-right
D = X(2:end,1:end-1) - X(1:end-1,2:end);
L = D(1:end-2,3:end); C = D(2:end-1,2:end-1); R = D(3:end,1:end-2);
Mm1 = GetM3(L,C,R,T);

% minor diagonal right-left
D = -D;
L = D(3:end,1:end-2); C = D(2:end-1,2:end-1); R = D(1:end-2,3:end);
Mm2 = GetM3(L,C,R,T);

F1 = (Mh1+Mh2+Mv1+Mv2)/4;
```

```
F2 = (Md1+Md2+Mm1+Mm2)/4;
F = [F1;F2];

function M = GetM3(L,C,R,T)
% marginalization into borders
L = L(:); L(L<-T) = -T; L(L>T) = T;
C = C(:); C(C<-T) = -T; C(C>T) = T;
R = R(:); R(R<-T) = -T; R(R>T) = T;

% get cooccurences [-T...T]
M = zeros(2*T+1,2*T+1,2*T+1);
for i=-T:T
    C2 = C(L==i);
    R2 = R(L==i);
    for j=-T:T
        R3 = R2(C2==j);
        for k=-T:T
            M(i+T+1,j+T+1,k+T+1) = sum(R3==k);
        end
    end
end

% normalization
M = M(:)/sum(M(:));
```

Running the following code in Matlab and using the previous function (spam686) we will create a **.csv** file with the features for the **Src** and **Stego** Images (SPAM-ImgSrc.csv and SPAM-Stego.csv):

```
%% If it will be running against the stego images
stego = 1
for i = 1:200
  myFile = dir(strcat(int2str(i),'-Stego*.pgm'))
  disp(myFile.name)
  x = spam686(myFile.name)

  if i == 1
     res = transpose(x)
  else
     res = [res ; transpose(x)]
  end
end

if (stego == 1)
  csvwrite('SPAM-Stego.csv',res)
else
  csvwrite('SPAM-ImgSrc.csv',res)
end
```

After that we will load the feature dataset (SPAM-ImgSrc.csv and SPAM-stego.csv) into R:

```
feature.src.data.file <- paste(img.src.dir, "SPAM-ImgSrc.csv", sep="/")
feature.stego.data.file <- paste(img.stego.dir, "SPAM-Stego.csv", sep="/")
```

```
dt.imgsrc <- read.table(feature.src.data.file, sep = ",")
# Class = 1 No Stego Image
dt.imgsrc$class <- 1
row.names(dt.imgsrc) <- paste0(row.names(dt.imgsrc),"-Src")

dt.imgstego <- read.table(feature.stego.data.file, sep = ",")
# Class = 2 Stego Image
dt.imgstego$class <- 2
row.names(dt.imgstego) <- stego.labels


# Some details about the data
dim(dt.imgsrc)

## [1] 200 687

kable(dt.imgsrc[1:5,c(1:5,687)])
```

	V1	V2	V3	V4	V5	class
1-Src	0.0299	0.0039	0.0043	0.0049	0.0049	1
2-Src	0.0088	0.0019	0.0021	0.0023	0.0021	1
3-Src	0.0305	0.0050	0.0058	0.0065	0.0066	1
4-Src	0.0375	0.0067	0.0069	0.0064	0.0053	1
5-Src	0.0276	0.0052	0.0055	0.0056	0.0049	1

```
str(dt.imgsrc[,c(1:5,687)])

## 'data.frame':    200 obs. of  6 variables:
##  $ V1   : num  0.02992 0.00882 0.03047 0.03754 0.02756 ...
##  $ V2   : num  0.00391 0.00192 0.00503 0.00665 0.00521 ...
##  $ V3   : num  0.00435 0.00215 0.00581 0.00686 0.00551 ...
##  $ V4   : num  0.0049 0.00232 0.00645 0.00638 0.00557 ...
##  $ V5   : num  0.00488 0.00206 0.00657 0.00527 0.00493 ...
##  $ class: num  1 1 1 1 1 1 1 1 1 ...
```

7.5.4 Split the Dataset into Train and Data

We will split the dataset using 1/3 for test and 2/3 for training:

```
### 7.5.4 Split the Dataset into Train and Data
(n.var <- length(dt.imgsrc))

## [1] 687
```

```r
# The firsts 686 variables are the predictors and the 687 is the class

(l.class <- dim(dt.imgsrc)[1])
```

```
## [1] 200
```

```r
(Train.class <- round(l.class * 2 / 3, digits = 0))
```

```
## [1] 133
```

```r
# Get the indices for the training and test samples
tt.ind.class <- get.train(dim(dt.imgsrc)[1], Train.class)

# Let's sort the values for easy visualization
tt.ind.class$train <- sort(tt.ind.class$train)
tt.ind.class$test <- sort(tt.ind.class$test)
tt.ind.class
```

```
## $train
##   [1]   2   3   4   5   6   7   8  12  14  16  17  18  19  20  22  23  24
##  [18]  25  26  27  28  30  31  32  33  37  39  42  43  45  48  49  50  51
##  [35]  52  53  54  56  57  58  59  60  61  62  64  65  68  69  70  71  72
##  [52]  73  76  77  78  80  81  82  83  85  86  91  94  95  96  97  98 101
##  [69] 102 103 104 105 106 107 109 112 113 114 115 117 118 120 121 123 124
##  [86] 125 126 127 128 129 130 131 132 133 134 135 137 138 140 142 143 144
## [103] 145 146 147 150 151 158 160 162 165 166 171 172 173 174 175 176 177
## [120] 178 179 180 181 183 187 189 190 191 192 195 196 199 200
##
## $test
##  [1]   1   9  10  11  13  15  21  29  34  35  36  38  40  41  44  46  47
## [18]  55  63  66  67  74  75  79  84  87  88  89  90  92  93  99 100 108
## [35] 110 111 116 119 122 136 139 141 148 149 152 153 154 155 156 157 159
## [52] 161 163 164 167 168 169 170 182 184 185 186 188 193 194 197 198
```

```r
# Length of the Train and Test
length(tt.ind.class$train)
```

```
## [1] 133
```

```r
length(tt.ind.class$test)
```

```
## [1] 67
```

```r
# Find Train and Test Sets
train.X.src.class <- dt.imgsrc[tt.ind.class$train,]

dim(train.X.src.class)
```

```
## [1] 133 687
```

```r
train.X.stego.class <- dt.imgstego[tt.ind.class$train,]
dim(train.X.stego.class)
```

```
## [1] 133 687
```

```r
test.X.src.class <- dt.imgsrc[tt.ind.class$test,]
dim(test.X.src.class)
```

```
## [1]  67 687

test.X.stego.class <- dt.imgstego[tt.ind.class$test,]
dim(test.X.stego.class)

## [1]  67 687

# Put all Together, first the train Set
train.X.all <- rbind (train.X.src.class, train.X.stego.class)
dim(train.X.all)

## [1] 266 687

train.Y.all <- train.X.all$class
length(train.Y.all)

## [1] 266

# Remove class from train.X.all set
train.X.all <- train.X.all[,1:(n.var-1)]

# The best results we get using the std data, let's transform the data
train.X.all.std <- f.data.std(train.X.all)
train.X.all.sp <- Sphere.Data(train.X.all)


# Do the same for test set
test.X.all <- rbind (test.X.src.class, test.X.stego.class)
test.Y.all <- test.X.all$class
# Remove class from train.X. set
test.X.all <- test.X.all[,1:(n.var-1)]

# Std the data to have better results
test.X.all.std <- f.data.std(test.X.all)
test.X.all.sp <- Sphere.Data(test.X.all)
```

7.5.5 Clustering Using K-means

7.5.5.1 PCA

Because the dataset have too many variables (686), we will first try to reduce the number of variables using PCA.

```
### 7.5.5 Clustering Using K-means
#### 7.5.5.1 PCA
pc.train <- prcomp(as.matrix(train.X.all.std), scale = TRUE, center = TRUE)

# Eigenvalues
eig.val <- get_eig(pc.train)

# Let's see the first 60
kable(eig.val[1:60,])
```

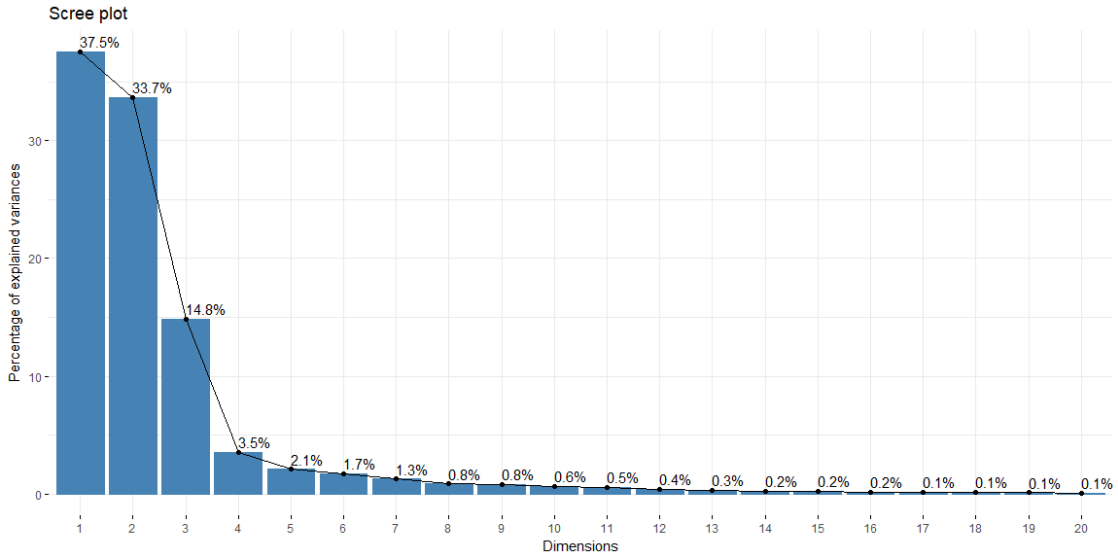
	eigenvalu	variance.percen	cumulative.variance.percen

	e	t	t
Dim.1	257.3851	37.5197	37.52
Dim.2	231.0180	33.6761	71.20
Dim.3	101.6748	14.8214	86.02
Dim.4	24.3261	3.5461	89.56
Dim.5	14.2817	2.0819	91.65
Dim.6	11.5032	1.6769	93.32
Dim.7	8.5818	1.2510	94.57
Dim.8	5.7277	0.8349	95.41
Dim.9	5.3218	0.7758	96.18
Dim.10	4.1470	0.6045	96.79
Dim.11	3.7508	0.5468	97.33
Dim.12	2.5107	0.3660	97.70
Dim.13	2.0543	0.2995	98.00
Dim.14	1.5678	0.2285	98.23
Dim.15	1.4192	0.2069	98.44
Dim.16	1.0835	0.1580	98.59
Dim.17	0.9754	0.1422	98.74
Dim.18	0.7626	0.1112	98.85
Dim.19	0.6398	0.0933	98.94
Dim.20	0.5585	0.0814	99.02
Dim.21	0.5263	0.0767	99.10
Dim.22	0.4833	0.0705	99.17
Dim.23	0.4462	0.0650	99.23
Dim.24	0.3433	0.0500	99.28
Dim.25	0.3044	0.0444	99.33

Dim.26	0.2563	0.0374	99.37
Dim.27	0.2477	0.0361	99.40
Dim.28	0.2324	0.0339	99.44
Dim.29	0.1951	0.0284	99.46
Dim.30	0.1767	0.0258	99.49
Dim.31	0.1739	0.0253	99.52
Dim.32	0.1717	0.0250	99.54
Dim.33	0.1384	0.0202	99.56
Dim.34	0.1333	0.0194	99.58
Dim.35	0.1156	0.0168	99.60
Dim.36	0.1130	0.0165	99.61
Dim.37	0.1066	0.0155	99.63
Dim.38	0.0976	0.0142	99.64
Dim.39	0.0937	0.0137	99.66
Dim.40	0.0865	0.0126	99.67
Dim.41	0.0815	0.0119	99.68
Dim.42	0.0805	0.0117	99.69
Dim.43	0.0751	0.0110	99.70
Dim.44	0.0713	0.0104	99.71
Dim.45	0.0685	0.0100	99.72
Dim.46	0.0665	0.0097	99.73
Dim.4	0.0627	0.0091	99.74

7			
Dim.48	0.0599	0.0087	99.75
Dim.49	0.0584	0.0085	99.76
Dim.50	0.0556	0.0081	99.77
Dim.51	0.0522	0.0076	99.78
Dim.52	0.0500	0.0073	99.78
Dim.53	0.0493	0.0072	99.79
Dim.54	0.0477	0.0070	99.80
Dim.55	0.0458	0.0067	99.80
Dim.56	0.0454	0.0066	99.81
Dim.57	0.0426	0.0062	99.82
Dim.58	0.0408	0.0060	99.82
Dim.59	0.0394	0.0057	99.83
Dim.60	0.0384	0.0056	99.83

```
fviz_screeplot(pc.train, addlabels = TRUE, ncp=20)
```




```
# Extract the results for variables
var <- get_pca_var(pc.train)

kable(print(var))

## Principal Component Analysis Results for variables
##  ===================================================
##   Name       Description
## 1 "$coord"   "Coordinates for the variables"
## 2 "$cor"     "Correlations between variables and dimensions"
## 3 "$cos2"    "Cos2 for the variables"
## 4 "$contrib" "contributions of the variables"
```

Name	Description
$coord	Coordinates for the variables
$cor	Correlations between variables and dimensions
$cos2	Cos2 for the variables
$contrib	contributions of the variables

```
# Let see the model generated (first five dimension and 10 variables)
kable(var$coord[1:5,1:5])
```

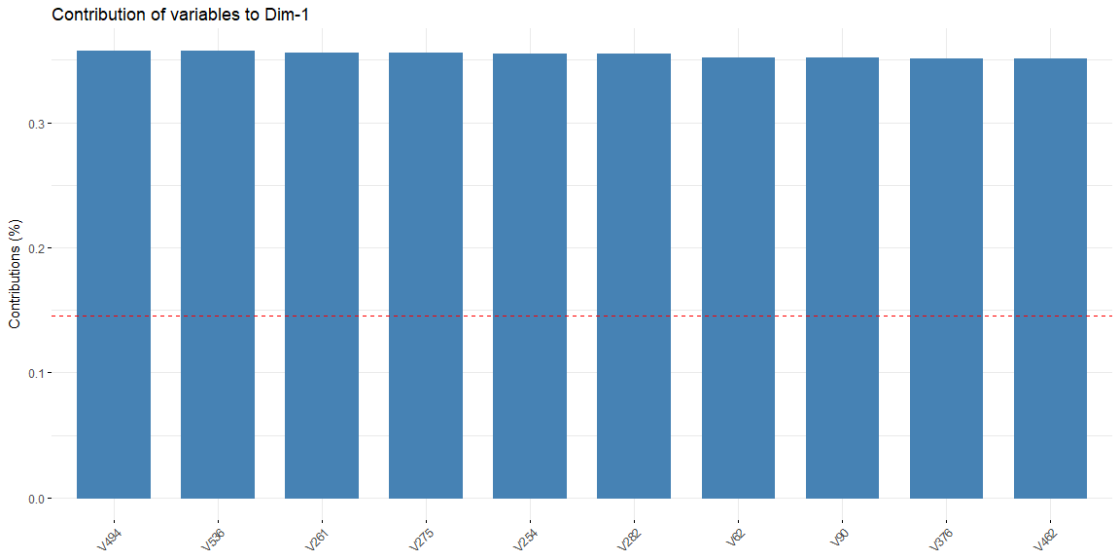
	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
V1	0.4391	0.2101	-0.6229	-0.3632	0.2071
V2	0.1465	0.4046	-0.8026	-0.1857	0.2386
V3	0.0214	-0.0142	-0.8512	-0.3500	0.2570
V4	-0.0478	-0.5180	-0.6505	-0.3506	0.2135

V5	-0.0519	-0.7622	-0.4639	-0.2394	0.1264

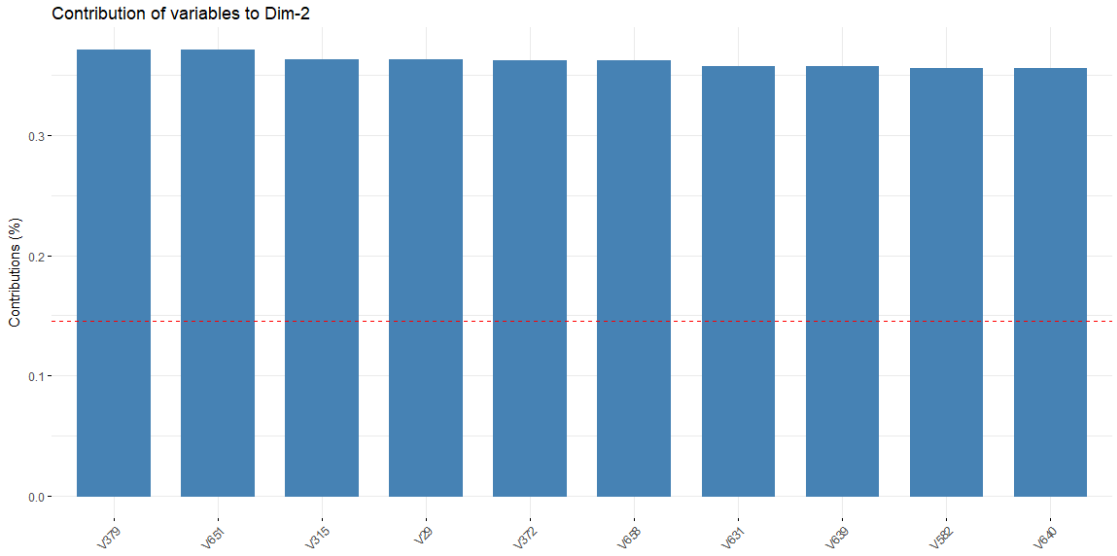
```
# Let see the contribution of each variable to each PC
kable(var$contrib[1:5,1:5])
```

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
V1	0.0749	0.0191	0.3816	0.5422	0.3002
V2	0.0083	0.0709	0.6336	0.1418	0.3985
V3	0.0002	0.0001	0.7126	0.5036	0.4626
V4	0.0009	0.1161	0.4162	0.5054	0.3190
V5	0.0010	0.2515	0.2117	0.2355	0.1119

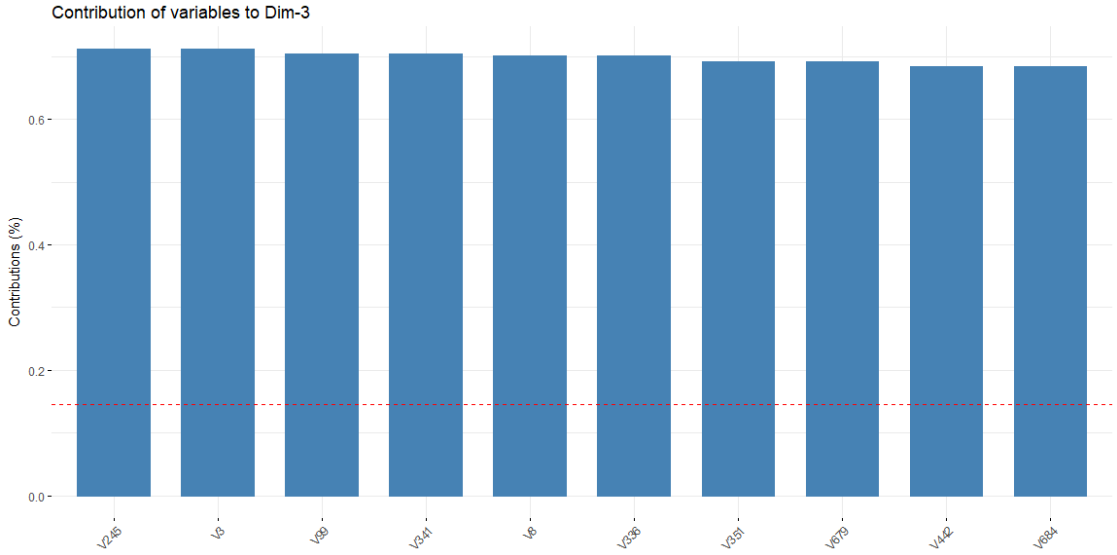
```
# Contributions of variables to PC1
fviz_contrib(pc.train, choice = "var", axes = 1, top = 10)
```




```
# Contributions of variables to PC2
fviz_contrib(pc.train, choice = "var", axes = 2, top = 10)
```




```
# Contributions of variables to PC3
fviz_contrib(pc.train, choice = "var", axes = 3, top = 10)
```




```
# Extract the results for individuals
ind <- get_pca_ind(pc.train)

# Let's use the first 60 variables for the model
xx.pc.train <- as.matrix(ind$coord[,1:60])
```

Now let's do clustering with K-means

```
min_k <- 2
max_k <- 4
min_seed <- 1
max_seed <- 100
method <- "euclidean"

# Find Best Seed and K Using the PCA Data on training
```

```r
file.name  <- paste(work.dir, "best_seeds_std_pca.Rds", sep="/")
file.name.et  <- paste(work.dir, "best_seeds_std_pca-et.Rds", sep="/")

if (file.exists(file.name)) {
  load(file.name,.GlobalEnv)
  load(file.name.et,.GlobalEnv)
} else {

  t1 <- proc.time()

  best_seeds_std_pca <- find_best_seedv2(xx.pc.train,
                                         method,
                                         min_seed,
                                         max_seed,
                                         min_k,
                                         max_k,
                                         train.Y.all)
  t2 <- proc.time()
  et <- elapsed_time(t1,t2)
  print(paste0("Best Seed for Kmeans PCA Finded ... time:",et))
  save(best_seeds_std_pca, file = file.name)
  save(et, file = file.name.et)
}
```

```
## [1] "Results for k=2"
## [1] "======================"
## [1] "Best Seed find: k=2 seed=1 errors=133 sum(whithinss)=137748.691430189"
## [1] "Best Seed find: k=2 seed=2 errors=133 sum(whithinss)=137632.951426919"
## [1] "Best Seed find: k=2 seed=5 errors=133 sum(whithinss)=137620.838844682"
## [1] ""
## [1] "Results for k=3"
## [1] "======================"
## [1] "Best Seed find: k=3 seed=1 errors=146 sum(whithinss)=99177.1254186074"
## [1] ""
## [1] "Results for k=4"
## [1] "======================"
## [1] "Best Seed find: k=4 seed=1 errors=180 sum(whithinss)=84096.8566379237"
## [1] "Best Seed find: k=4 seed=4 errors=178 sum(whithinss)=84082.2855437066"
## [1] "Best Seed find: k=4 seed=22 errors=177 sum(whithinss)=85422.2307733355"
## [1] "Best Seed find: k=4 seed=26 errors=175 sum(whithinss)=84303.4687395225"
## [1] "Best Seed find: k=4 seed=29 errors=170 sum(whithinss)=84410.0557223992"
## [1] ""
## [1] ""
## [1] "Final Results"
## [1] "=============="
## [1] "Best Seed find: k=2 seed=5 errors=133 sum(whithinss)=137620.838844682"
## [1] "Best Seed for Kmeans PCA Finded ... time:21"
```

```r
(k <- best_seeds_std_pca$best_k)
```

```
## [1] 2
```

```r
(best_seed <- best_seeds_std_pca$best_seed)
```

```
## [1] 5
```

```
res.train.kmeans_pca <- confusionMatrix(best_seeds_std_pca$best_km$cluster,
train.Y.all)
res.train.kmeans_pca
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2
##          1 78 78
##          2 55 55
##
##                Accuracy : 0.5
##                  95% CI : (0.438, 0.562)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 0.5244
##
##                   Kappa : 0
##  Mcnemar's Test P-Value : 0.0564
##
##             Sensitivity : 0.586
##             Specificity : 0.414
##          Pos Pred Value : 0.500
##          Neg Pred Value : 0.500
##              Prevalence : 0.500
##          Detection Rate : 0.293
##    Detection Prevalence : 0.586
##       Balanced Accuracy : 0.500
##
##        'Positive' Class : 1
##
```

```
# Let's see the Complete Classification/Missclassification Considering the Type the
next
# function will calculate that

plot_results_by_type <- function(predict, real.class, main) {

  new.set <- data.frame(predict)
  new.set$classification <- new.set == real.class
  # Type = 1 ImgSrc (Clean), Type =2 Stegoa, Type =3 Stegob
  new.set$type <- ifelse(grepl("-Src",row.names(new.set)),1,
                         ifelse(grepl("-Stegoa",row.names(new.set)),2,3))
  new.set$factorC <- with(new.set,
                          interaction(factor(classification),  factor(type)))
  plot(new.set$factorC, main = main, col = c(1,1,2,2,3,3))
}
```

Let's do PCA on the test set and create the cluster with the k and best_seed:

```
pc.test <- prcomp(as.matrix(test.X.all.std), scale = TRUE, center = TRUE)

# Eigenvalues

eig.val <- get_eig(pc.test)
```

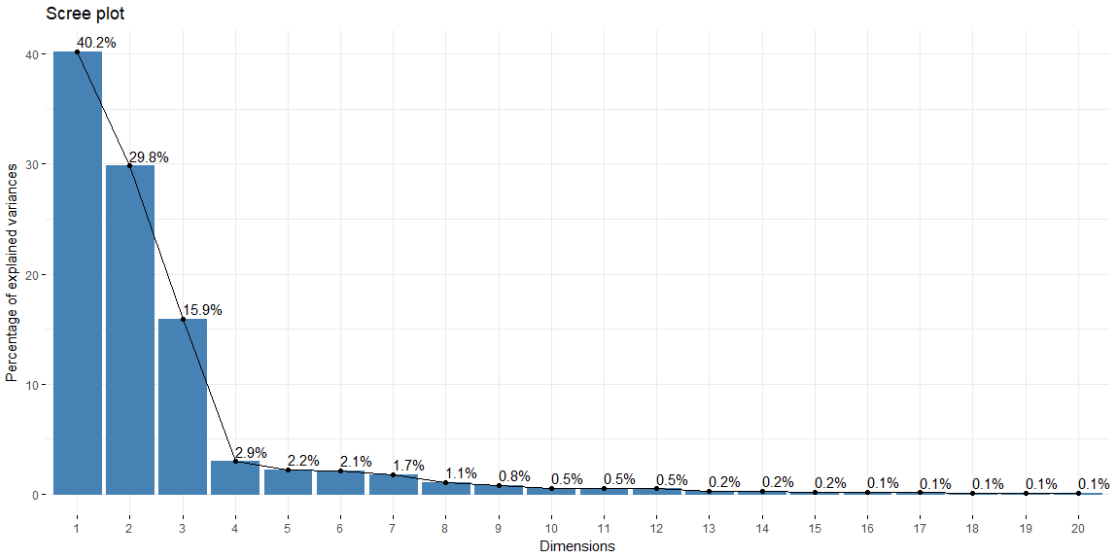
```
# Let's see the first 60
kable(eig.val[1:60,])
```

	eigenvalue	variance.percent	cumulative.variance.percent
Dim.1	275.7018	40.1898	40.19
Dim.2	204.6533	29.8328	70.02
Dim.3	109.0694	15.8993	85.92
Dim.4	20.1928	2.9436	88.87
Dim.5	14.9430	2.1783	91.04
Dim.6	14.3148	2.0867	93.13
Dim.7	11.7427	1.7118	94.84
Dim.8	7.3320	1.0688	95.91
Dim.9	5.4682	0.7971	96.71
Dim.10	3.5467	0.5170	97.23
Dim.11	3.4505	0.5030	97.73
Dim.12	3.1726	0.4625	98.19
Dim.13	1.5885	0.2316	98.42
Dim.14	1.4115	0.2058	98.63
Dim.15	1.2266	0.1788	98.81
Dim.16	1.0035	0.1463	98.95
Dim.17	0.7527	0.1097	99.06
Dim.18	0.6638	0.0968	99.16
Dim.19	0.5826	0.0849	99.24
Dim.20	0.5450	0.0794	99.32
Dim.21	0.4685	0.0683	99.39
Dim.22	0.4505	0.0657	99.46
Dim.23	0.3618	0.0527	99.51

Dim.24	0.3122	0.0455	99.56
Dim.25	0.2660	0.0388	99.59
Dim.26	0.2512	0.0366	99.63
Dim.27	0.2243	0.0327	99.66
Dim.28	0.1816	0.0265	99.69
Dim.29	0.1566	0.0228	99.71
Dim.30	0.1418	0.0207	99.73
Dim.31	0.1263	0.0184	99.75
Dim.32	0.1243	0.0181	99.77
Dim.33	0.1189	0.0173	99.79
Dim.34	0.1106	0.0161	99.80
Dim.35	0.1024	0.0149	99.82
Dim.36	0.0921	0.0134	99.83
Dim.37	0.0838	0.0122	99.84
Dim.38	0.0808	0.0118	99.86
Dim.39	0.0675	0.0098	99.87
Dim.40	0.0658	0.0096	99.88
Dim.41	0.0591	0.0086	99.88
Dim.42	0.0577	0.0084	99.89
Dim.43	0.0561	0.0082	99.90
Dim.44	0.0527	0.0077	99.91
Dim.4	0.0517	0.0075	99.92

5			
Dim.46	0.0467	0.0068	99.92
Dim.47	0.0422	0.0062	99.93
Dim.48	0.0393	0.0057	99.94
Dim.49	0.0375	0.0055	99.94
Dim.50	0.0337	0.0049	99.95
Dim.51	0.0324	0.0047	99.95
Dim.52	0.0303	0.0044	99.95
Dim.53	0.0291	0.0042	99.96
Dim.54	0.0282	0.0041	99.96
Dim.55	0.0269	0.0039	99.97
Dim.56	0.0258	0.0038	99.97
Dim.57	0.0240	0.0035	99.97
Dim.58	0.0225	0.0033	99.98
Dim.59	0.0218	0.0032	99.98
Dim.60	0.0207	0.0030	99.98

```
fviz_screeplot(pc.test, addlabels = TRUE, ncp=20)
```




```
# Extract the results for variables
var <- get_pca_var(pc.test)

kable(print(var))

## Principal Component Analysis Results for variables
##  ===================================================
##   Name       Description
## 1 "$coord"   "Coordinates for the variables"
## 2 "$cor"     "Correlations between variables and dimensions"
## 3 "$cos2"    "Cos2 for the variables"
## 4 "$contrib" "contributions of the variables"
```

Name	Description
$coord	Coordinates for the variables
$cor	Correlations between variables and dimensions
$cos2	Cos2 for the variables
$contrib	contributions of the variables

```
# Let see the model generated (first five dimension and 10 variables)
kable(var$coord[1:5,1:5])
```

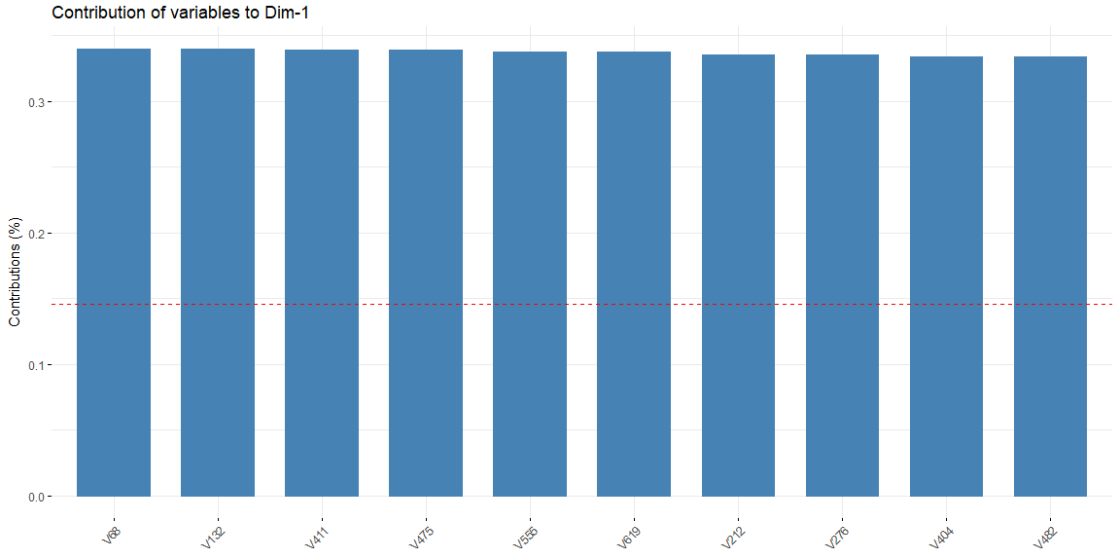
	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
V1	-0.1206	0.5327	-0.6067	0.2255	-0.2551
V2	0.2195	0.4650	-0.7552	0.1074	-0.1802
V3	0.0035	0.0935	-0.8616	-0.1116	-0.3631
V4	-0.3809	-0.2964	-0.6124	-0.2503	-0.4682

V5	-0.5762	-0.4714	-0.4488	-0.2132	-0.2915

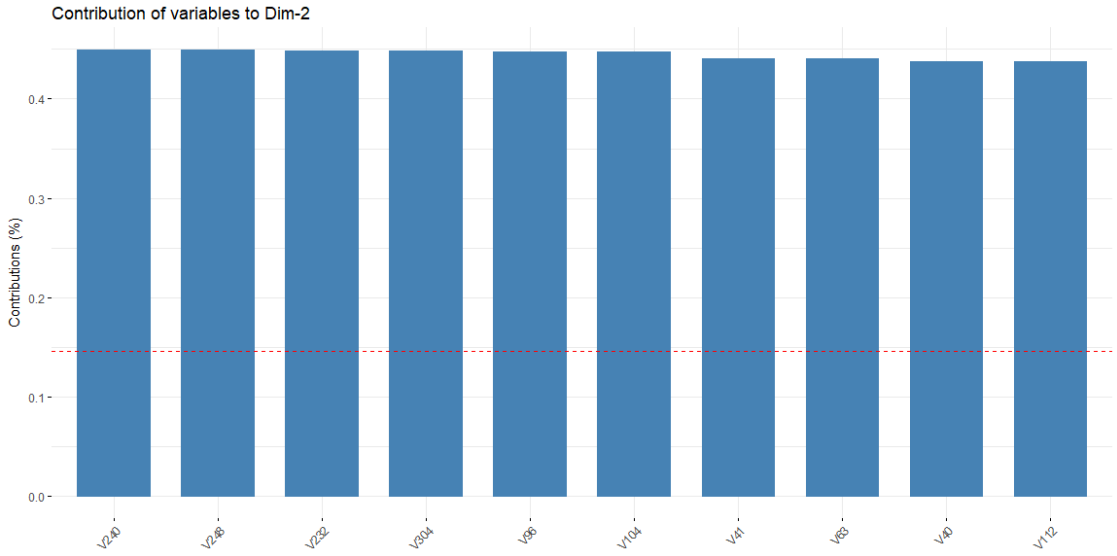
```
# Let see the contribution of each variable to each PC
kable(var$contrib[1:5,1:5])
```

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
V1	0.0053	0.1387	0.3374	0.2519	0.4356
V2	0.0175	0.1056	0.5228	0.0571	0.2172
V3	0.0000	0.0043	0.6807	0.0616	0.8823
V4	0.0526	0.0429	0.3438	0.3103	1.4670
V5	0.1204	0.1086	0.1847	0.2250	0.5686

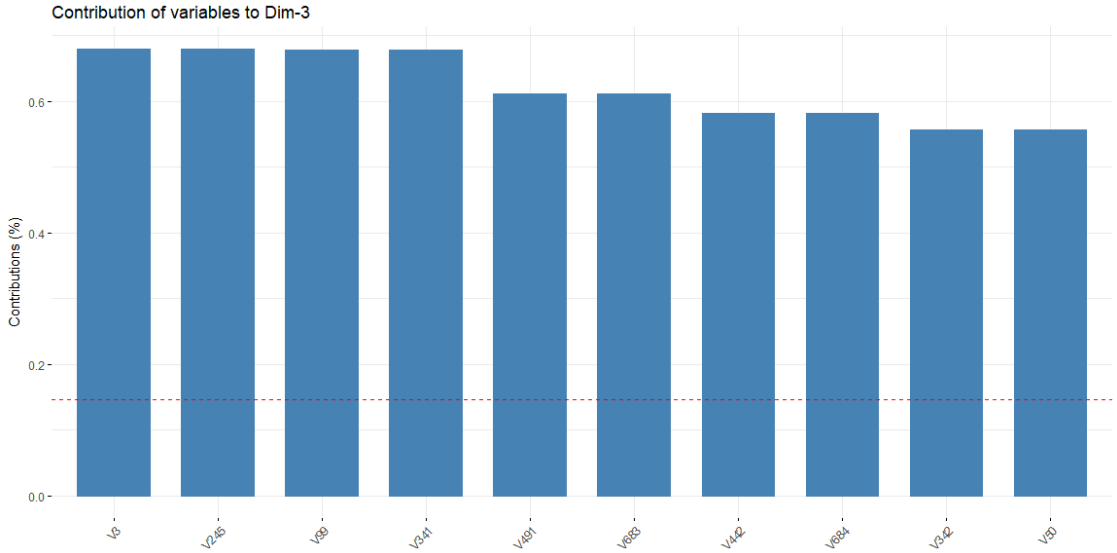
```
# Contributions of variables to PC1
fviz_contrib(pc.test, choice = "var", axes = 1, top = 10)
```




```
# Contributions of variables to PC2
fviz_contrib(pc.test, choice = "var", axes = 2, top = 10)
```




```
# Contributions of variables to PC3
fviz_contrib(pc.test, choice = "var", axes = 3, top = 10)
```



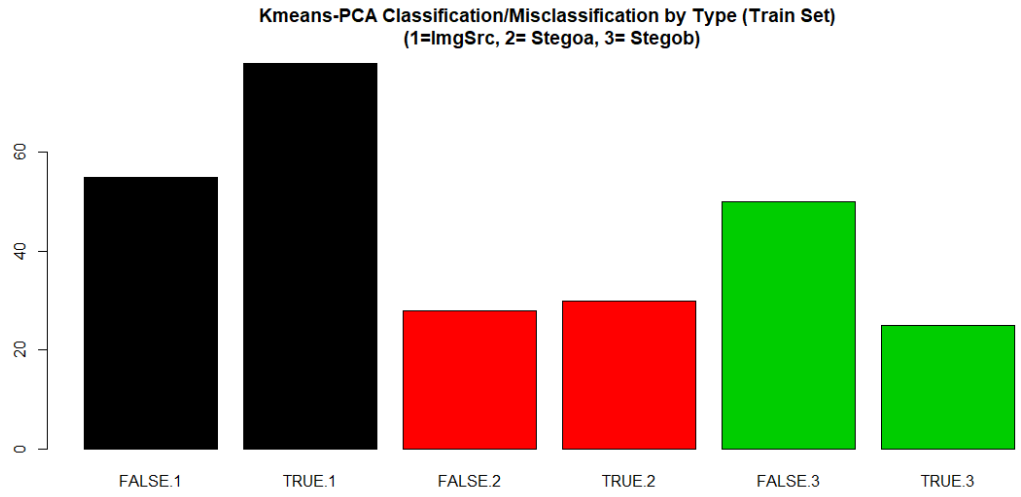

```
# Extract the results for individuals
ind <- get_pca_ind(pc.test)

# Let's use the first 60 variables for the model
xx.pc.test <- as.matrix(ind$coord[,1:60])
```

Let's check the K-means output

```
xx.km <- eclust(xx.pc.test,k=k,hc_method=method, nstart=10, graph = FALSE, seed =
best_seed)
kmeans_class_pca <- correct_kmeans_ids(test.Y.all,xx.km$cluster)

res.test.kmeans_pca <- confusionMatrix(kmeans_class_pca, test.Y.all)
res.test.kmeans_pca
```

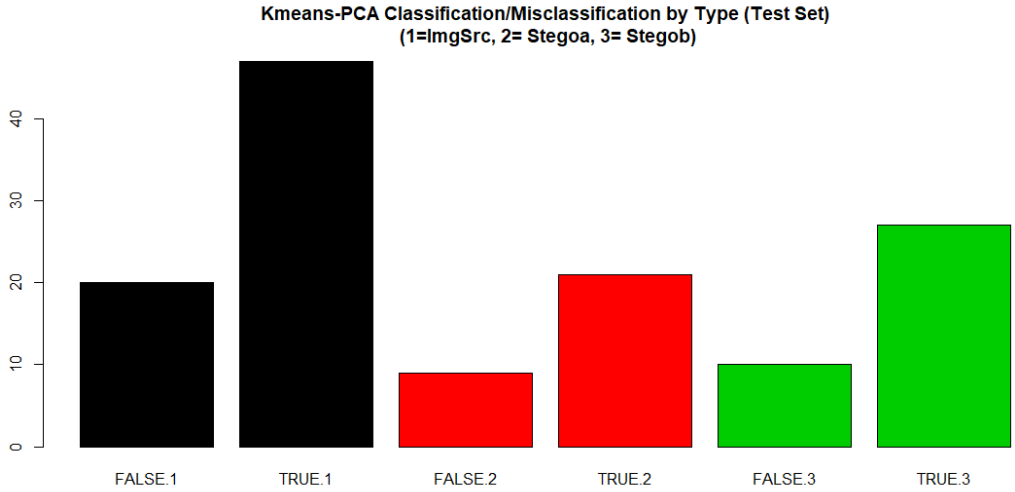
```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2
##          1 47 47
##          2 20 20
##
##                Accuracy : 0.5
##                  95% CI : (0.412, 0.588)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 0.53440
##
##                   Kappa : 0
##  Mcnemar's Test P-Value : 0.00149
##
##             Sensitivity : 0.701
##             Specificity : 0.299
##          Pos Pred Value : 0.500
##          Neg Pred Value : 0.500
##              Prevalence : 0.500
##          Detection Rate : 0.351
##    Detection Prevalence : 0.701
##       Balanced Accuracy : 0.500
##
##        'Positive' Class : 1
##
```

```
main <- paste0("Kmeans-PCA Classification/Misclassification by Type (Train Set) \n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")

plot_results_by_type(best_seeds_std_pca$best_km$cluster,
                     train.Y.all,
                     main)
```

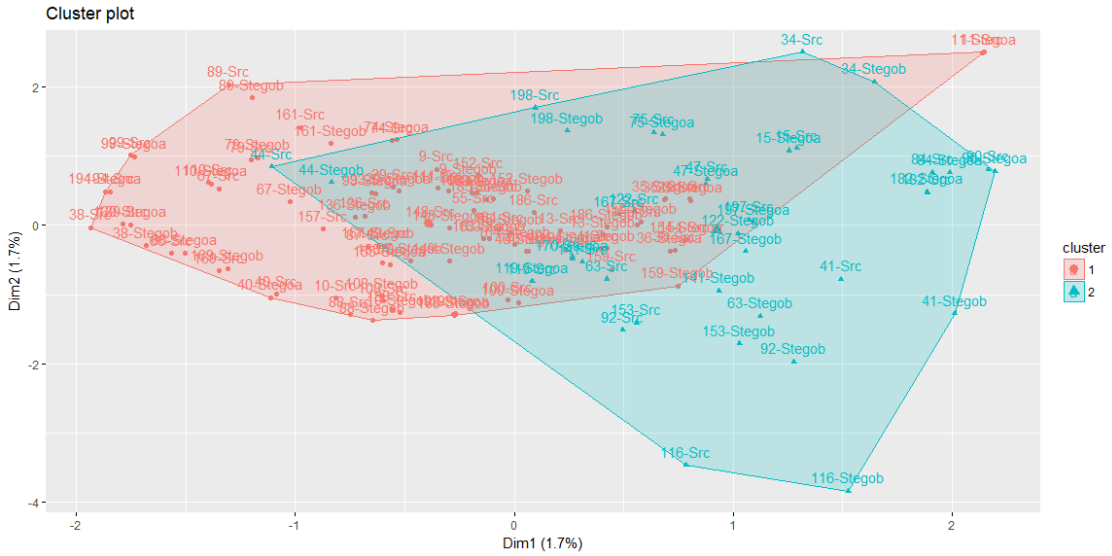



```
main <- paste0("Kmeans-PCA Classification/Misclassification by Type (Test Set)\n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")
```

```
plot_results_by_type(xx.km$cluster,
                     train.Y.all,
                     main)
```

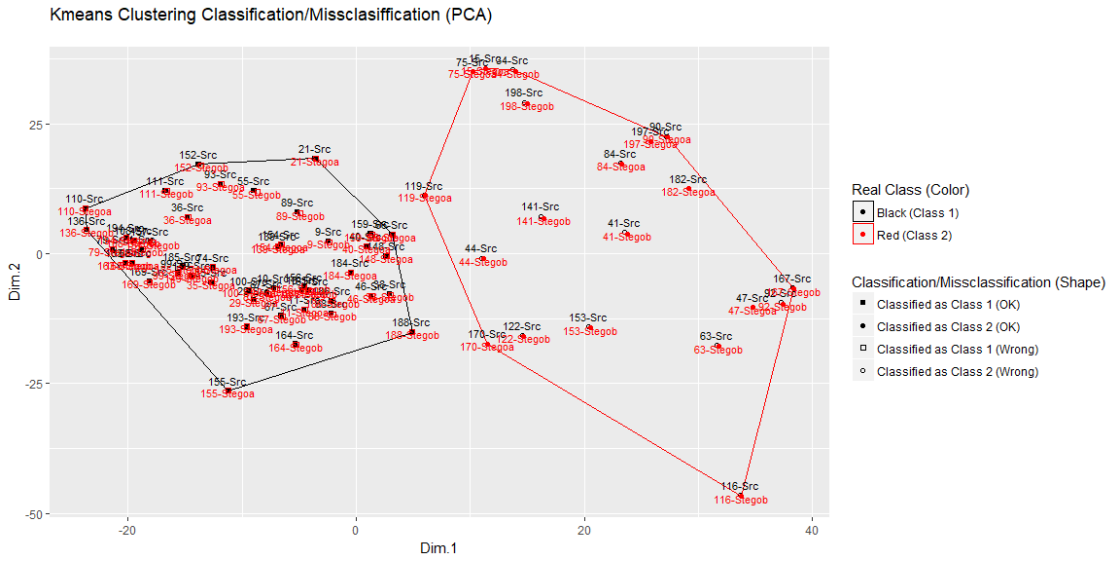



```
# RMSE
(rmse_kmeans_pca <- sqrt(mean((as.numeric(kmeans_class_pca)-
as.numeric(test.Y.all))^2)))

## [1] 0.7071

# Store the Values for Report
results_all <- data.frame("Method"= "Kmeans Clustering PCA",
                          "Prediction Accuracy in Training Set" =
res.train.kmeans_pca$overall[1] ,
                          "Prediction Accuracy in Test Set" =
res.test.kmeans_pca$overall[1],
                          "RMSE Test"= rmse_kmeans_pca,
                          "Time Elapsed" = et,
                          stringsAsFactors = FALSE)

fviz_cluster(xx.km)
```

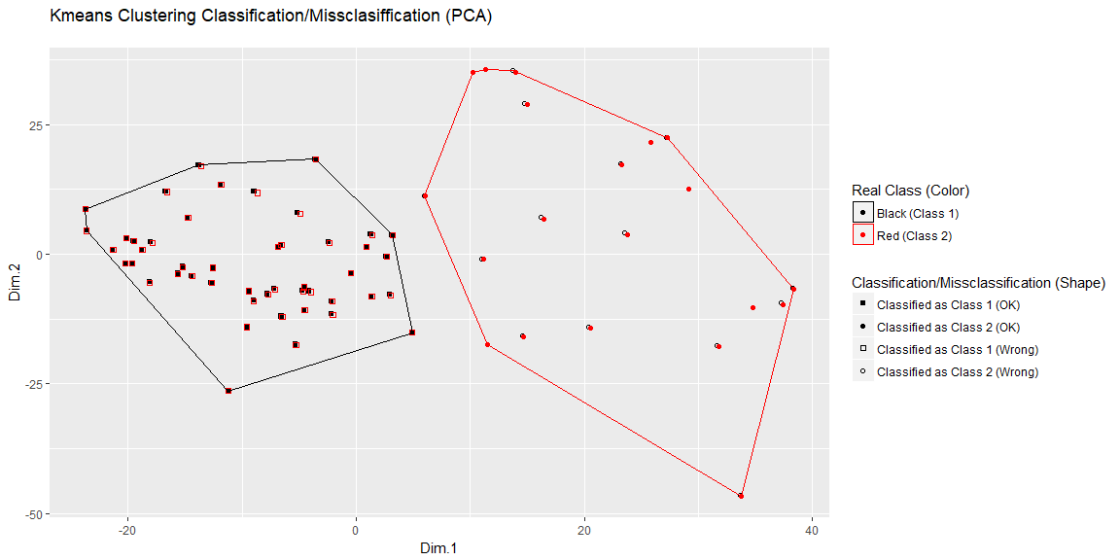



```
#This function will be used to plot the results

plot_results <- function(X.data, Y.data, Y.predict, title, var1 = NULL, var2 = NULL,
labels = TRUE) {

  res <- data.frame(X.data)
  res$class <- Y.data
  res$ID <- row.names(res)
  res$predict_class <- Y.predict
  res$classification_ok <- (res$class == res$predict_class)
  res$stego <- grepl("-Stego",res$ID)

  if (is.null(var1)) {
    var1 <- colnames(res)[1]
  }

  if (is.null(var2)) {
    var2 <- colnames(res)[2]
  }

  g <- ggplot(res,
         aes(res[[var1]], res[[var2]],
             shape = as.factor(
               ifelse(res$classification_ok, res$class,
                      as.numeric(res$predict_class) + 2 )))) +
    scale_color_manual(values = c(1,2),
                       name ="Real Class (Color)",
                       labels =c("Black (Class 1)","Red (Class 2)")) +
    scale_shape_manual(values=c(15,16,0,1),
                       name ="Classification/Missclassification (Shape)",
                       labels=c("Classified as Class 1 (OK)", "Classified as Class 2
(OK)",
                                "Classified as Class 1 (Wrong)","Classified as Class
2 (Wrong)")) +
    geom_point() +
```

```
    aes(color = as.factor(res$class)) +

    labs(title = title) + xlab(var1) + ylab(var2) +

    stat_chull(aes(group = as.factor(res$predict_class),
                   color = as.factor(res$predict_class)),
               geom = "polygon", fill = NA)

  if (labels) {
    # Add the labels to the graph
    g <- g + geom_text(aes(label = res$ID),
                       size = 3,
                       vjust = ifelse(res$stego, 0.7,-0.7),
                       color = res$class)
  }
  g
}

# Let's find some good variables to plot
vars <- find_unique_variables(xx.pc.test)

plot_results(xx.pc.test, test.Y.all, kmeans_class_pca,
             paste0("Kmeans Clustering Classification/Missclasiffication (PCA)\n"),
             "Dim.1","Dim.2", labels = TRUE)
```




```
plot_results(xx.pc.test, test.Y.all, kmeans_class_pca,
             paste0("Kmeans Clustering Classification/Missclasiffication (PCA)\n"),
             "Dim.1","Dim.2", labels = FALSE)
```

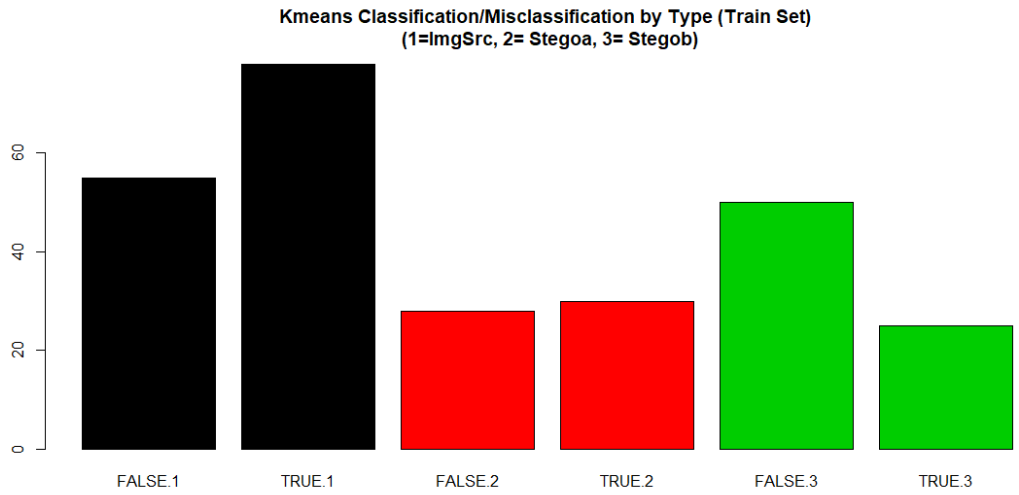


7.5.6.1 All Data Whithout PCA

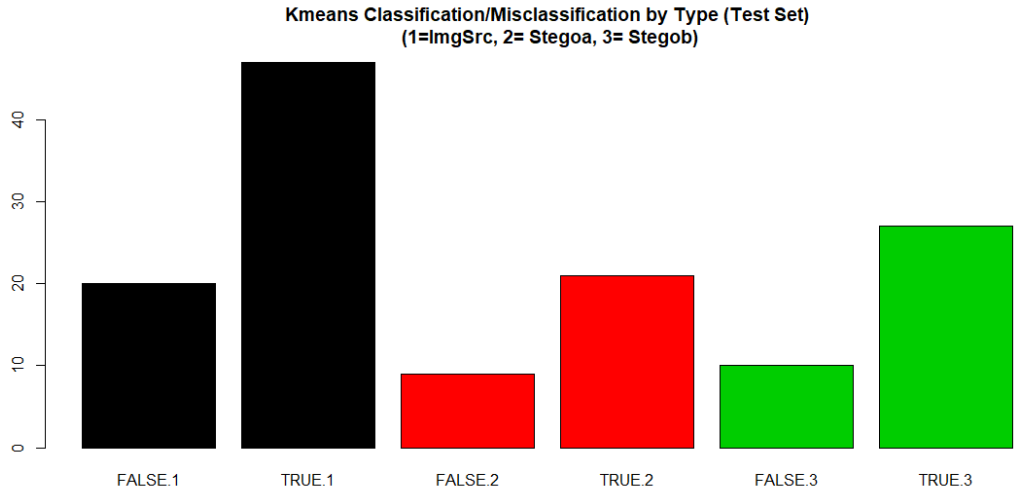
```
#### 7.5.6.1 All Data Whithout PCA
min_k <- 2
max_k <- 4
min_seed <- 1
max_seed <- 100
method <- "euclidean"

# Find Best Seed and K and Kmeans for the all Std Data
file.name  <- paste(work.dir, "best_seeds_std_m.Rds", sep="/")
file.name.et  <- paste(work.dir, "best_seeds_std_m-et.Rds", sep="/")

if (file.exists(file.name)) {
  load(file.name,.GlobalEnv)
  load(file.name.et,.GlobalEnv)
} else {
  t1 <- proc.time()
  best_seeds_std_m <- find_best_seedv2(train.X.all.std,
                                       method,
                                       min_seed,
                                       max_seed,
                                       min_k,
                                       max_k,
                                       train.Y.all)
  t2 <- proc.time()
  et <- elapsed_time(t1,t2)
  print(paste0("Best Seed for Kmeans Finded ... time:", et))
  save(best_seeds_std_m, file = file.name)
  save(et, file = file.name.et)
}

## [1] "Results for k=2"
## [1] "======================"
## [1] "Best Seed find: k=2 seed=1 errors=133 sum(whithinss)=138049.217786475"
## [1] "Best Seed find: k=2 seed=2 errors=133 sum(whithinss)=137933.517214132"
## [1] "Best Seed find: k=2 seed=5 errors=133 sum(whithinss)=137921.347041104"
```

```
## [1] ""
## [1] "Results for k=3"
## [1] "======================"
## [1] "Best Seed find: k=3 seed=1 errors=146 sum(whithinss)=99477.3966720622"
## [1] ""
## [1] "Results for k=4"
## [1] "======================"
## [1] "Best Seed find: k=4 seed=1 errors=180 sum(whithinss)=84396.1932425245"
## [1] "Best Seed find: k=4 seed=4 errors=178 sum(whithinss)=84381.9150457813"
## [1] "Best Seed find: k=4 seed=22 errors=177 sum(whithinss)=85721.490818753"
## [1] "Best Seed find: k=4 seed=26 errors=175 sum(whithinss)=84602.0685874486"
## [1] "Best Seed find: k=4 seed=29 errors=170 sum(whithinss)=84709.0117149969"
## [1] ""
## [1] ""
## [1] "Final Results"
## [1] "=============="
## [1] "Best Seed find: k=2 seed=5 errors=133 sum(whithinss)=137921.347041104"
## [1] "Best Seed for Kmeans Finded ... time:201"

(k <- best_seeds_std_m$best_k)

## [1] 2

(best_seed <- best_seeds_std_m$best_seed)

## [1] 5

res.train.kmeans <- confusionMatrix(best_seeds_std_m$best_km$cluster, train.Y.all)
res.train.kmeans

## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2
##          1 78 78
##          2 55 55
##
##                Accuracy : 0.5
##                  95% CI : (0.438, 0.562)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 0.5244
##
##                   Kappa : 0
##  Mcnemar's Test P-Value : 0.0564
##
##             Sensitivity : 0.586
##             Specificity : 0.414
##          Pos Pred Value : 0.500
##          Neg Pred Value : 0.500
##              Prevalence : 0.500
##          Detection Rate : 0.293
##    Detection Prevalence : 0.586
##       Balanced Accuracy : 0.500
##
##        'Positive' Class : 1
##
```

```r
# Use the k and best seeds in the test set

xx.km2 <- eclust(test.X.all.std,k=k,hc_method=method, nstart=10, graph = FALSE, seed
= best_seed)

kmeans_class <- correct_kmeans_ids(test.Y.all,xx.km2$cluster)

res.test.kmeans <- confusionMatrix(kmeans_class, test.Y.all)
res.test.kmeans

## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2
##          1 47 47
##          2 20 20
##
##                Accuracy : 0.5
##                  95% CI : (0.412, 0.588)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 0.53440
##
##                   Kappa : 0
##  Mcnemar's Test P-Value : 0.00149
##
##             Sensitivity : 0.701
##             Specificity : 0.299
##          Pos Pred Value : 0.500
##          Neg Pred Value : 0.500
##              Prevalence : 0.500
##          Detection Rate : 0.351
##    Detection Prevalence : 0.701
##       Balanced Accuracy : 0.500
##
##        'Positive' Class : 1
##

main <- paste0("Kmeans Classification/Misclassification by Type (Train Set) \n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")

plot_results_by_type(best_seeds_std_m$best_km$cluster,
                     train.Y.all,
                     main)
```




```
main <- paste0("Kmeans Classification/Misclassification by Type (Test Set)\n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")

plot_results_by_type(xx.km2$cluster,
                     train.Y.all,
                     main)
```

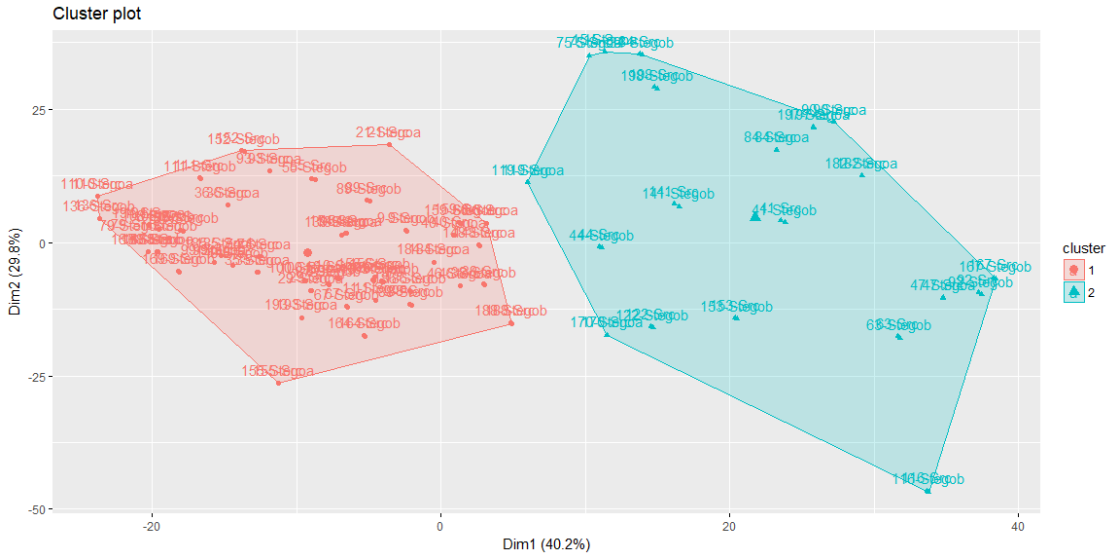



```
# RMSE
(rmse_kmeans <- sqrt(mean((as.numeric(kmeans_class)-as.numeric(test.Y.all))^2)))

## [1] 0.7071

# Store the Values for Report
results_all <- rbind(results_all,
                     data.frame("Method"= "Kmeans Clustering",
                                "Prediction Accuracy in Training Set" =
res.train.kmeans$overall[1] ,
                                "Prediction Accuracy in Test Set" =
```

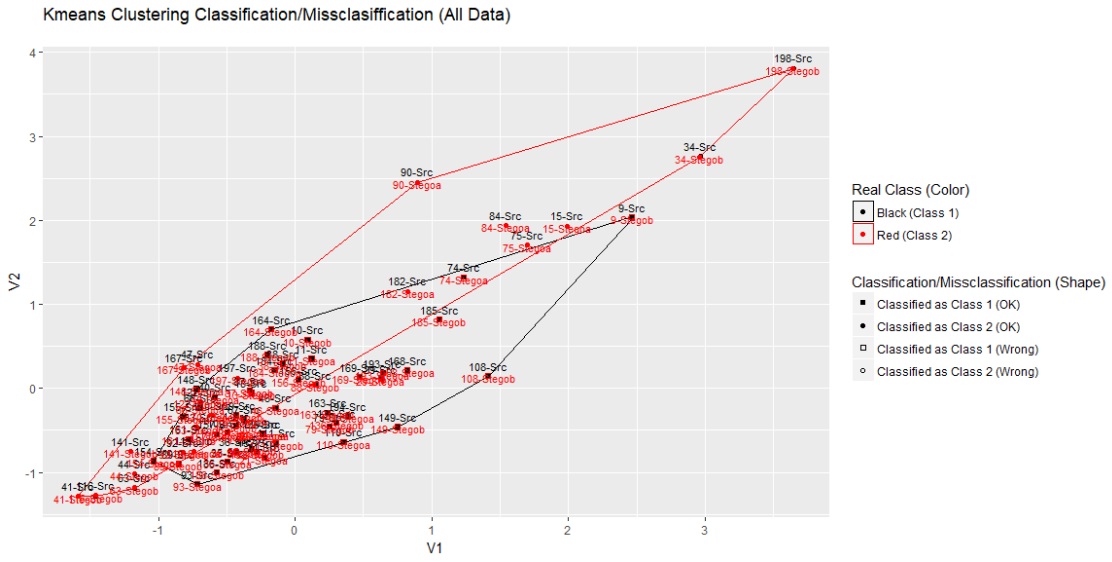
```
res.test.kmeans$overall[1],
                                "RMSE Test"= rmse_kmeans,
                                "Time Elapsed" = et,
                                stringsAsFactors = FALSE))
```

Let's see the results

```
fviz_cluster(xx.km2)
```

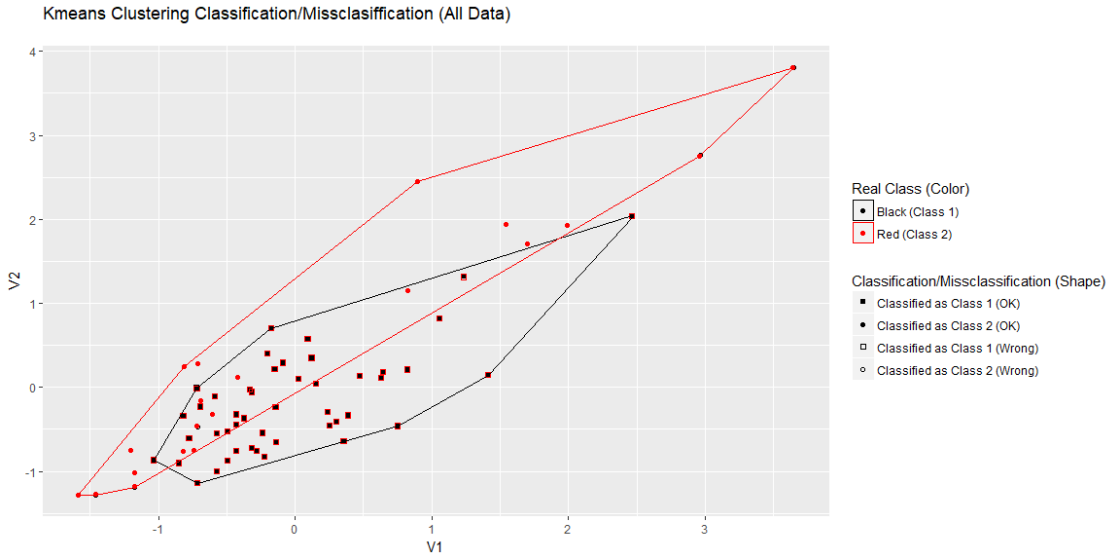



```
vars <- find_unique_variables(test.X.all.std)

plot_results(test.X.all.std, test.Y.all, kmeans_class,
             paste0("Kmeans Clustering Classification/Missclasiffication (All
Data)\n"),
             "V1","V2", labels = TRUE)
```




```
plot_results(test.X.all.std, test.Y.all, kmeans_class,
             paste0("Kmeans Clustering Classification/Missclasiffication (All
```

```
Data)\n"),
             "V1","V2", labels = FALSE)
```



7.5.7 Classification Using Support Vector Machine (SVM)

According with the paper the best results was obtained using the following parameters:

- Gaussian Kernel (RBF)
- Penalization Parameter (C) = {0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000}
- Kernel Parameter (sigma) = 2^(-d - 3, ..., -d +3) where d = log2 (number of features)

7.5.7.1 SVM Radial (Gaussian Kernel)

```
### 7.5.7 Classification Using Support Vector Machine (SVM)
### 7.5.7.1 SVM Radial (Gaussian Kernel)
(d <- log2(686))

## [1] 9.422

(sigma_values <- 2^(c(-d-3, -d-2, -d-1, -d, -d + 1, -d +2, -d+3)))

## [1] 0.0001822 0.0003644 0.0007289 0.0014577 0.0029155 0.0058309 0.0116618

(c_values <- c(0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000))

## [1] 1e-03 1e-02 1e-01 1e+00 1e+01 1e+02 1e+03 1e+04

kernel_method_type <- "svmRadial"
# Grid Parameters
(grid_radial <- expand.grid(C = c_values, sigma = sigma_values))

##        C     sigma
## 1  1e-03 0.0001822
## 2  1e-02 0.0001822
## 3  1e-01 0.0001822
## 4  1e+00 0.0001822
## 5  1e+01 0.0001822
```

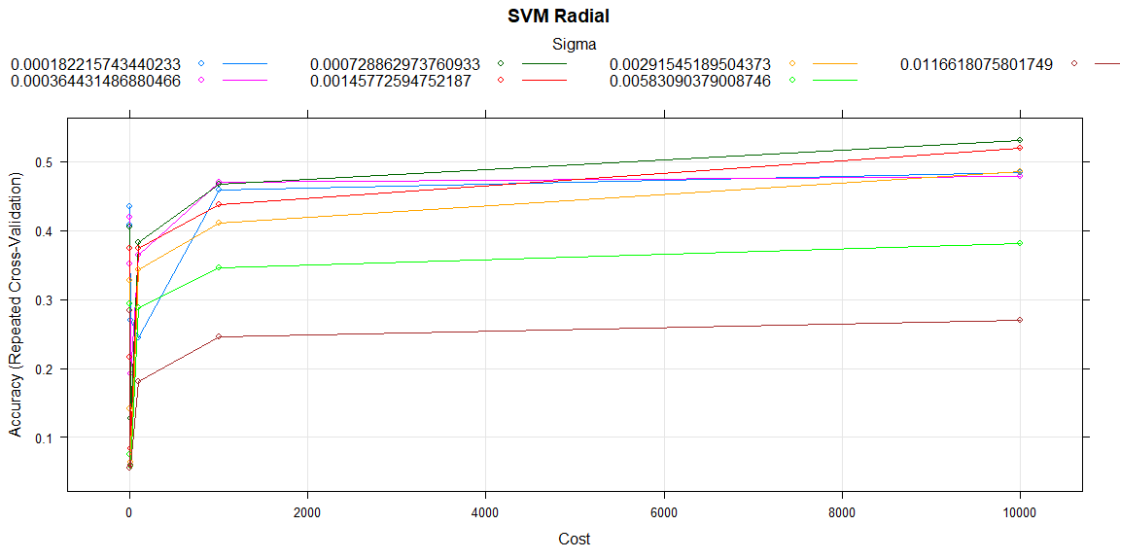
```
## 6  1e+02 0.0001822
## 7  1e+03 0.0001822
## 8  1e+04 0.0001822
## 9  1e-03 0.0003644
## 10 1e-02 0.0003644
## 11 1e-01 0.0003644
## 12 1e+00 0.0003644
## 13 1e+01 0.0003644
## 14 1e+02 0.0003644
## 15 1e+03 0.0003644
## 16 1e+04 0.0003644
## 17 1e-03 0.0007289
## 18 1e-02 0.0007289
## 19 1e-01 0.0007289
## 20 1e+00 0.0007289
## 21 1e+01 0.0007289
## 22 1e+02 0.0007289
## 23 1e+03 0.0007289
## 24 1e+04 0.0007289
## 25 1e-03 0.0014577
## 26 1e-02 0.0014577
## 27 1e-01 0.0014577
## 28 1e+00 0.0014577
## 29 1e+01 0.0014577
## 30 1e+02 0.0014577
## 31 1e+03 0.0014577
## 32 1e+04 0.0014577
## 33 1e-03 0.0029155
## 34 1e-02 0.0029155
## 35 1e-01 0.0029155
## 36 1e+00 0.0029155
## 37 1e+01 0.0029155
## 38 1e+02 0.0029155
## 39 1e+03 0.0029155
## 40 1e+04 0.0029155
## 41 1e-03 0.0058309
## 42 1e-02 0.0058309
## 43 1e-01 0.0058309
## 44 1e+00 0.0058309
## 45 1e+01 0.0058309
## 46 1e+02 0.0058309
## 47 1e+03 0.0058309
## 48 1e+04 0.0058309
## 49 1e-03 0.0116618
## 50 1e-02 0.0116618
## 51 1e-01 0.0116618
## 52 1e+00 0.0116618
## 53 1e+01 0.0116618
## 54 1e+02 0.0116618
## 55 1e+03 0.0116618
## 56 1e+04 0.0116618

# Cross Validation Parameters
trctrl <- trainControl(method = "repeatedcv",
                       number = 10,
```

```
                       repeats = 3)


file.name  <- paste(work.dir, "svm_radial.Rds", sep="/")
file.name.et  <- paste(work.dir, "svm_radial-et.Rds", sep="/")

if (file.exists(file.name)) {
  load(file.name,.GlobalEnv)
  load(file.name.et,.GlobalEnv)
} else {
  t1 <- proc.time()
  svm_Radial_Grid <- train(y = factor(train.Y.all),
                           x = train.X.all,
                           method = kernel_method_type,
                           trControl=trctrl,
                           preProcess = c("center", "scale"),
                           trace = FALSE,
                           tuneGrid = grid_radial)
  t2 <- proc.time()
  et <-  elapsed_time(t1,t2)
  print(paste0("SVM-Radial Executed ... time:",et))
  save(svm_Radial_Grid, file = file.name)
  save(et, file = file.name.et)
}
```

We can see the main results here:

```
# Let's see some details about the model
svm_Radial_Grid

## Support Vector Machines with Radial Basis Function Kernel
##
## 266 samples
## 686 predictors
##   2 classes: '1', '2'
##
## Pre-processing: centered (686), scaled (686)
## Resampling: Cross-Validated (10 fold, repeated 3 times)
## Summary of sample sizes: 240, 240, 240, 238, 239, 239, ...
## Resampling results across tuning parameters:
##
##   C      sigma      Accuracy  Kappa
##   1e-03  0.0001822  0.43527   -0.10971
##   1e-03  0.0003644  0.41879   -0.14267
##   1e-03  0.0007289  0.40587   -0.16850
##   1e-03  0.0014577  0.37419   -0.23187
##   1e-03  0.0029155  0.32831   -0.32363
##   1e-03  0.0058309  0.29369   -0.39286
##   1e-03  0.0116618  0.28353   -0.41319
##   1e-02  0.0001822  0.43527   -0.10971
##   1e-02  0.0003644  0.41879   -0.14267
##   1e-02  0.0007289  0.40587   -0.16850
##   1e-02  0.0014577  0.37419   -0.23187
##   1e-02  0.0029155  0.32831   -0.32363
##   1e-02  0.0058309  0.29369   -0.39286
```

```
##   1e-02  0.0116618  0.28353   -0.41319
##   1e-01  0.0001822  0.43527   -0.10971
##   1e-01  0.0003644  0.41879   -0.14267
##   1e-01  0.0007289  0.40587   -0.16850
##   1e-01  0.0014577  0.37419   -0.23187
##   1e-01  0.0029155  0.32831   -0.32363
##   1e-01  0.0058309  0.29369   -0.39286
##   1e-01  0.0116618  0.28353   -0.41319
##   1e+00  0.0001822  0.40811   -0.16733
##   1e+00  0.0003644  0.35202   -0.28585
##   1e+00  0.0007289  0.29324   -0.40741
##   1e+00  0.0014577  0.21559   -0.56179
##   1e+00  0.0029155  0.14137   -0.71175
##   1e+00  0.0058309  0.07508   -0.84710
##   1e+00  0.0116618  0.05513   -0.88691
##   1e+01  0.0001822  0.27040   -0.45452
##   1e+01  0.0003644  0.19299   -0.61025
##   1e+01  0.0007289  0.12779   -0.74026
##   1e+01  0.0014577  0.08382   -0.83047
##   1e+01  0.0029155  0.06382   -0.87084
##   1e+01  0.0058309  0.05884   -0.88063
##   1e+01  0.0116618  0.06012   -0.87776
##   1e+02  0.0001822  0.24452   -0.50781
##   1e+02  0.0003644  0.36434   -0.26862
##   1e+02  0.0007289  0.38224   -0.23276
##   1e+02  0.0014577  0.37483   -0.24784
##   1e+02  0.0029155  0.34372   -0.31046
##   1e+02  0.0058309  0.28831   -0.42139
##   1e+02  0.0116618  0.18036   -0.63695
##   1e+03  0.0001822  0.45902   -0.08077
##   1e+03  0.0003644  0.47018   -0.05799
##   1e+03  0.0007289  0.46766   -0.06339
##   1e+03  0.0014577  0.43751   -0.12300
##   1e+03  0.0029155  0.41101   -0.17674
##   1e+03  0.0058309  0.34596   -0.30654
##   1e+03  0.0116618  0.24538   -0.50797
##   1e+04  0.0001822  0.48390   -0.03082
##   1e+04  0.0003644  0.47869   -0.04214
##   1e+04  0.0007289  0.53017    0.05939
##   1e+04  0.0014577  0.52010    0.03891
##   1e+04  0.0029155  0.48509   -0.03108
##   1e+04  0.0058309  0.38123   -0.23641
##   1e+04  0.0116618  0.26930   -0.46094
##
## Accuracy was used to select the optimal model using the largest value.
## The final values used for the model were sigma = 0.0007289 and C = 10000.

plot(svm_Radial_Grid, main = "SVM Radial")
```

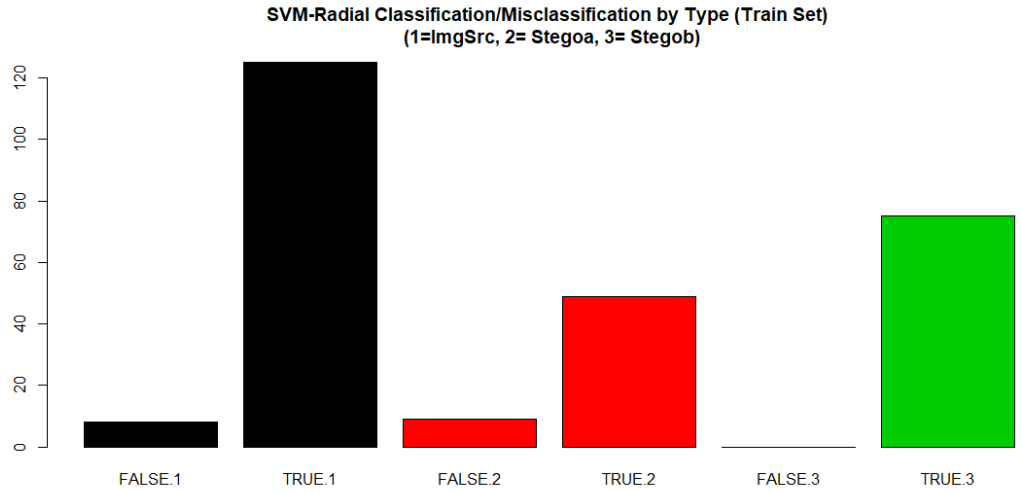



```
# Let's check the detail in the Training Set
res.svmradial.training <- confusionMatrix(svm_Radial_Grid$finalModel@fitted,
train.Y.all)
res.svmradial.training
```

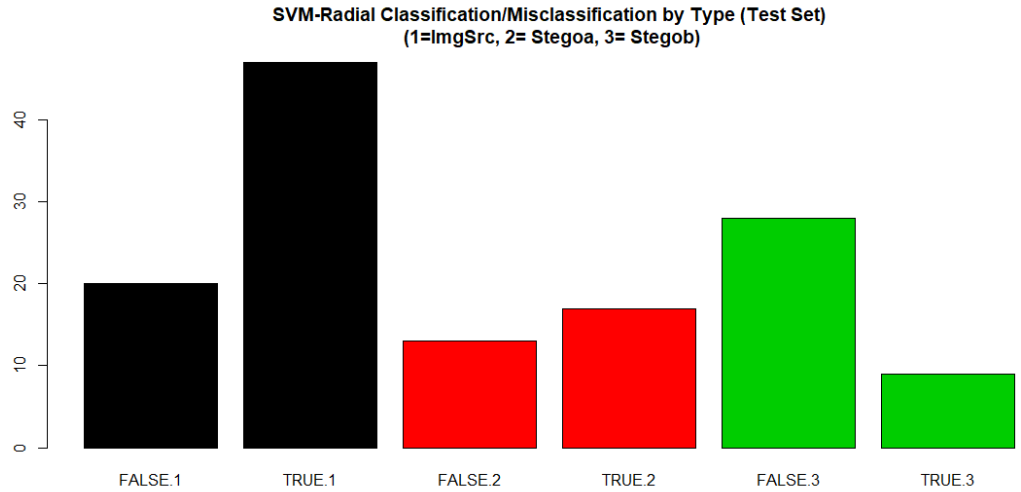
```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   1   2
##          1 125   9
##          2   8 124
##
##                Accuracy : 0.936
##                  95% CI : (0.9, 0.962)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : <2e-16
##
##                   Kappa : 0.872
##  Mcnemar's Test P-Value : 1
##
##             Sensitivity : 0.940
##             Specificity : 0.932
##          Pos Pred Value : 0.933
##          Neg Pred Value : 0.939
##              Prevalence : 0.500
##          Detection Rate : 0.470
##    Detection Prevalence : 0.504
##       Balanced Accuracy : 0.936
##
##        'Positive' Class : 1
##
```

```
# Let's use the model in test set
test_pred_rgrid <- predict(svm_Radial_Grid, newdata = test.X.all)
test_pred_rgrid
```

```
##   [1] 1 1 1 1 1 1 1 1 1 1 2 2 2 1 2 1 2 2 1 1 2 1 1 1 1 1 1 2 1 2 1 1 1
##  [36] 1 1 1 2 1 2 2 1 1 1 2 1 1 1 1 2 1 1 2 1 1 1 1 2 2 1 2 1 1 1 2 2 1 2 2
##  [71] 1 2 1 2 2 2 1 1 2 2 2 2 2 1 2 2 1 2 2 1 1 1 2 2 2 1 2 2 2 2 1 1 1 2 2
## [106] 2 2 2 2 1 2 1 2 1 1 1 2 2 2 1 2 2 1 2 1 2 2 1 2 2 1 1 2 2
## Levels: 1 2

res.svmradial <- confusionMatrix(test_pred_rgrid, test.Y.all)

res.svmradial

## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2
##          1 47 25
##          2 20 42
##
##                Accuracy : 0.664
##                  95% CI : (0.578, 0.743)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 9.01e-05
##
##                   Kappa : 0.328
##  Mcnemar's Test P-Value : 0.551
##
##             Sensitivity : 0.701
##             Specificity : 0.627
##          Pos Pred Value : 0.653
##          Neg Pred Value : 0.677
##              Prevalence : 0.500
##          Detection Rate : 0.351
##    Detection Prevalence : 0.537
##       Balanced Accuracy : 0.664
##
##        'Positive' Class : 1
##

main <- paste0("SVM-Radial Classification/Misclassification by Type (Train Set) \n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")
data_radial_train <- data.frame(svm_Radial_Grid$finalModel@fitted)
row.names(data_radial_train) <- row.names(train.X.all)

plot_results_by_type(data_radial_train,
                     train.Y.all,
                     main)
```

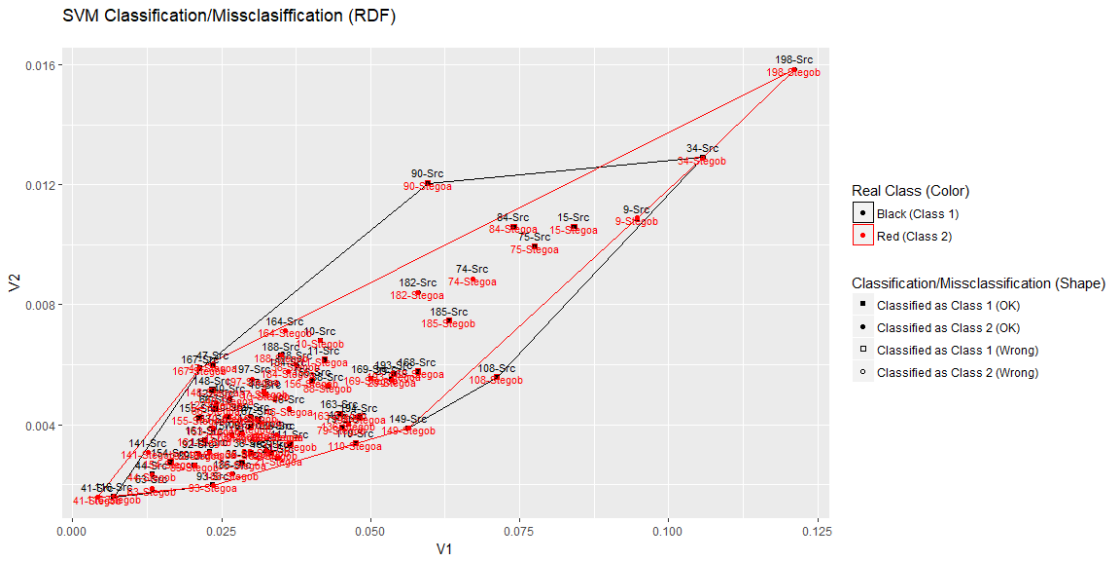



```
data_radial_test <- data.frame(test_pred_rgrid)
row.names(data_radial_test) <- row.names(test.X.all)


main <- paste0("SVM-Radial Classification/Misclassification by Type (Test Set)\n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")

plot_results_by_type(data_radial_test,
                     train.Y.all,
                     main)
```

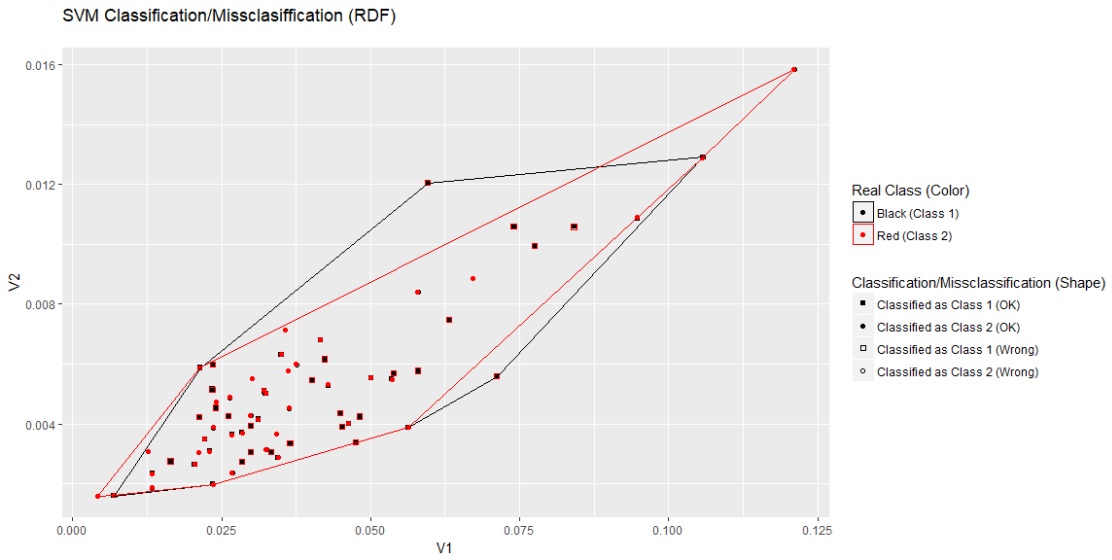



```
# RMSE Resulting
(rmse_svmradial <- sqrt(mean((as.numeric(test_pred_rgrid)-
as.numeric(test.Y.all))^2)))

## [1] 0.5795
```

```
# Store the Values for Report
results_all <- rbind(results_all,
                     data.frame("Method"= "SVM Gausian Kernel",
                                "Prediction Accuracy in Training Set" =
res.svmradial.training$overall[1] ,
                                "Prediction Accuracy in Test Set" =
res.svmradial$overall[1],
                                "RMSE Test"= rmse_svmradial,
                                "Time Elapsed" = et,
                                stringsAsFactors = FALSE))

plot_results(test.X.all, test.Y.all, test_pred_rgrid ,
             paste0("SVM Classification/Missclasiffication (RDF)\n"),
             "V1","V2")
```




```
plot_results(test.X.all, test.Y.all, test_pred_rgrid ,
             paste0("SVM Classification/Missclasiffication (RDF)\n"),
             "V1","V2", labels = FALSE)
```



Let's compare with a Linear SVM

7.5.7.2 Linear SVM

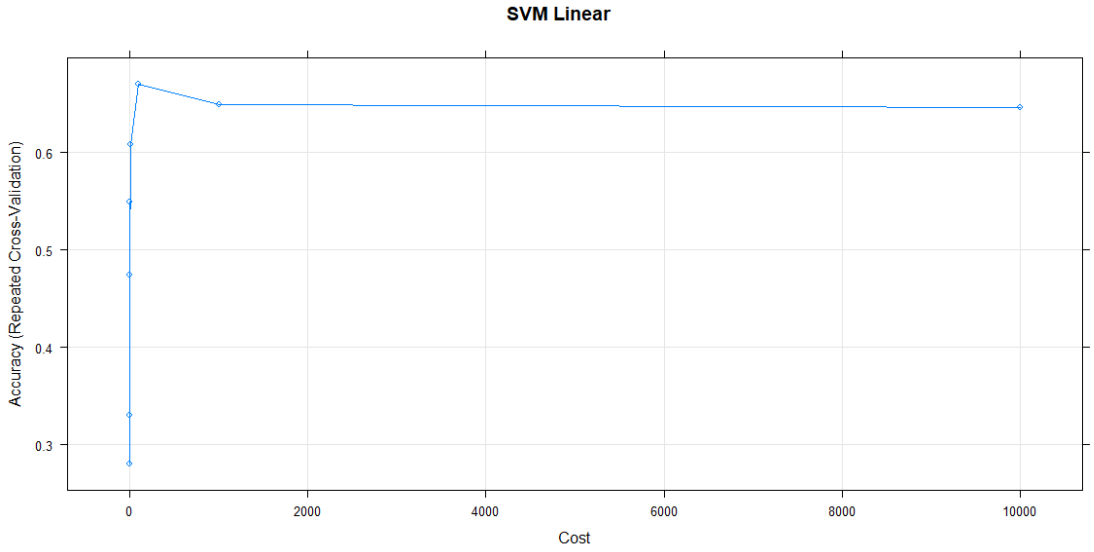
```
### 7.5.7.2 Linear SVM
# Setting Hyperparameters According with Paper

kernel_method_type <- "svmLinear"

grid_Linear <- expand.grid(C = c_values)

file.name  <- paste(work.dir, "svm_linear.Rds", sep="/")
file.name.et  <- paste(work.dir, "svm_linear-et.Rds", sep="/")

if (file.exists(file.name)) {
  load(file.name,.GlobalEnv)
  load(file.name.et,.GlobalEnv)
} else {
  t1 <- proc.time()
  svm_Linear_Grid <- train(y = factor(train.Y.all),
                           x = train.X.all,
                           method = kernel_method_type,
                           trControl=trctrl,
                           preProcess = c("center", "scale"),
                           tuneGrid = grid_Linear,
                           trace = FALSE,
                           tuneLength = 10)
  t2 <- proc.time()
  et <- elapsed_time(t1,t2)
  print(paste0("SVM Linear Executed ... time:", et))
  save(svm_Linear_Grid, file = file.name)
  save(et, file = file.name.et)
}
```

We can see the main results here:

```r
# Let's see some details about the model
svm_Linear_Grid
```

```
## Support Vector Machines with Linear Kernel
##
## 266 samples
## 686 predictors
##   2 classes: '1', '2'
##
## Pre-processing: centered (686), scaled (686)
## Resampling: Cross-Validated (10 fold, repeated 3 times)
## Summary of sample sizes: 240, 240, 238, 239, 240, 239, ...
## Resampling results across tuning parameters:
##
##   C      Accuracy  Kappa
##   1e-03  0.3298    -0.33591
##   1e-02  0.2807    -0.43822
##   1e-01  0.5489     0.09844
##   1e+00  0.4738    -0.05143
##   1e+01  0.6084     0.21799
##   1e+02  0.6696     0.33981
##   1e+03  0.6496     0.29906
##   1e+04  0.6460     0.29223
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was C = 100.
```

```r
plot(svm_Linear_Grid, main = "SVM Linear")
```




```r
# Let's check the detail in the Training Set
res.svmlinear.training <- confusionMatrix(svm_Linear_Grid$finalModel@fitted,
train.Y.all)
res.svmlinear.training
```

```
## Confusion Matrix and Statistics
##
##           Reference
```

```
## Prediction   1   2
##          1 131   1
##          2   2 132
##
##                Accuracy : 0.989
##                  95% CI : (0.967, 0.998)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : <2e-16
##
##                   Kappa : 0.977
##  Mcnemar's Test P-Value : 1
##
##             Sensitivity : 0.985
##             Specificity : 0.992
##          Pos Pred Value : 0.992
##          Neg Pred Value : 0.985
##              Prevalence : 0.500
##          Detection Rate : 0.492
##    Detection Prevalence : 0.496
##       Balanced Accuracy : 0.989
##
##        'Positive' Class : 1
##
```

```
# Let's use the model in test set

test_pred_lgrid <- predict(svm_Linear_Grid, newdata = test.X.all)
test_pred_lgrid
```

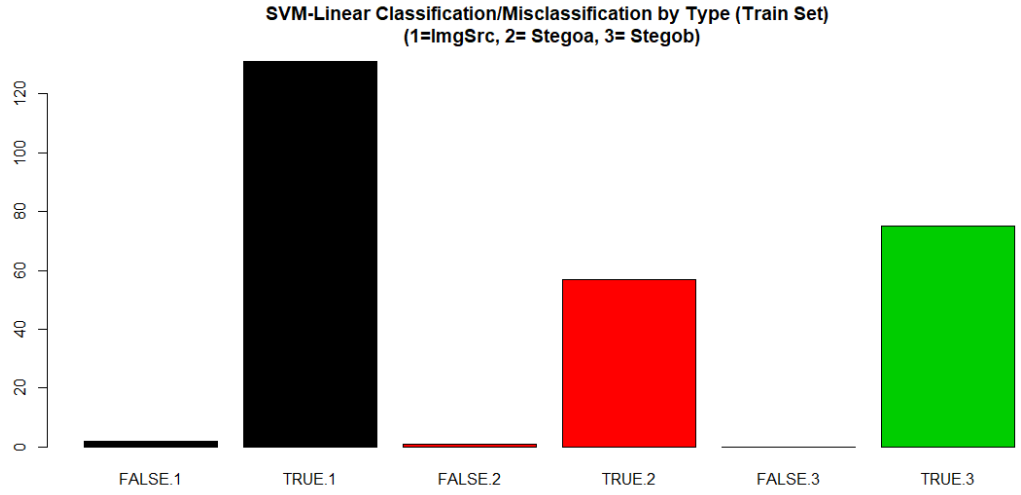
```
##   [1] 2 1 1 1 1 2 1 1 1 1 1 1 2 1 1 2 1 2 2 1 1 1 2 2 2 1 1 1 1 2 1 2 1 2 1
##  [36] 1 1 2 2 2 1 1 1 1 1 2 1 2 1 1 1 1 1 2 2 2 1 1 1 1 1 1 1 1 1 2 2 2 2
##  [71] 1 2 2 1 1 2 2 1 2 2 2 2 2 1 2 2 2 2 1 2 2 2 2 2 2 1 2 1 2 1 2 1 1 2 2
## [106] 2 2 2 2 1 2 1 2 1 2 1 2 2 2 2 2 2 2 2 2 1 1 1 1 2 2 1 2 1 2
## Levels: 1 2
```

```
res.svmlinear <- confusionMatrix(test_pred_lgrid, test.Y.all)

res.svmlinear
```

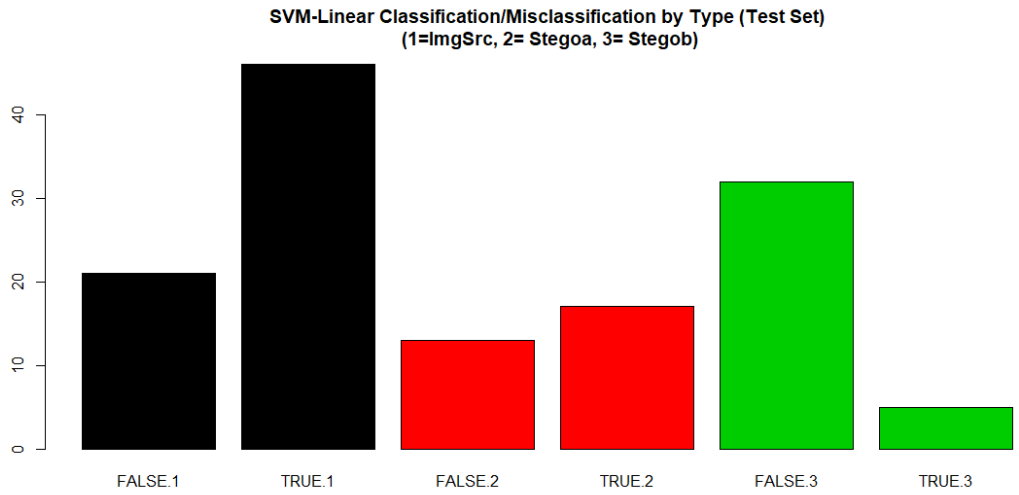
```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2
##          1 46 21
##          2 21 46
##
##                Accuracy : 0.687
##                  95% CI : (0.601, 0.764)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 9.35e-06
##
##                   Kappa : 0.373
##  Mcnemar's Test P-Value : 1
##
##             Sensitivity : 0.687
```

```
##             Specificity : 0.687
##          Pos Pred Value : 0.687
##          Neg Pred Value : 0.687
##              Prevalence : 0.500
##          Detection Rate : 0.343
##    Detection Prevalence : 0.500
##       Balanced Accuracy : 0.687
##
##        'Positive' Class : 1
##
```

```
main <- paste0("SVM-Linear Classification/Misclassification by Type (Train Set) \n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")

data_linear_train <- data.frame(svm_Linear_Grid$finalModel@fitted)
row.names(data_linear_train) <- row.names(train.X.all)

plot_results_by_type(data_linear_train,
                     train.Y.all,
                     main)
```




```
main <- paste0("SVM-Linear Classification/Misclassification by Type (Test Set)\n",
               " (1=ImgSrc, 2= Stegoa, 3= Stegob)")

data_linear_test <- data.frame(test_pred_lgrid)
row.names(data_linear_test) <- row.names(test.X.all)

plot_results_by_type(data_linear_test,
                     train.Y.all,
                     main)
```




```
# RMSE Resulting
(rmse_svmlinear <- sqrt(mean((as.numeric(test_pred_lgrid)-
as.numeric(test.Y.all))^2)))

## [1] 0.5599

# Store the Values for Report
results_all <- rbind(results_all,
                     data.frame("Method"= "SVM Linear Kernel",
                                "Prediction Accuracy in Training Set" =
res.svmlinear.training$overall[1] ,
                                "Prediction Accuracy in Test Set" =
res.svmlinear$overall[1],
                                "RMSE Test"= rmse_svmlinear,
                                "Time Elapsed" = et,
                                stringsAsFactors = FALSE))
```

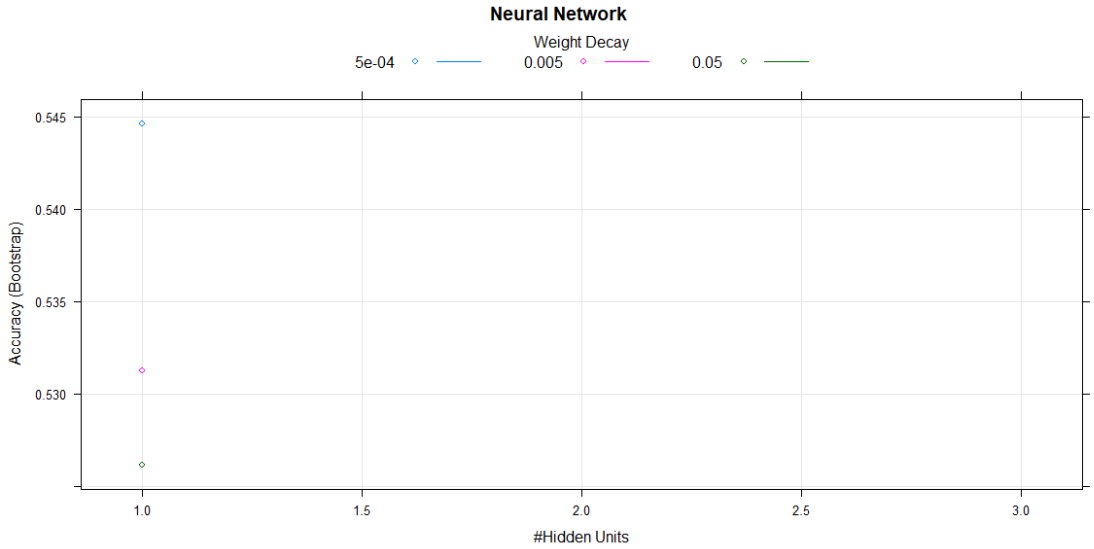
7.5.8 Classification Using Neural Networks (NN)

```
### 7.5.8 Classification Using Neural Networks (NN)
file.name  <- paste(work.dir, "nnet.Rds", sep="/")
file.name.et  <- paste(work.dir, "nnet-et.Rds", sep="/")

if (file.exists(file.name)) {
  load(file.name,.GlobalEnv)
  load(file.name.et,.GlobalEnv)
} else {

  grid_n_net <- expand.grid(decay = c(0.0005, 0.005, 0.05), size = c(1,2,3))
  t1 <- proc.time()
  n_net <- train(y = factor(train.Y.all),
                 x = train.X.all,
                 method="nnet",
                 preProcess = c("center", "scale"),
                 tuneGrid = grid_n_net,
                 trace = FALSE,
                 maxit = 500)
```

```
  t2 <- proc.time()
  et <- elapsed_time(t1,t2)
  print(paste0("Neural Network Executed ... time:", et))
  save(n_net, file = file.name)
  save(et, file = file.name.et)
}
```

Let's see the results:

```
# Let's see some details about the model
n_net

## Neural Network
##
## 266 samples
## 686 predictors
##   2 classes: '1', '2'
##
## Pre-processing: centered (686), scaled (686)
## Resampling: Bootstrapped (25 reps)
## Summary of sample sizes: 266, 266, 266, 266, 266, 266, ...
## Resampling results across tuning parameters:
##
##   decay  size  Accuracy  Kappa
##   5e-04  1     0.5446    0.09104
##   5e-04  2        NaN        NaN
##   5e-04  3        NaN        NaN
##   5e-03  1     0.5313    0.06549
##   5e-03  2        NaN        NaN
##   5e-03  3        NaN        NaN
##   5e-02  1     0.5261    0.05445
##   5e-02  2        NaN        NaN
##   5e-02  3        NaN        NaN
##
## Accuracy was used to select the optimal model using the largest value.
## The final values used for the model were size = 1 and decay = 5e-04.

plot(n_net, main = "Neural Network")
```




```
# Let's check the detail in the Training Set (I was not able to find the fitted
values in nnet)
#res.n_net.training <- confusionMatrix(n_net$finalModel$fitted.values, train.Y.all)
#res.n_net.training

# Let's use the model in test set
test_pred_n_net <- predict(n_net, newdata = test.X.all)
test_pred_n_net
```

```
##   [1] 2 1 1 1 1 1 1 2 1 2 1 1 1 2 2 1 1 2 2 2 1 1 1 1 2 1 1 1 1 2 2 1 1 1 1
##  [36] 1 2 1 1 2 1 1 1 1 1 2 1 1 1 1 1 1 1 2 1 1 1 1 2 1 1 1 1 1 1 2 1 2 2 2
##  [71] 1 2 1 2 2 2 2 1 2 1 2 2 1 1 2 2 2 2 1 2 1 2 2 2 1 1 2 2 1 1 2 1 2 2 1
## [106] 2 2 1 2 1 2 1 2 1 2 1 2 2 2 1 2 2 2 2 1 2 1 2 2 1 1 2 2 2
## Levels: 1 2
```

```
res.n_net <- confusionMatrix(test_pred_n_net, test.Y.all)
res.n_net
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  2
##          1 50 24
##          2 17 43
##
##                Accuracy : 0.694
##                  95% CI : (0.609, 0.771)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 4.12e-06
##
##                   Kappa : 0.388
##  Mcnemar's Test P-Value : 0.349
##
##             Sensitivity : 0.746
##             Specificity : 0.642
##          Pos Pred Value : 0.676
```

```
##          Neg Pred Value : 0.717
##              Prevalence : 0.500
##          Detection Rate : 0.373
##    Detection Prevalence : 0.552
##       Balanced Accuracy : 0.694
##
##        'Positive' Class : 1
##
```

```
# RMSE Resulting
(rmse_n_net <- sqrt(mean((as.numeric(test_pred_n_net)-as.numeric(test.Y.all))^2)))
```

```
## [1] 0.5531
```

```
# Store the Values for Report
results_all <- rbind(results_all,
                     data.frame("Method"= "Neural Networks",
                                "Prediction Accuracy in Training Set" =
                                  max(n_net$results$Accuracy, na.rm = TRUE),
                                "Prediction Accuracy in Test Set" =
res.n_net$overall[1],
                                "RMSE Test"= rmse_n_net,
                                "Time Elapsed" = et,
                                stringsAsFactors = FALSE))
```

7.6 Comparing Results

```
### 7.6 Comparing Results
rownames(results_all) <- NULL
kable(results_all)
```

Method	Prediction Accuracy in Training Set	Prediction Accuracy in Test Set	RMSE Test	Time Elapsed
Kmeans Clustering PCA	0.5000	0.5000	0.7071	21
Kmeans Clustering	0.5000	0.5000	0.7071	201
SVM Gausian Kernel	0.9361	0.6642	0.5795	1175
SVM Linear Kernel	0.9887	0.6866	0.5599	180
Neural Networks	0.5446	0.6940	0.5531	227