Problem Set 1

Rajvi Jasani

GitHub Repository

This is the link to my GitHub repository https://github.com/rajvijasani/STATS506-Problem-Set-1.git

Problem 1 - Wine Data

```
setwd("E:/UM/STATS 506/Repos/STATS506-Problem-Set-1")

# Assigning column names for the data frame
colNames <- c(
  "wineClass",
  "alcohol",
  "malicAcid",
  "ash",
  "alcalinityOfAsh",
  "magnesium",
  "totalPhenols",
  "flavanoids",
  "nonflavanoidPhenols",
  "proanthocyanins",
  "colorIntensity",
  "hue",
  "odOfDilutedWines",
  "proline"
)

# Importing the data set
wine <- read.table("data/wine.data", sep = ",", col.names = colNames)
```

```r
# Checking number of data samples for each class of wine
classCount <- table(wine$wineClass)
print(classCount)
```

```
 1  2  3
59 71 48
```

The number of data samples for each class of wine are the same as mentioned in the wine.names file.

```r
# Calculating correlation of alcohol content and color intensity
corRel <- cor(wine$alcohol, wine$colorIntensity)
print(corRel)
```

```
[1] 0.5463642
```

The correlation coefficient (r) between alcohol content and color intensity of wine is 0.5463642. As r is positive, we can say that there is a positive correlation, i.e. if one variable increases, the other also increases.

```r
# Spliting the data frame based on wine classes
# This returns a list of 3 lists grouped on the 3 wine classes
splitWine <- split(wine, wine$wineClass)
```

Attribution of Source: Asked UM GPT to suggest ways to split dataset by groups to enable me to apply correlation function to each.

```r
# Using lapply to calculate correlation between alcohol and color intensity for each list ge
#' Anonymous function to calculate correlation
#' @param splitWineList list (subset of the original dataset) containing samples of same cla
#' @return correlation coefficient between alcohol and color intensity from data in the give
corRelByClass <- lapply(splitWine, function(splitWineList) {
  return(cor(splitWineList$alcohol, splitWineList$colorIntensity))
})
print(corRelByClass)
```

```
$`1`
[1] 0.4082913

$`2`
[1] 0.2697891

$`3`
[1] 0.3503777
```

From the output, we can observe that class 1 of wine has the highest correlation while class 2 has the lowest correlation between alcohol content and color intensity.

```r
# Finding the index of row with highest value of color intensity
maxColorIntensityIndex <- which.max(wine$colorIntensity)
# Using the index to get corresponding alcohol content value
print(wine$alcohol[maxColorIntensityIndex])
```

```
[1] 14.34
```

The alcohol content of the sample of wine with the highest color index is 14.34.

```r
# Counting the number of samples where proanthocyanins > ash
counter = 0
for (i in 1:nrow(wine)) {
  if (wine$proanthocyanins[i] > wine$ash[i]) {
    counter <- counter + 1
  }
}
# Calculating the percentage
percentageWine <- (counter / nrow(wine)) * 100
print(percentageWine)
```

```
[1] 8.426966
```

Therefore, approximately 8.43% of the samples have more proanthocyanins than ash.

```r
# Calculating average of each variable except wineClass
overallAverage <- colMeans(wine[, -1])
# Converting above obtained vector into a dataframe
overallAverageDf <- as.data.frame(t(overallAverage), row.names = "Overall")
```

```r
# Calculating average of each variable grouped by wineClass
groupAverage <- aggregate(. ~ wineClass, wine, mean)
# Removing the wineClass column from the data frame
groupAverage <- groupAverage[, -1]
# Binding row-wise, the two dataframes obtained above
averagesTable <- rbind(overallAverageDf, groupAverage)
```

Attribution of Source: Asked UM GPT to suggest ways to get average of all variables by group and for ways to combine and display the table of averages.

```r
print(averagesTable)
```

```
         alcohol malicAcid      ash alcalinityOfAsh magnesium totalPhenols
Overall 13.00062  2.336348 2.366517        19.49494  99.74157     2.295112
1       13.74475  2.010678 2.455593        17.03729 106.33898     2.840169
2       12.27873  1.932676 2.244789        20.23803  94.54930     2.258873
3       13.15375  3.333750 2.437083        21.41667  99.31250     1.678750
        flavanoids nonflavanoidPhenols proanthocyanins colorIntensity       hue
Overall  2.0292697           0.3618539        1.590899       5.058090 0.9574494
1        2.9823729           0.2900000        1.899322       5.528305 1.0620339
2        2.0808451           0.3636620        1.630282       3.086620 1.0562817
3        0.7814583           0.4475000        1.153542       7.396250 0.6827083
        odOfDilutedWines   proline
Overall         2.611685  746.8933
1               3.157797 1115.7119
2               2.785352  519.5070
3               1.683542  629.8958
```

The table above lists the overall as well group-wise averages for each variable.

```r
# Using the splitWine list created above to extract values of total phenol for each class
# Pairwise t-test on class 1 and class 2
test12 <- t.test(splitWine[[1]]$totalPhenols, splitWine[[2]]$totalPhenols)
print(test12)
```

```

    Welch Two Sample t-test

data:  splitWine[[1]]$totalPhenols and splitWine[[2]]$totalPhenols
t = 7.4206, df = 119.14, p-value = 1.889e-11
```

```
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.4261870 0.7364055
sample estimates:
mean of x mean of y
 2.840169  2.258873
```

```r
# Pairwise t-test on class 1 and class 3
test13 <- t.test(splitWine[[1]]$totalPhenols, splitWine[[3]]$totalPhenols)
print(test13)
```

```

    Welch Two Sample t-test

data:  splitWine[[1]]$totalPhenols and splitWine[[3]]$totalPhenols
t = 17.12, df = 98.356, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 1.026801 1.296038
sample estimates:
mean of x mean of y
 2.840169  1.678750
```

```r
# Pairwise t-test on class 2 and class 3
test23 <- t.test(splitWine[[2]]$totalPhenols, splitWine[[3]]$totalPhenols)
print(test23)
```

```

    Welch Two Sample t-test

data:  splitWine[[2]]$totalPhenols and splitWine[[3]]$totalPhenols
t = 7.0125, df = 116.91, p-value = 1.622e-10
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.4162855 0.7439610
sample estimates:
mean of x mean of y
 2.258873  1.678750
```

Attribution of Source: Asked UM GPT for inbuilt function to calculate t-test.

Problem 2 - AskAManager.org Data

```r
# Importing data
salary = read.csv("data/AskAManager.csv")
# Re-assigning names to columns
names(salary) <- c(
  "index",
  "timestamp",
  "age",
  "industry",
  "jobTitle",
  "jobDescription",
  "annualSalary",
  "bonus",
  "currency",
  "otherCurrency",
  "additionalDescription",
  "country",
  "state",
  "city",
  "overallExperience",
  "fieldExperience",
  "levelOfEducation",
  "gender",
  "race"
)
print(names(salary))
```

```
 [1] "index"                 "timestamp"             "age"
 [4] "industry"              "jobTitle"              "jobDescription"
 [7] "annualSalary"          "bonus"                 "currency"
[10] "otherCurrency"         "additionalDescription" "country"
[13] "state"                 "city"                  "overallExperience"
[16] "fieldExperience"       "levelOfEducation"      "gender"
[19] "race"
```

Number of samples in original dataset

```r
print(nrow(salary))
```

```
[1] 28062
```

```r
# Choosing samples that have salary in USD
salaryRestricted <- salary[salary$currency == "USD",]
```

Number of samples in restricted dataset (less than the original)

```r
print(nrow(salaryRestricted))
```

```
[1] 23374
```

Cleaning based on age and experience

```r
# Need to look at all the possible values for age, overall experience and field experience
print(table(salaryRestricted$age))
```

```

    18-24      25-34      35-44      45-54      55-64 65 or over   under 18 
      991      10386       8323       2700        875         86         13 
```

```r
print(table(salaryRestricted$overallExperience))
```

```

  1 year or less    11 - 20 years      2 - 4 years    21 - 30 years 
             410             8137             2450             3066 
   31 - 40 years 41 years or more        5-7 years     8 - 10 years 
             735              112             4016             4448 
```

```r
print(table(salaryRestricted$fieldExperience))
```

```

  1 year or less    11 - 20 years      2 - 4 years    21 - 30 years 
            1180             5523             5045             1573 
   31 - 40 years 41 years or more        5-7 years     8 - 10 years 
             333               34             5460             4226 
```

Mapping range values to numeric values for age, overall experience and field experience

```r
#' Function to map age values given in range to minimum limit of the range in numeric format
#'
#' @param ageRanges takes column of age values from the dataset
#'
#' @return column of mapped/factored age values in numeric format
mapAge <- function(ageRanges) {
  ageFactors <- c(
    "under 18" = 0,
    "18-24" = 18,
    "25-34" = 25,
    "35-44" = 35,
    "45-54" = 45,
    "55-64" = 55,
    "65 or over" = 65
  )
  return(as.numeric(ageFactors[ageRanges]))
}

#' Function to map experience values given in range to maximum limit of the range in numeric
#'
#' @param experienceRanges takes column of overall or field experience values from the datase
#'
#' @return column of mapped/factored experience values in numeric format
mapExperience <- function(experienceRanges) {
  experienceFactors <- c(
    "1 year or less" = 1,
    "2 - 4 years" = 4,
    "5-7 years" = 7,
    "8 - 10 years" = 10,
    "11 - 20 years" = 20,
    "21 - 30 years" = 30,
    "31 - 40 years" = 40,
    "41 years or more" = 41
  )
  return(as.numeric(experienceFactors[experienceRanges]))
}
```

Attribution of Source: Asked UM GPT to suggest ways to factor character ranges to numeric values.

Mapping/Factoring columns

```r
salaryRestricted$minAge <- sapply(salaryRestricted$age, mapAge)
salaryRestricted$maxOverallExperience <- sapply(salaryRestricted$overallExperience, mapExperi
salaryRestricted$maxFieldExperience <- sapply(salaryRestricted$fieldExperience, mapExperience
```

Cleaning data for impossible age and experience combinations

```r
salaryCleaned <- salaryRestricted[salaryRestricted$minAge >= 18 &
                                  salaryRestricted$maxOverallExperience <= (salaryRestricte
                                  salaryRestricted$maxFieldExperience <= (salaryRestricted$
```

Number of samples in cleaned dataset (less than the restricted)

```r
print(nrow(salaryCleaned))
```

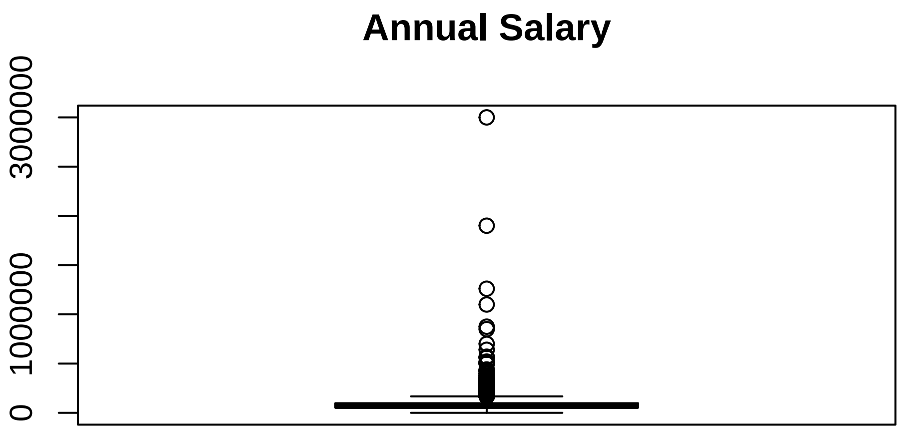
```
[1] 7834
```

Visualizing salaries to understand the trends

```r
summary(salaryCleaned$annualSalary)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
      0   52000   70000   82387   98000 3000000 
```

```r
boxplot(salaryCleaned$annualSalary, main = "Annual Salary")
```



From summary and box plot of the annual salaries, we can identify some extreme values. Salaries equal to 0 USD might be a mistake or we might have to consider what the person has written in additional description field. Salaries as high as 3000000 USD are possible but rare. Thus it would be safe to restrict lower limit to a little less than the 1st Quartile value, say 30,000 USD and the upper limit to a bit more than the 3rd Quartile value, say 300,000 USD. This assumption is based on summary statistics, plots and my personal intuition. To further justify it or modify it, we can look into sources such as US Bureau of Labor Statistics https://www.bls.gov/. However I have not chosen to do that as the dataset covers jobs from many different industries and many different positions which makes the task difficult.

```
minThreshold <- 30000
maxThreshold <- 300000
salaryFinal <- salaryCleaned[salaryCleaned$annualSalary >= minThreshold &
                              salaryCleaned$annualSalary <= maxThreshold, ]
```

Number of samples in final dataset (less than the cleaned)

```
print(nrow(salaryFinal))
```

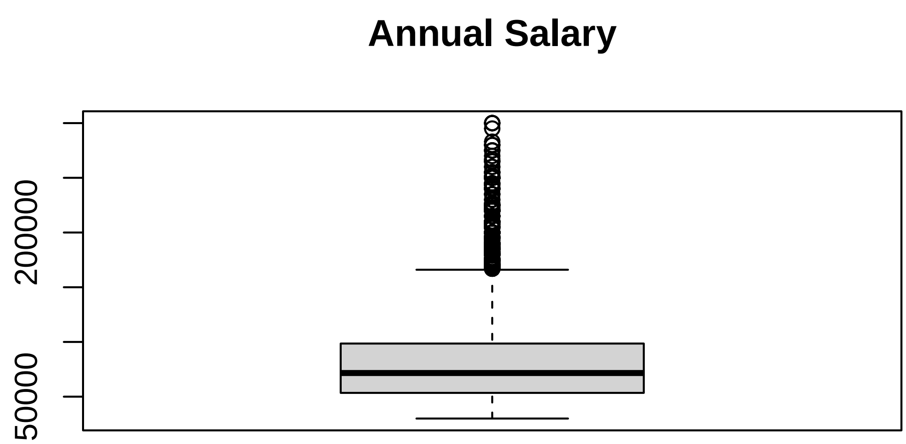
```
[1] 7573
```

Final summary statistics and box plot

```r
summary(salaryFinal$annualSalary)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  30000   53461   71600   81218   98530  300000 
```

```r
boxplot(salaryFinal$annualSalary, main = "Annual Salary")
```



Problem 3 - Palindromic Numbers

```r
#' Function to check if given input is Palindromic and output the reversed number
#'
#' @param num positive integer input
#'
#' @return named list with 2 elements, a logical "isPalindromic" indicating if input is a Pal
isPalindromic <- function(num) {
  # Checking if input is numeric; if not, converting it to numeric
  if (!is.numeric(num)) {
    num <- as.numeric(num)
  }
```

```
  # Checking if input is positive; if not, showing relevant error
  if (num < 0) {
    stop("number must be positive")
  }
  # Checking if input is an integer; if not, showing relevant error
  if (num != floor(num)) {
    stop("number must be an integer")
  }
  result <- list()
  numOG <- num
  numReverse <- 0

  # Mathematical way of reversing a number
  while (num > 0) {
    # Extracting last digit
    remainder <- num %% 10
    # Appending it to reverse of the number
    numReverse <- numReverse * 10 + remainder
    # Discarding the last digit in the original number
    num <- num %/% 10
  }
  # To handle cases with trailing zeros because
  # I have used mathematical approach of reversing a number
  if (nchar(as.character(numOG))!=nchar(as.character(numReverse))) {
    result["warning"] <- "Your input has trailing zeros. The computed reverse might not be ac
  }
  if (numReverse == numOG) {
    result["isPalindromic"] <- TRUE
    result["reversed"] <- numReverse
  }
  else{
    result["isPalindromic"] <- FALSE
    result["reversed"] <- numReverse
  }
  return(result)
}
```

Attribution of Source: Asked UM GPT for better way to check if a number is an integer instead of using is.integer() function.

```
#' Function to get the next palindromic number strictly greater than the input
#'
```

```r
#' @param num positive integer input
#'
#' @return vector containing the next palindromic number
nextPalindrome <- function(num) {
  # Checking if input is numeric; if not, converting it to numeric
  if (!is.numeric(num)) {
    num <- as.numeric(num)
  }
  # Checking if input is positive; if not, showing relevant error
  if (num < 0) {
    stop("number must be positive")
  }
  # Checking if input is an integer; if not, showing relevant error
  if (num != floor(num)) {
    stop("number must be an integer")
  }
  # We need a number strictly greater than the input.
  # In some cases the input itself might be a palindrome.
  # To avoid that, we start checking with the number after the input
  num <- num + 1
  # While the number is not a palindrome,
  while (isPalindromic(num)["isPalindromic"] == FALSE) {
    # Go to the next number
    num <- num + 1
  }
  return (c(num))
}
```

Finding the next palindrome for each of the following

```r
nextPalindrome(391)
```

```
[1] 393
```

```r
nextPalindrome(9928)
```

```
[1] 9999
```

```r
nextPalindrome(19272719)
```

```
[1] 19277291
```

```r
nextPalindrome(109)
```

```
[1] 111
```

```r
nextPalindrome(2)
```

```
[1] 3
```

Attribution of Source: Asked ChatGPT if a single digit number can be called a palindrome. It can be.