DAEN 500- DL1 – Data Analytics Fundamentals

Fall 2020 Final Examination Exercise

11/24 – 12/05/2020

Final Submission Deadline: NLT 11:59PM (EST). Saturday, Dec 5, 2020

*Failure to submit ON TIME will result in DAEN COURSE FAILURE*

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This exam is **OPEN BOOK/OPEN NOTES**. You may consult any of the course texts, and the various reference materials recommended in the syllabus. ***The exam of course IS NOT “Open Web”,*** especially in that you may NOT utilize expert “help” sites such as Stack Overflow, or other programming help or collaboration sites.

HONOR CODE CERTIFICATION

**Your signature above declares that you have followed the conditions of this exam, and that the work is yours alone**. **Specifically:**

This must be your own work, authored and completed by you. As stated earlier, this is an “open source exam” – allowing books, notes or courseware, as well as *general* expert advice gained PRIOR to exam. YOU MAY NOT, HOWEVER, SEED OR USE ANY ADVICE ON HOW TO SOLVE THE QUESTION OR ANY CODE WRITTEN BY ANY OTHER INDIVIDUAL. *Any violation will result in an immediate failure in the exam and for the course, as well as referral to the GMU Honor Committee for determination of any other appropriate disciplinary consequences.*

*NOTE: Your* ***submission*** *of any responses, files, programs, etc. in response to the DAEN500 final exam instructions, will also be your personal certification of your full compliance with the spirit and letter of the* ***GMU Honor Code*** *standards for take home and/or in-class exams.*

Additionally, you are restricted from discussing the substance of the questions on this exam with any other individual, until after you have submitted your final response for grading. The completed exam -- with your answers embedded in this docx document (add extra pages as necessary) should be submitted following instructions contained in the Final Exam Instructions BB site. If you have any trouble submitting and have extra parts of the answers you have trouble appending to this document, you may simply submit additional pages separately (the exam submission site is set for multiple submissions, just in case). Make certain all are submitted PRIOR TO THE DEADLINE!

 FINAL EXAM PROBLEMS

COMPLETE ALL & INSERT ANSWERS BELOW QUESTIONS

# Problem 1: Python Programming Problem (15 Points Total)

* **Design and implement a Python program that is based on the following requirements: a) program will find all numbers which are divisible by 7 but are not a multiple of 5; and b) numbers between 2000 and 3200.**
* **INSERT (cut&paste) your Python code in space below and *then insert a screen shot in space below, showing code, your successful run, input and output.***

NOTE of alternative for help: To help test your code, you also may use a Python “programming window” found in the. **Zybooks Section 35 Additional Material**.

######################### PYTHON CODE ###########################

# Declare the variable(s), in this case a list is needed to append values

divisible = 7

multiple = divisible - 2 # should result in numerical 5

minimum\_range = 2000

maximum\_range = minimum\_range + 1200 # should result in numerical 3200

divisible\_seven\_not\_multiple\_five = []

# We have a range given so we would use a for loop

for i in range(minimum\_range, maximum\_range):

# Logic of #'s is that we want something where 7 is divisible by said number

# but 5 cannot be a multiple of those numbers

# It's pretty simple here because we want numbers that aren't a multiple of 5, opposite of # the logic for 7

if (i % multiple != 0) & (i % divisible == 0):

# We must append each value to the list, being stored within the empty list from above, # basic concatenation

divisible\_seven\_not\_multiple\_five.append(str(i))

# Now we print out all values stored within the string separated by a comma

print("These are the numbers:" + " " + ', '.join(divisible\_seven\_not\_multiple\_five))

**Python Code written in Jupyter Notebook Python IDE**

**Graphical user interface, text, application, email

Description automatically generated**

**OUTPUT OF PYTHON CODE**

**A picture containing text

Description automatically generated**

# Problem 2: Python Programming Problem

# (15 Points Total)

* **Design and implement a Python program that is based on the following requirements:**

**a) define a class which has *at least two* methods**

* + **Method 1 – getString: to get a string from console input; and,**
  + **Method 2 - printString: to print the string in upper case.**

**b) demonstrate code works using three different test input strings**

* ***INSERT* *code below* and *INSERT* a screen shot of the program and successfully run output that *includes test input for input strings (test strings must include (a) all upper case, (b) all lower case, and (c) mix of upper and lower case).***

######################### PYTHON CODE ###########################

# Note, for this to work, the user must enter a string, not a empty string

# String can contain numbers, the logic will overlook the numbers as they're not numbers #per say but characters,

# and character numbers can not be capitalized

# Using the class letterString allows us to read and write strings as files

class letterString():

# We need a \_\_init\_\_ function or method to call in the other methods in the class

# We instantiate a main function that compiles the code, this is necessary when working

# with multiple classes

def \_\_init\_\_(self):

self.new\_str = ""

# Per instructions we need a function that prompts the user to input a string

# This method accepts the string from the user

def getString(self):

self.new\_str = input()

# The next string gets the retrieved stored string stored within the self variable

# instantiated and then prints

# that exact string, no matter case, in end result of UPPER CASE output ONLY

# This method will print the input string in all upper case

def printString(self):

print(self.new\_str.upper())

# Next we call each of the methods that is compiled within the main, aka init function

# declared up top.

new\_str = letterString()

# This will call the method in which a user will input their string of choice, it invokes that

# method

new\_str.getString()

# The print method will be invoked, printing out the string in upper case letters only, no

# matter the string

new\_str.printString()

**Python Code written in Jupyter Notebook Python IDE**

Graphical user interface, text, application, email

Description automatically generated

**OUTPUTS OF PYTHON CODE**

**\*NOTE\*** I Provide the Input of the String, the output is provided as well but includes the input as well for QC purposes as well as the Python IDE doing its usual course.

* + **(a) Input of all upper case ->**

**Input:**

****

**Output:**

****

* + **(b) Input of all lower case ->**

**Input:**

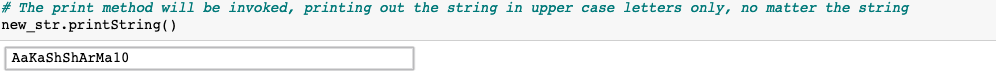
****

**Output:**

****

* + **(c) Input of a mix of upper and lower case ->**

**Input:**

****

**Output:**





# Problem 3: R Programming Problem

# oints Total)

**Perform the following problems using R:**

* + Create a vector of courses (e.g., MATH 101) you have taken previously. Make sure you have at least 8 courses. Name the vector myCourses
  + Get the length of the vector myCourses
  + Get the first two courses from myCourses
  + Get the 3rd and 4th courses from myCourses
  + Sort myCourses using a method
  + Sort myCourse in the reverse direction
* *INSERT* *code below* and *INSERT* a screen shot of the program and successfully run output.

########################## R CODE ###############################

# Create a vector of courses (e.g., MATH 101) you have taken previously.

# Make sure you have at least 8 courses. Name the vector myCourses

myCourses <- c("IT 101", "IT 106", "IT 109", "IT 206", "IT 209", "CS 112", "CS 211", "DAEN 500", "HIST 103", "CALC 1")

# Get the length of the vector myCourses

length(myCourses)

# Get the first two courses from myCourses

myCourses[1:2]

# Get the 3rd and 4th courses from myCourses

myCourses[3:4]

# Sort myCourses using a method

sort(myCourses, decreasing = FALSE)

# Sort myCourse in the reverse direction

sort(myCourses, decreasing = TRUE)

# Clean up of memory

rm(list = ls())

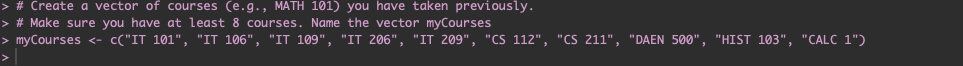
**Screen Shot of the Program written in R Studio**

Text

Description automatically generated

**OUTPUTS OF R CODE**

* + **Create a vector of courses (e.g., MATH 101) you have taken previously. Make sure you have at least 8 courses. Name the vector myCourses**





* + **Get the length of the vector myCourses**

****

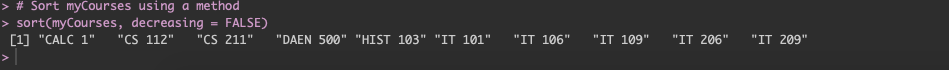
* + **Get the first two courses from myCourses**

****

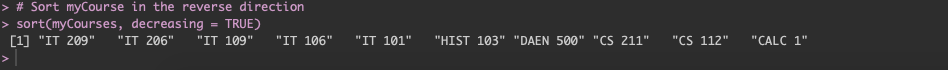
* + **Get the 3rd and 4th courses from myCourses**

****

* + **Sort myCourses using a method**

****

* + **Sort myCourse in the reverse direction**

****



# Problem 4: Principal Component Analysis

# (25 points)

**Provide a description of the following:**

1. What is a component – Provide a description (5 points)
2. Principal Component Analysis – Provide a description.(5 points)
3. Provide an specific example of Principal Component Analysis(15 points)

**1) What is a component - provide a description:**

The principal components are the most concise, informative descriptors of our data as a whole. We are looking for new directions. Each consecutive direction tries to explain the maximum remaining variance in our 𝑋 data. Each direction is orthogonal to all the other directions. These new directions are the "principal components." Applying PCA to your data transforms your original data columns (variables) onto the new principal component axes.

According to the Zybooks exercises a component is a new variable Zi formed by some combination of predictor variables X1, X2, …, Xp. Transforming predictor variables into components aids in determining which best explain variability in the data and may reduce the number of parameters in the analysis (Zybooks).

According to Zybooks, correlation values work in correlated pairs and are used to calculate said components. Components aren't simple pairs of correlated data though, however, these pairs are weighted combinations of predictor variables! The weights of the predictor variables in the components is determined by all of the correlations between the predictor variables (Zybooks).

**2) Principal Component Analysis - provide a description:**

Principal Component Analysis (PCA) finds linear combinations of current predictor variables that create new "principal components," where these principal components explain the maximum possible amount of variance in your predictors. PCA ultimately transforms variables into possibly fewer components to simplify the analyses. A goal of PCA is to maximize the data variability along as few components as possible.

The transformation of variables into principal components can be treated as a rotation of the data with the original variable axes being rotated into the direction of the principal components. The first principal component becomes the new x-axis. Each additional principal component is a new axis of data with less of the variability of the data (Zybooks). Well, we're transforming our data. We are going to look at how all of the 𝑋 variables relate to one another, then summarize these relationships. This is done with the covariance matrix. Then, we will take this summary and look at which combinations of our 𝑋 variables are most important. We will decompose matrices. In other terms, break one matrix down, and then further decompose it into multiple matrices.

This gives us our covariance matrix broken down into its eigenvectors! The eigenvector is a linear algebra term that allows us to understand the most important "directions" in our data, which are our principal components! We can also see exactly how important each mixture is, then rank these mixtures. Each eigenvector gives us an eigenvalue. The eigenvalue is a number that tells us how important each principal component is. The sum of the eigenvalues for the correlation matrix equals the number of input variables in the data. This helps with the selection of components.

Remember that one of our goals with PCA is to do dimensionality reduction-reducing the number of features we use in our model. Measuring how important each principal component is dependent on using the eigenvalue. The next step would be to rank the columns by their eigenvalues, then drop the columns with the smallest eigenvalues. This shows those with little importance, thus keeping the columns with big eigenvalues, which are deemed important. But how many features do we discard? A useful measure is the explained variance, which is calculated from the eigenvalues. This can be further explained within 2 assumptions of PCA.

- Linearity: PCA detects and controls for linear relationships, so assuming that the data does not hold non-linear relationships so we don't end up caring about these non-linear relationships.

- Large variances define importance: If data is spread in a direction, that direction is important! If there is little spread in a direction, that direction is not very important.

When should you use PCA? You would use PCA:

- When you want to reduce the number of variables but aren't sure what variables or how many to consider

- When you want to ensure variables are independent of one another which could lead to less interpretability. This could be iffy.

**3) Provide a specific example of Principal Component Analysis**

There are many use case scenarios where we can use PCA, for instance:

- 20+ Variables with High Multicollinearity

- 100+ Variables

- Image Processing

SPECIFIC process and example of applying PCA?

Utilizing the Wine data set from the UCI Machine Learning Repository, we can perform PCA to the data set. I decided that using the wine quality dataset would allow us to better understand how PCA works based on the quality and spread of the data. Specifically, we are going to use physicochemical properties of the wine in order to predict the quality of the wine from two data sets related to wine, red and white.

Stacking the data sets together, we see that they have the same columns. We then can decide if this is a classification or regression problem. My next step would be to fit a multiple linear regression model on the data with our predictor variable being wine quality. To show off the strength of PCA, the Python package, sklearn, has a module called polynomial features which allows us to create many, many more features. On our wine data set, we will apply polynomial features to all variables excluding the wine quality variable.

After fitting our model, train/test splitting the data to a randomized 30% test size and 70% train size we then can perform a R^2 score to analyze the model's performance on predicting the wine quality of the testing data split vs the training data split. But where do we apply PCA in this process? Before this, we've created a model for our data set. We now need to perform dimensionality reduction which refers to (approximately) reducing the number of features we use in our model. Dimensionality reduction has a number of advantages but can suffer from some drawbacks, though. Let's get the advantages of dimensionality reduction while minimizing the drawbacks!

How do we break down how dimensionality reduction can be applied to this situation?

- Feature Elimination: dropping variables from our model.

- Feature Extraction: take existing features and mix them together in a very particular way.

Then we drop a number of these "new" variables but keep the variables that are still a mix of the old variables. This enables us to still reduce the amount of features in our model, but we are able to keep all of the foremost important pieces of the first features. Now we must perform feature scaling because it's essential for ML algorithms to calculate distances between our data. We must then decompose the information. this is often an "under the hood" unique feature that PCA does. It takes one matrix and decomposes that matrix into multiple matrices making the processing computationally efficient.

Now we finally instantiate a PCA metric on our multiple linear regression model. All of our data is scaled, randomized, split and then transformed into our new data set-statistically mentioned as Z\_train (Remember X\_train and y\_train is what served as our x variables and y variable aka the predictor variable).

Our PCA process has been complete and we can start our analysis, such as:

1) measure how important each principal component is using the eigenvalue

2) rank the columns of Z\_train by their eigenvalues

3) Apply "Proportion of Explained Variance" (calculated from eigenvalues) - But what percentage features can we discard:   
- Drop the columns with small eigenvalues, those with little importance  
- Keep the columns with big eigenvalues, which are deemed very important

4) Factor Loadings - correlation between the original data and the new principal component

The PCA file from RapidMiner Studio as well as the red wine data set will also be provided in my Github repository, submitted separately.

**Principal Component Analysis on Red Wine Dataset in RapidMiner Studio**

Dimensionality reduction in the statistics realm usually revolves around the dimension of our data set, the size, or in other terms, how many attributes does the data set has. Understanding the wine data set here in RapidMiner studio is an extension of my processes in the explanation above. This kind of showcases the example in a toolset learned within DAEN 500 DL1.

Feature Processing and Data Cleaning (Main Reduction)

Check for Duplicate Values

* Must identify a unique column/attribute to filter out the duplicate values for other rows.
* Must be careful here as removing duplicates can remove the entire data set. There isn't a unique column for this data set to filter out duplicates

![A picture containing table

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD0RXhpZgAATU0AKgAAAAgABAE7AAIAAAAOAAAISodpAAQAAAABAAAIWJydAAEAAAAcAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEFha2FzaCBTaGFybWEAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzgwAACSkgACAAAAAzgwAADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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KO7llmKPHm63jh9r5UEdCCPpQB2dFcZJ4au5XPnWplCaQ8MRlmWQrNvJUZ45APXGB60P4e1QRstmn2dpdJSOV/MHzThwWBwckkZGenPWgDs6K46XQtSW3muLG1EDx3UU9pZmRfk2jD85wM5z17VC3hjUEs7JHjkmRbZhJFHLGrLMzbi2WBHfG5eRjigDrr7UbbTo43vHZBLIIk2ozlmOcABQT2p9peQX1uJrSQSRkkZwQQR1BB5B9jWRrNheS2GkrbxPcyWl3DLKPMXcVUHJy20E/lms630XUrXUrTUfs28i8up5IFkXMYlUBRknBxjnFAHXVU/tS1N5Laq7vNC6JIqRO2wuMrkgYxgdeg71wdvo93HPHps1j5l2NJkAj8xf3bGdtrZzjjINajaBqv9rLK8XmgXdjI0vmL8wjjKu3Jz1P1NAHZ1FLdQQ3EMEsirLOWESHq2Bk/kK5W20fU7fSr2MWCSXzIQbh7ni5PmFuVBx93u2PTpUGneHb621KzuriwEiW95M23Me4Rsq+WQM4wG3HA6HoKAO2orkNM8P6hBcuboTmUpMslwtwiLLuzt6KXJ5HLH5ccelWfDGk32m3spuLcRQGELlmXcWB/2DhuP4iAxoA6aiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACsnxBrbaJb27x232l55fLVTJsA4JznB9PSrep6hFpWmT3s4ZkiXO1erEnAUe5JA/GuM8TJq3l6Xdatcxgy3PFnFGNsOUb+Lqx/Ss6ik4+47M1pOCn76uv6t+Jof8Jne/9AeL/wADD/8AG6P+Ezvf+gPF/wCBh/8AjdYE91b22z7TPHD5jbE8xwu5vQZ6mmPf2cau0l3AgQEuWkA24ODn0weKj2U/53+H+RftYf8APtf+Tf5nRf8ACZ3v/QHi/wDAw/8Axuj/AITO9/6A8X/gYf8A43WFBPFcwrNbSpNE4yrxsGVvoRTmOFJxnA6DvR7Kf87/AA/yD2sP+fa/8m/zNv8A4TO9/wCgPF/4GH/43R/wmd7/ANAeL/wMP/xuuROuRqxDQuCOCCaYfEEQOPJf8xR7Kf8AO/w/yD2sP+fa/wDJv8zsf+Ezvf8AoDxf+Bh/+N0f8Jne/wDQHi/8DD/8brmbHUVvmfZEyBe5q5R7Kf8AO/w/yD2sP+fa/wDJv8za/wCEzvf+gPF/4GH/AON0f8Jne/8AQHi/8DD/APG6wbi5gtITLdTRwRjq8jhVH4mmm8tlYq1xCGHUFxxxu/lz9OaPZT/nf4f5B7WH/Ptf+Tf5m7L44uoImlm0dPLQZYrd5IHsNldgjB0Vl6MMivJ729t7vQ7mayuIriPYRvicOM+mRXb2l3qWkXFnb6rOl5Z3ZWOK5EYR45COFYDgg4wCO/WnCM4zd5XXy8+yQqkqcoLljZ67X8u7Z0VFFFbGAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFAGV4ltJrzQpVtU8yaJ0mSP++UcNt/HGK5vxTq9lq1lpEtlMrn7Z80ZOHjOxshl6g13Ncf42srVJtOukt4luHuSrShAGYbG4J71nUnyRv6fi7GtKDnKy839yucjrehLrMluzTFPJDqykvtdWxkHY6n+EdyPY0yTQ5/P1Ce2v/ImvtuWWL7m0jGMEH7uQec85BFbNFaGRR0fTjpWmJaGYzlXkcyEEE7nZu5J/ixnPNXqKKAMjWLL/l5iH++B/OsaOCS4uBHCu5j2rrpADGwPIIOaxtBA+0XBxyFUZoAs2dm8U0JECwCNSGbfkyZHfH51pUUUAZ2taV/a9rFEJjC8UolVgWwTgrg7WU4wx6EVXXQGiuhPbXQgdbP7HHtizsUDggkk5Dc8k8ce9bNFAGAmlPpOg6ks10bp7hzMzkEYOxVxyzH+HPXvjtXoN/dR6tcaZpVg6zSRzRXFy6HKwonzYJ7EkAAVyeqY/sq5z08s16Hoq6cumR/2SLbycDP2bbt3Y5zjvWal77j5f5mjj+7UvN/oX6KKK0MwooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACuW8cf6rTP+vo/+gNXU1y3jj/VaZ/19H/0Bq58T/D+a/NHThf4nyl+TMCiiiug5gooooACMgg96jhgjt49kKhR7d6kooAKKKKACsLUvEv9nz3a/ZBIlurjd5uGZ1hM2NuOF2jG717Vu1BJYWk0ryzWsEkjxmJ3aMEsh6qT3HtQBlSXc91perrdR+VJBJ5ewSBwAYkbg7R/e755zzjAHe3lnDo0+m6ppyLbvNNFb3McYwsyP8uSOm4Egg/WuQ1SFF0q9MaKrSKWcgYLHAGT6nAA/AV2lraahrNzZT6lbiysrMiWK3Mgd5ZAPlZscADqB69am65rFWfLc6KiiiqJCiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAK5bxx/qtM/wCvo/8AoDV1Nct44/1Wmf8AX0f/AEBq58T/AA/mvzR04X+J8pfkzAoooroOYKKKKACiiigAooooAKbHIk0SSwuskbqGR1OQwPQg9xVDWobqa3gFmJmCzAypDL5bsm09GyP4tpPPIBHtXMTW2u6Z4bMTLNElvbeY0qXAxGFsSmzAOeJV3ccZIPrgA63VW26Tcn/pma7nStbeSeHT9Tsnsbp490ILh0mAHO1h3HUg815msN1D4f1AXgmUMzGJJ5fMdU2rwWyf4txHPAIHtXomvMrQaHDHg3T3sLRAdQF5c/QLnP1qOVc7l1LcnyKPS/8AkdFRRRVkBRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFct44/wBVpn/X0f8A0Bq6muW8cf6rTP8Ar6P/AKA1c+J/h/Nfmjpwv8T5S/JmBRRRXQcwUUUUAFFFFABRRRQAUUUUAVNVG7SbkH/nma73SNDt7JlvJJZru7aML59w+5lX+6o4Cj6CuD1P/kF3P/XM/wAq9Ot/+PWL/cH8qwUn7Zx6WX5s3cV7BS63f5IkooorcwCiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAK5bxx/qtM/6+j/6A1dTVPU9JtNYt1hvoy6o+9SrFSp6ZBH1NY1oSnC0d9PwdzehOMKl5ba/irHB0V1H/CE6N/cuf/AqT/Gj/hCdG/uXP/gVJ/jU89f+Rff/AMArkw/87/8AAf8AgnL0V1H/AAhOjf3Ln/wKk/xo/wCEJ0b+5c/+BUn+NHPX/kX3/wDADkw/87/8B/4Jy9FdR/whOjf3Ln/wKk/xo/4QnRv7lz/4FSf40c9f+Rff/wAAOTD/AM7/APAf+CcvRXUf8ITo39y5/wDAqT/Gj/hCdG/uXP8A4FSf40c9f+Rff/wA5MP/ADv/AMB/4Jy9FdR/whOjf3Ln/wACpP8AGj/hCdG/uXP/AIFSf40c9f8AkX3/APADkw/87/8AAf8AgnG6n/yC7n/rmf5V6db/APHrF/uD+VYsfgzRY5VcwyybSCFkndlJ9wTzW9RTjP2jnNW0S3v38l3CpKmqahBt6t7W3t5vsFFFFdBzBRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAf/9k=)

Check for Missing Values, Balancing Outliers, and Removing Useless Attributes

* It’s important to use the descriptive statistics pane to get a better idea of what data is missing within the missing column. Those we can decide to drop. It’s best to not get rid of ALL null values, rather replace them with 0 for numerical data types or N/A for string data types. Dropping too many can also remove the entire data set.
* Create Filters operator will allow us to subset/filter out missing values as well as fix the acceptance of data points that don’t fit within a range, aka outliers
* Remove Useless Attribute operator cleans out useless attributes that show little to no variety in the individual columns.

![Graphical user interface

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD0RXhpZgAATU0AKgAAAAgABAE7AAIAAAAOAAAISodpAAQAAAABAAAIWJydAAEAAAAcAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEFha2FzaCBTaGFybWEAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzc5AACSkgACAAAAAzc5AADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Graphical user interface, application

Description automatically generated

2nd Phase of Reduction

\* GOOD Point to Note \*

If you have a signal that has variation and variation has information; the more unpredictable the variation will result in more information. 2 signals that are highly correlated with each other, then contain the same information. This is the next part of our PCA modeling process. We want to remove correlated attributes.

Graphical user interface, application

Description automatically generated

We're already so much to the data that is impacting its size and variety which is a small part of the process within dimensionality reduction! Let’s say we have so many variables, but we don’t know what is causing the collinearity. We can focus on weight by index, mainly the Gini index because it allows us to find the most important input given the target variable. Higher the weight of an attribute means the importance is more considered.

Graphical user interface, application

Description automatically generated

On our wine data set, we can apply this weighted index and then derive a subset of values that can be reduced, those weighted values being of least importance.

Doing all this data preparation is key in avoiding the “curse of dimensionality.” This affliction refers to what happens when we add more variables to a multivariate model. The more dimensions of components we add, the likelihood of predicting certain amounts gets more difficult. We can now create a simple PCA application to the model on our wine data set. Note that I’ve provided the parameters to the right of the screenshot to showcase that I’ve chosen the fixed number option, the most popular choice, for the dimensionality reduction choice with 12 components being our 12 dimensions/directions OR our attributes.

Text, application

Description automatically generated

In our next step as mentioned in the processing above, we must assess our outputs. The output(s) of running our PCA model on the wine data set:

We have our Eigenvalues in the results pane. This shows us our standard deviation on each of the 12 components. We can assess the proportion of variance and how they’re summed up as well.

Table

Description automatically generated

We can click the ExampleSet(Apply model) within the adjacent tab. Each row resembles an observation. This will showcase the weights of each observation on those 12 components. Our data set has 1,599 total observations-too large to showcase but here is a subset of the head count of the 1st 25 observations.

Graphical user interface, application, table

Description automatically generated

Now let's click the statistics tab on the left bar under the data tab to gather more information. We can see how they're all "real" (float) based on non-missing values, minimum, maximum, etc. We can also click a component to gather more comprehensive information such as the average or standard deviation as well as a visual bar graph. Expanding the histogram for the 1st component reveals more knowledge.

Chart

Description automatically generated

Chart, histogram

Description automatically generated

We can also assess or view other awesome charts that RapidMiner provides and creates based on our wine data set. We get a pretty scatter plot where the color corresponds to component 1.

Chart, scatter chart

Description automatically generated

Clicking back on the PCA tab in the above menu and clicking cumulative variance in the left bar gives us the cumulative variance of each of the principal components. We see from the rounded bend at component 2 that 20% of the variance provides diminishing returns proving that maybe two components rather than 12, is a reasonable place to stop for the components.

Chart

Description automatically generated

We can click on Eigenvectors to see how each of these variables contribute to all 12 of the principal components.

Graphical user interface, application

Description automatically generated

# Problem 5: Multiple vs. Logistic

# (30 points)

# Describe: What is difference between Multiple Regression and Logistic Regression? What circumstances might determine which to use? (10 points)

# Demonstrate: Using any data, and any tool set you’ve learned about, show differences (20 points)

# SUGGESTION: may be solved using RapidMiner, or other toolsets, BOTH TO ANALYZE AND TO VISUALIZE REGRESSION DIFFERENCES.

Step 1: Perform a quick search of the [UCIS public data archive](https://archive.ics.uci.edu/), a well-curated site which you already have seen as part of your introductory RapidMiner training.

Step 2: Pick a dataset you find interesting, input dataset into regression tools you’ve chosen.

Step 3: Run regression, .and use visualizations to demonstrate the conceptual answers you provided for 5.(a).

**a) What is difference between Multiple Regression and Logistic Regression? What circumstances might determine which to use?**

Logistic regression is a natural bridge to connect regression and classification problems. Logistic or "logit" regression is the most commonly used binary classification algorithm, usually the most efficient and shares similar properties to linear regression. It may prove to yield better results than a linear regression model would normally. Because it's a regression model, logistic regression will predict continuous values such as probabilities between 0 and 1. However, it usually works as a classification-based problem classifying something as binary, 0 and 1. Think of logistic regression as yes and no. Logistic regressions help find the best-fitting model. This model best describes the relationship between a binary outcome and a bunch of independent variables. Logistic regression generates coefficients. These coefficients predict a “logit” transformation. We can see this as the probability that the feature of interest is present. What are some circumstances of using logistic regression?

- Example: What is the probability that someone shows up to vote?

- Example: Based on the predicted probability, do we predict that someone votes?

Multiple regression or multi-linear regression is the most commonly used and most efficient linear regression model. The idea revolves around a single continuous dependent variable and its relationship with two or more independent variables, assuming that a linear relationship exists between the dependent and independent variables. According to Zybooks, multiple linear regression is a way to model the linear relationship between one quantitative response variable and one or more predictor variables. Changing the values of predictor variables affects the value of the response variable. Knowing the worth or weight of the predictors often allows us to predict the response.

It's also assumed that there isn't a strong correlation between each of the independent variables. These independent variables are continuous as well, but some cases have them be categorical or string/character based. This can be solved through the dummy-variable principle, or the idea of converting these string variables into 0's and 1's. We can estimate the multiple linear regression model using sample data to find a sample multiple linear regression function. The most common method to estimate the model is called "least squares." Multi-linear regression has some other assumptions that allow it to stick out as well, stated from Zybooks:

- Population linear regression function, which represents where one would expect "Y" to be, given a particular set of values for X1, X2, X3, ...

- The multiple linear regression model adds the population linear regression function and the regression error term together. The regression error in the multiple linear regression model is a random variable.

Some circumstances of using multi-linear regression. Multi-linear regression predicts/trends of future values such as housing prices on new homes based off of the older homes and land surrounding it. Multi-regression can be used for forecasting based on changing an independent variable and observing how the dependent variable alters as well. For instance, predicting GPA results when altering consistent study time and time under tension of focus. This all encompasses the idea of the strength of independent variables on the dependent variables, categorical or not. Logistic regression is usually used in fraud or anomaly detection such as spam emails or if someone is contagious or not. What's the difference, and what circumstance helps choose when to use one over the other?

If you think about it, logistic regression is an extension of multiple regression. Multiple regression has been around for a longer period of time. Multi-regression encompasses more data points and doesn't revolve around success/failure, or true and false, and more so of what data points affect others and the projected trend that will occur. Understanding the difference between linear regression and multi-linear regression is key here in better isolating the main difference between multi-linear and logistic.

Linear regression creates a relationship between two variables, a single independent variable and a single dependent variable, where a single linear relationship might exist. That linear line is created close to the data. Finding the slope and intercept helps us find that line while also curtailing regression-based inaccuracies. Multi-linear regression is different here because we can utilize n-number of independent variables on our singular continuous dependent variable. Multi-collinearity might exist in this situation which we will have to take care of. Now how does the multi-linear regression differ over the logistic regression?

Logistic regression is more often than not, used when we have no clear distinction of linearity due to having no existent multivariate normality and there’s a T/F, Y/N, Binomial parallel of dependent variables. This is key because we mainly use logistic regression for classification problems! I know, it’s named logistic regression, but it’s used on classification problems. This is different than multi-linear because multi-regression doesn’t take categorical based variables. This results in the predicted output to be discrete within a range of 0 to 1. Logistic regressions also have a “S” (sigmoid function) shaped visual graphic to showcase the relationship whereas linear is a single straight line.

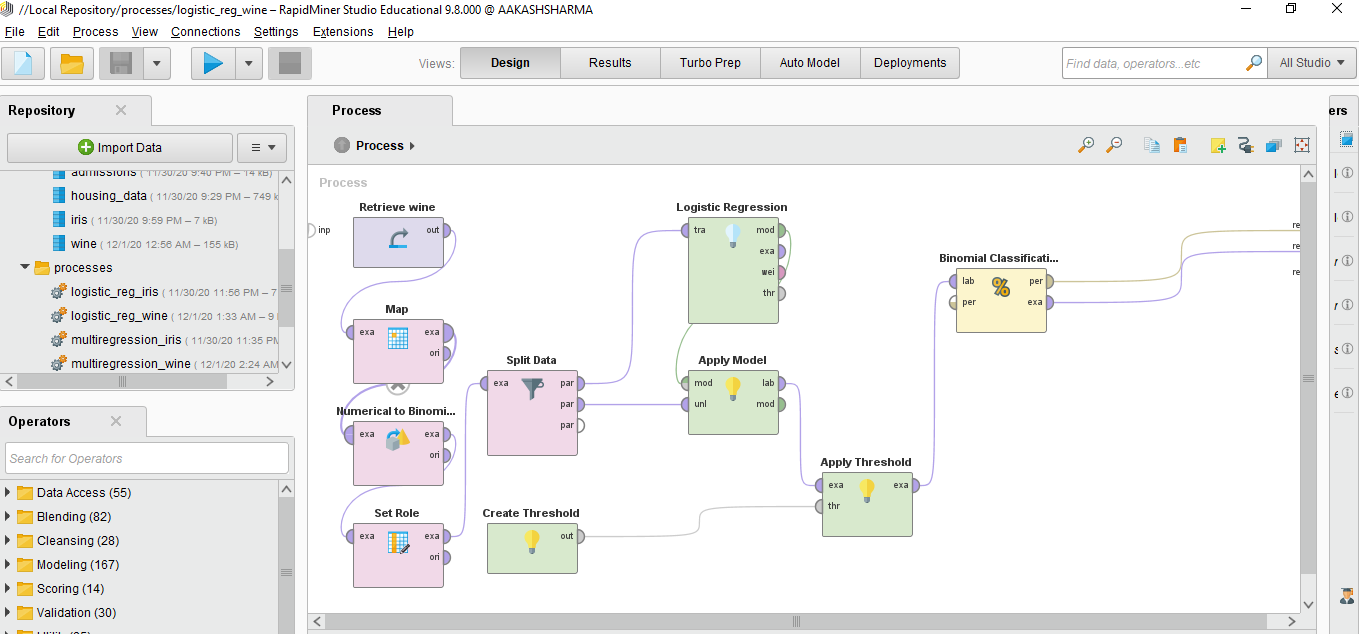
This ends up being more computationally expensive. Multi-regression can be mentally visualized throw a multidimensional scatter plot with multi-linear (multiple lines) trends occurring. Logistic regression, sick/not sick, dead/alive, etc. is more simplistic. This is the key difference between the two!

**b) Demonstrate: Using any data, and any tool set you’ve learned about, show differences.**

To fully understand the differences between Logistic Regression and Multi-linear regression, I will provide visuals such as screen shots of my models, their respective statistics, any graphs and charts that show case their performance on the exact same data set. The data set used is the same as above in the principal component analysis example regarding red wine. The target variable of both, the RapidMiner Studio label, is the quality of the red wine. We should use the same data set and variable of interest to gauge the performance, purpose, and difference of each. I’ll first provide screen shots of the models and then I will discuss the differences.

The model files from RapidMiner Studio as well as the red wine data set will also be provided in my GitHub repository, submitted separately.

**Logistic model on the “Red Wine” dataset from UCI’s ML Repository**

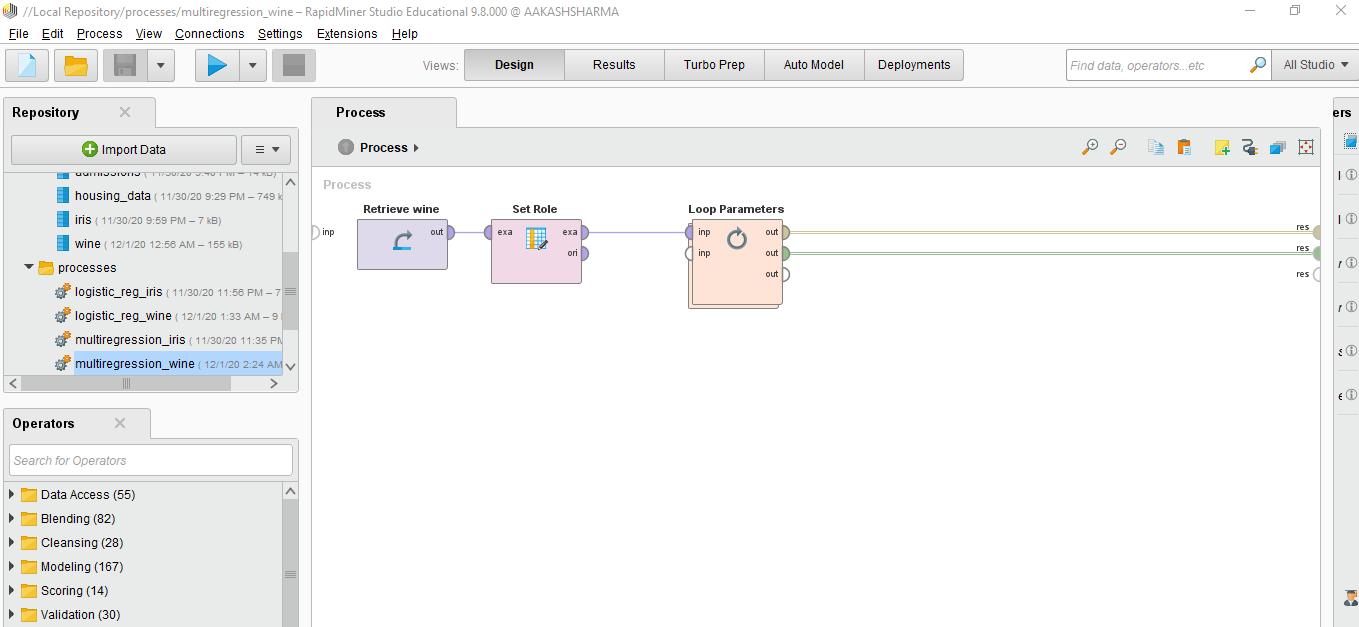


Logistic Model Building Process:

* Import “Red Wine” data set from UCI ML Repository
* Isolate the “quality” column as our variable, or Y variable of interest
* **Logistic Regression relies on Binomial, Yes/No, True/False, 0/1**
  + Group “quality” values of 0-5 as low, and map them using the value as 0 using the “Map” block
  + Group “quality” values of 6-8 as high, and map them using the value as 1 using the “Map” block
* Take a subset of the “quality” variable, and then convert the 0’s group and 1’s group, to True/False, true being 1 and false being 0 respectively using the “Numerical to Binomial” block
* Set the “quality” column as the label or predictor column using the “Set Role” block
* Train/Test/Split the data using a 70% training set, 30% testing set, a randomized shuffle of the data with a local random seed of 1992
* Run the data through the “Logistic Regression” model block using the “Apply Model” block to apply a model on the example set.
  + Usually, the goal is to get a prediction on unseen data or to transform data by applying a preprocessing model (RapidMiner Studio).
  + Have model “Standardize” numeric columns to 0 mean and unit variance
  + Include constant term in the model by adding intercept
  + Have model compute p-values
  + Have model remove collinear columns in case of linearly dependent columns
* Create and apply 75% threshold for crisp classification based on prediction confidences by specifying the classes of the wine set as first and second class, respectively.
  + Should it occur that the confidence for the second class is > than the given threshold then the prediction is set to this second class otherwise it is set to the first class (RapidMiner Studio).
  + This helps with model performance 😊
* As stated above we can use a Logit Regression model for classification problems
  + This is a Binomial Classification problem!
* Run the model, assess, and analyze outputs

**Multi-Linear Regression model on the “Red Wine” dataset from UCI’s ML Repository**

Multi-Linear Regression 1st Level Hierarchy (Outer Shell)

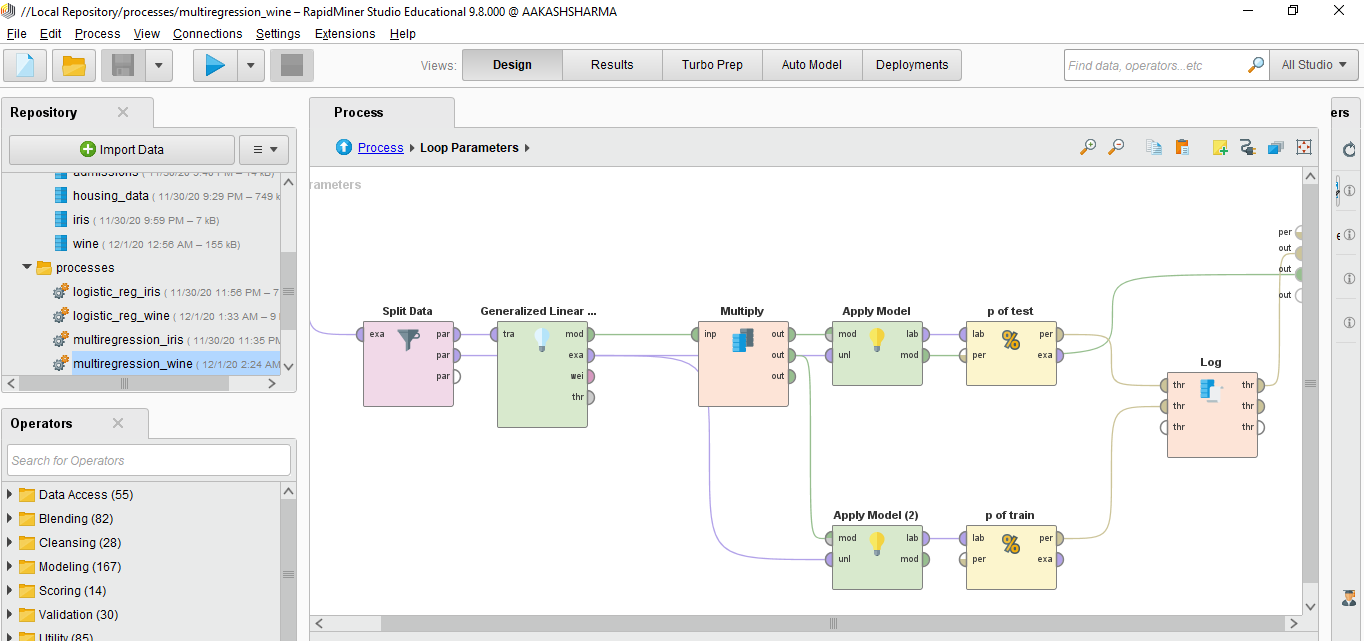


\*Note\* The “Inner Shell” exists within the “Loop Parameters” block (purpose of this block is stated within the model building process below). You must double click that to enter the inner layer where the model exists. This is currently the outer layer!

Multi-Linear Regression Model 1st Level Hierarchy (Outer Shell) - Building Process:

* Import “Red Wine” data set from UCI ML Repository
* Isolate the “quality” column as our variable, or Y variable of interest
* Utilize the “Loop Parameters” block to handle errors where it will fail on errors
  + Our parameter is our model, is passed within this loop block
  + Our model being multiple, or 2, Generalized Liner Models and its Lambda function
  + Lambda application on the model allows shrinking or regularization of the coefficients, this is different than a Logistic Regression as, Logit models will sacrifice lambda functions – Lasso or Ridge Regression Metrics
    - Prediction accuracy can be improved
    - Variance in the data may decrease
    - Model interpretability improves

Multi-Linear Regression 2nd Level Hierarchy (Inner Shell)



\*Note\* if you want to go back up a hierarchy or directory in RapidMiner Studio, click the Process next to the “Loop Parameters” statement.

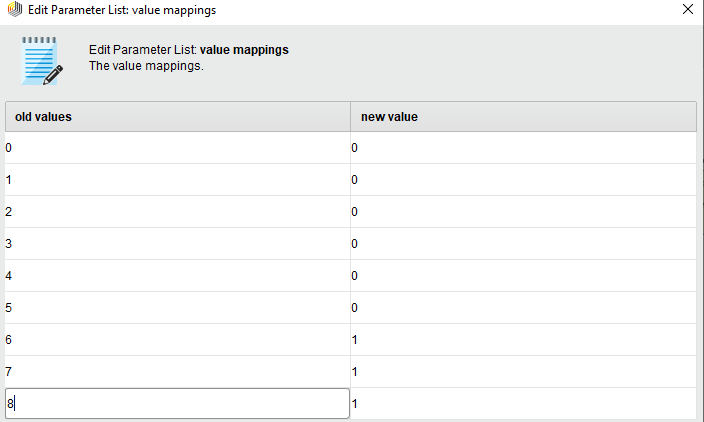
Multi-Linear Regression Model 2nd Level Hierarchy (Inner Shell) - Building Process:

* Train/Test/Split the data using a 70% training set, 30% testing set, a randomized shuffle of the data with a local random seed of 1992
* Create a Generalized Linear model
  + Utilize regularization
  + An alpha value of 0
    - Alpha parameter controls distribution between the L1 (Lasso) and L2 (Ridge) lambda penalties
    - Alpha value of 1.0 is Lasso and 0.0 produces Ridge – I use a Ridge
* Use a “Multiply” operator to create multiple copies, in this case, multiple models of our model. We create two for this example
  + Multiple here creates two models in the background that’s why we don’t see another block. This way changing one model won’t change another model
* Run the data through our generalized linear regression model block using the “Apply Model” block to apply a model on the example set.
  + Since we have two models, we have two different apply model blocks
* As you would expect, we have two model performance blocks:
  + One to gauge how one similar generalized linear model performs on test data
  + And the other to gauge the similar generalized linear model performance on the training data
  + The performance blocks both utilize:
    - Root Mean Squared Error
      * Average Root Mean Squared Error (RapidMiner Studio)
    - Squared Correlation
      * Returns the squared correlation coefficient between the label and prediction attributes (RapidMiner Studio)
* Finally, we apply a “Log” Operator to see the values calculated during the execution of the process
  + Examine values of different parameters in all iteration of the loop
  + A log curve is applied as well giving us:
    - R Square of training, the p value(s) of the training set and the squared correlation
    - R Square of testing, the p value(s) of the testing set and the squared correlation
    - Lambda

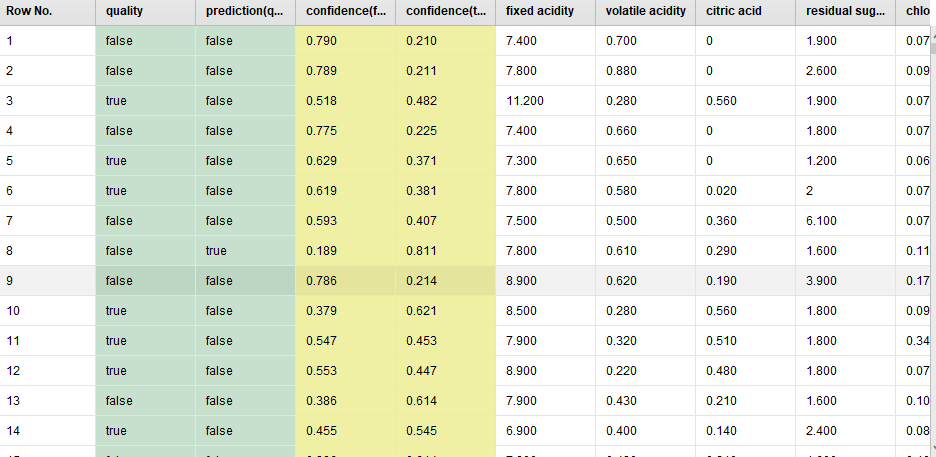
**How the Chosen Models Differ? How do we see the difference between the two models and the characteristics?**

* Logistic Regression uses a dichotomous relationship such as True/False, 0/1, Yes/No whereas the Multi-Linear Regression doesn’t:

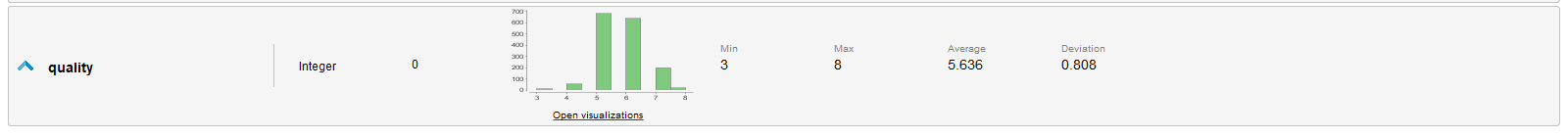
Here we map binary values, 0 and 1 within our label variable, or our predictor Y-variable which is the quality variable within the wine data set.



Next, we convert the 0’s and 1’s to binomial relationship that the logistic regression classifier can recognize and process. If you don’t do this, you get errors within the model building process that require this fix.

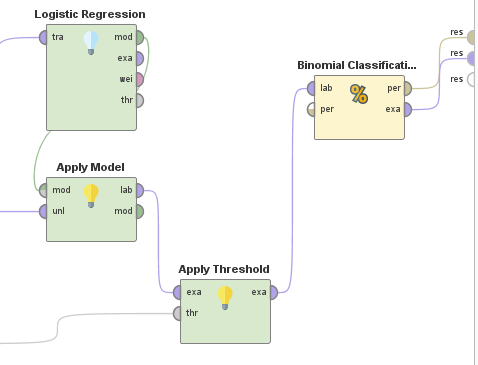


Our Logistic Regression model uses discrete variables whereas our Multi-Linear Regression uses continuous variables. Therefore, mapping a nominal (quality predictor string variable) to numerical (0’s and 1’s) to binomial (True and False) is required here. RapidMiner complains and will not allow the model to successfully run. We don’t have to dummy variable, one-hot encode or map our Y-variable in our Multi-Linear Regression data set whereas we did so in our Logistic Regression model. We can click the statistics tab to see our spread of the quality wine in our Multi Regression based model



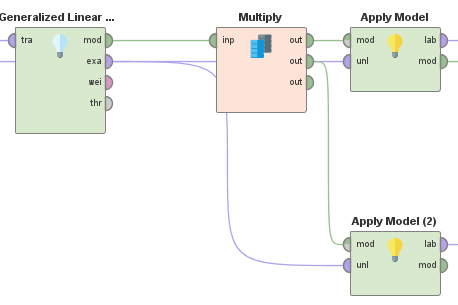
Our Logistic regression is more of a predictor model as it says based off a single x-variable can we predict the Y-variable. Our Multi-Linear Regression uses many linear relationships of the different quality of wines, meaning we never had to map or convert the ranges of quality wines. The range was 0-8, 0 being low quality and 8 being the best quality. We grouped, the range 0-5, as low-quality wine and the range 6-8, as high-quality wine. This grouping was only done in the Logistic Regression model. It was done to have two classes, which is dichotomous.

* Logistic Regression model performs as both a classification and a regression model. On our wine data set, we see how the Logit model is used as a binomial classification model:



It seems counter intuitive for a Logistic Regression model to be used as a classification model. Our model is used statistically to predict, the probability of a certain class existing based off a dependent variable. The probability of predicting a higher quality of red wine vs. a lower quality of red wine based off the ratio of quality wine. This gets more into cross-entropy and gradient descent which are “under the hood” tools that the RapidMiner Logistic Regression model utilizes.

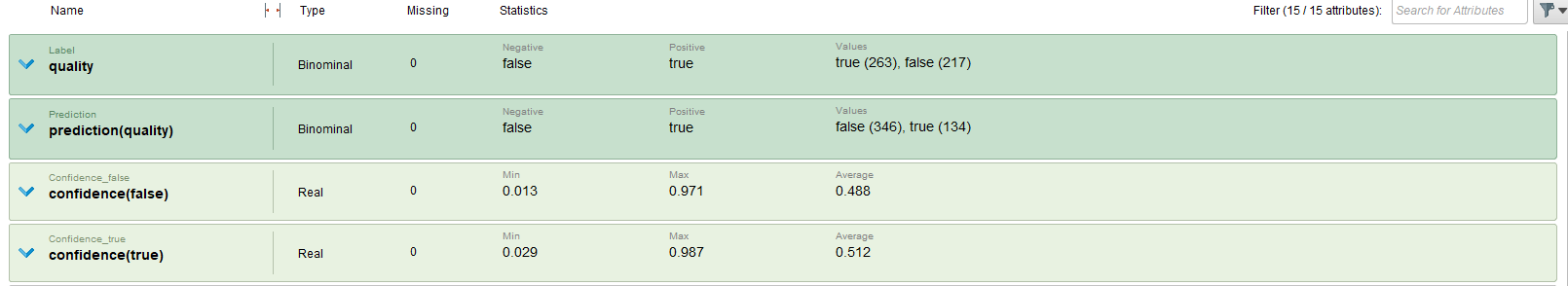
Our Multi-Linear Regression model differs here because we leave the labeling, the y-predictor variable alone, and create two generalized linear models, multi-models, in order enact two different linear relationships on the same data structure.



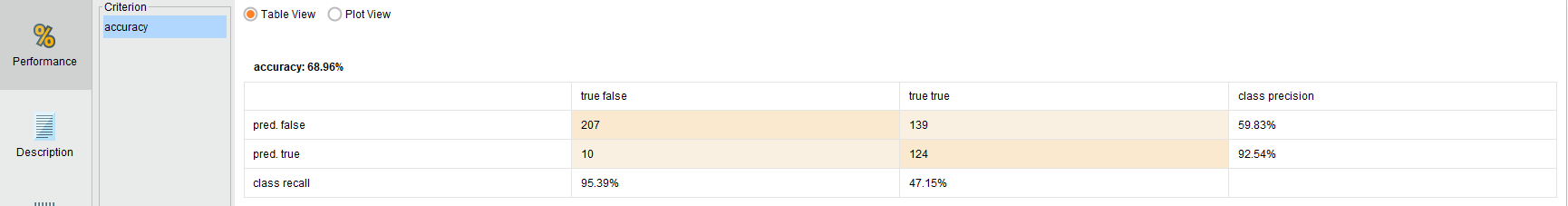
* We can see how the models perform on the same data set:

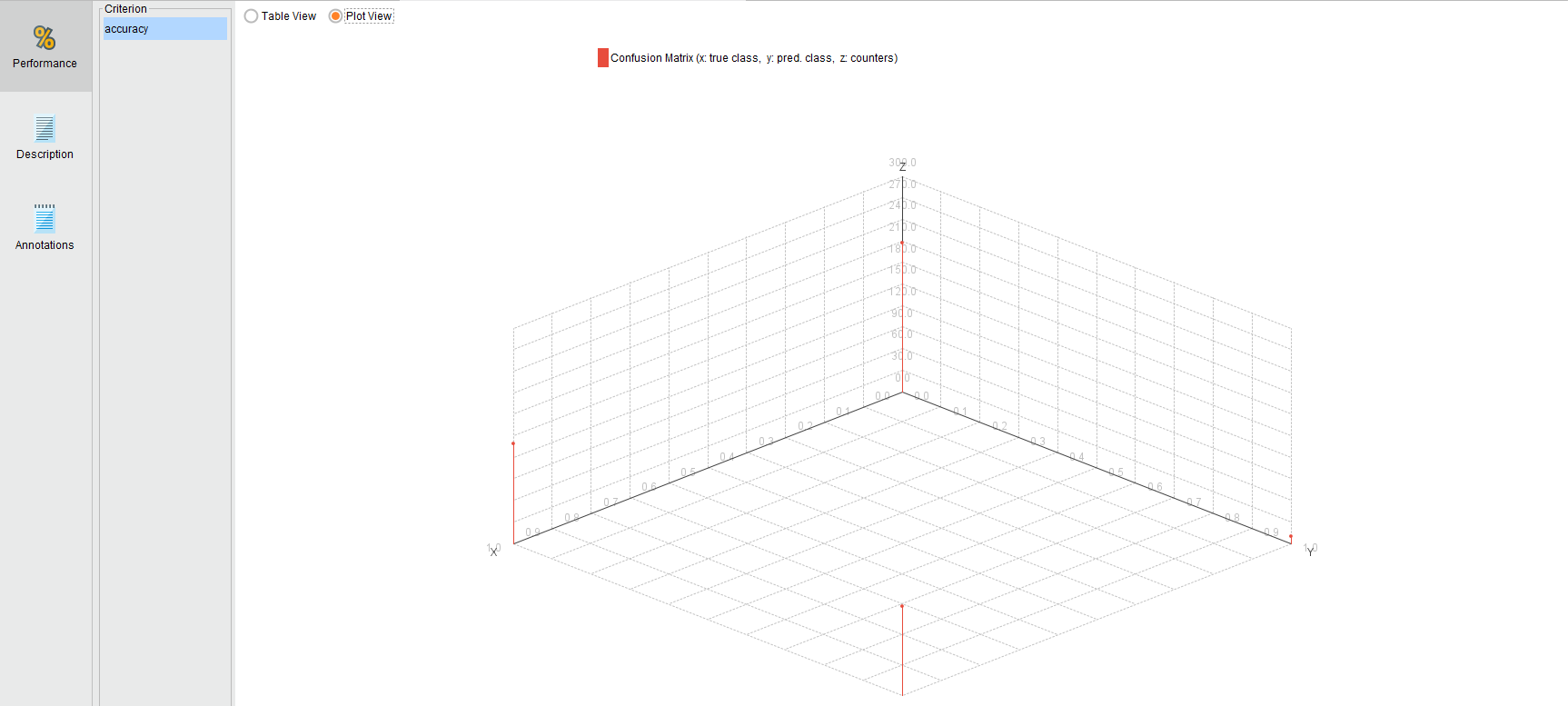
Logistic Regression Results and Analysis

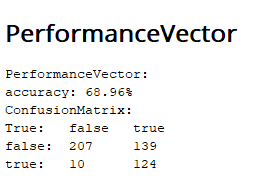
This image allows us to see how the model predicts the quality based off of the binomial labeling, both before and after. This is in the statistics pane of viewing the data before modeling, and after.



These next three images showcase the same thing, the confusion matrix. A confusion matrix is great for showing false positives (FP), false negatives (FN), true positives (TP) and true negatives (TN). This confusion matrix also provides the precision which shows us how close estimates are from unalike trials are to each other. The standard error is a measure of this!When it’s small, trial estimates are more precise vs. when it’s large, which means they’re less precise. We are also given the accuracy of our model when it comes to predicting TP, FP, TN, and FN.

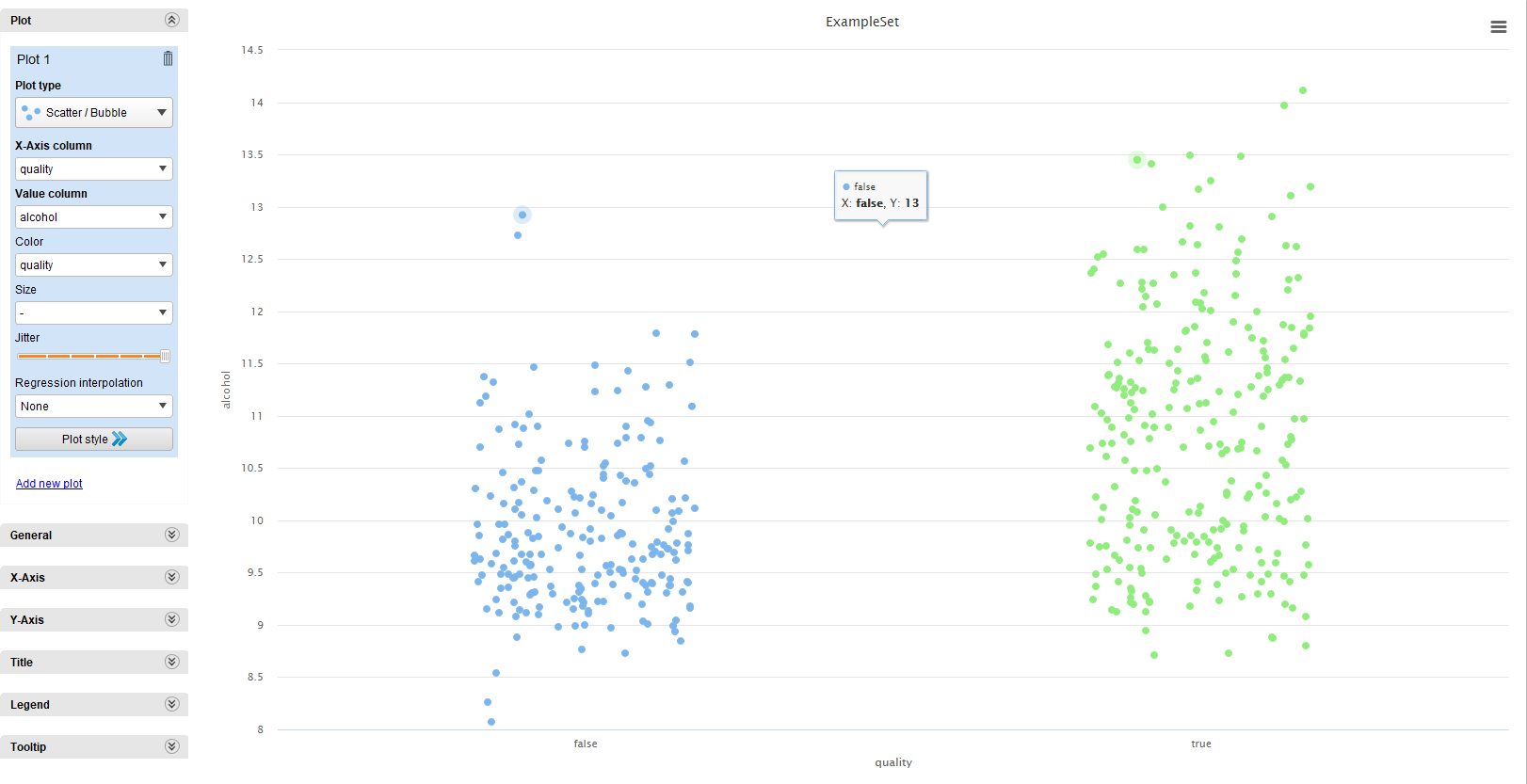






Our analysis here is just viewing the “quality” data column over another dependent variable, before and after predictions are made. This is good for some exploratory data analysis before model building and after model building. This works best here because it’s two dichotomous variables whereas this would be hard for our multi-linear regression model.

Before Modeling:

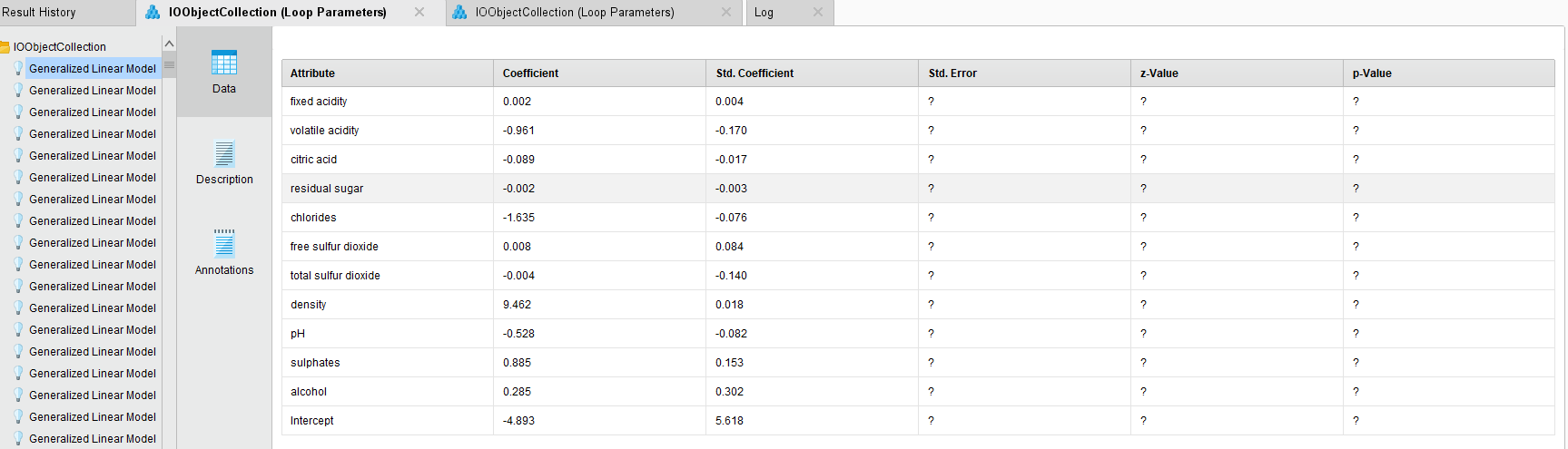


After Modeling:

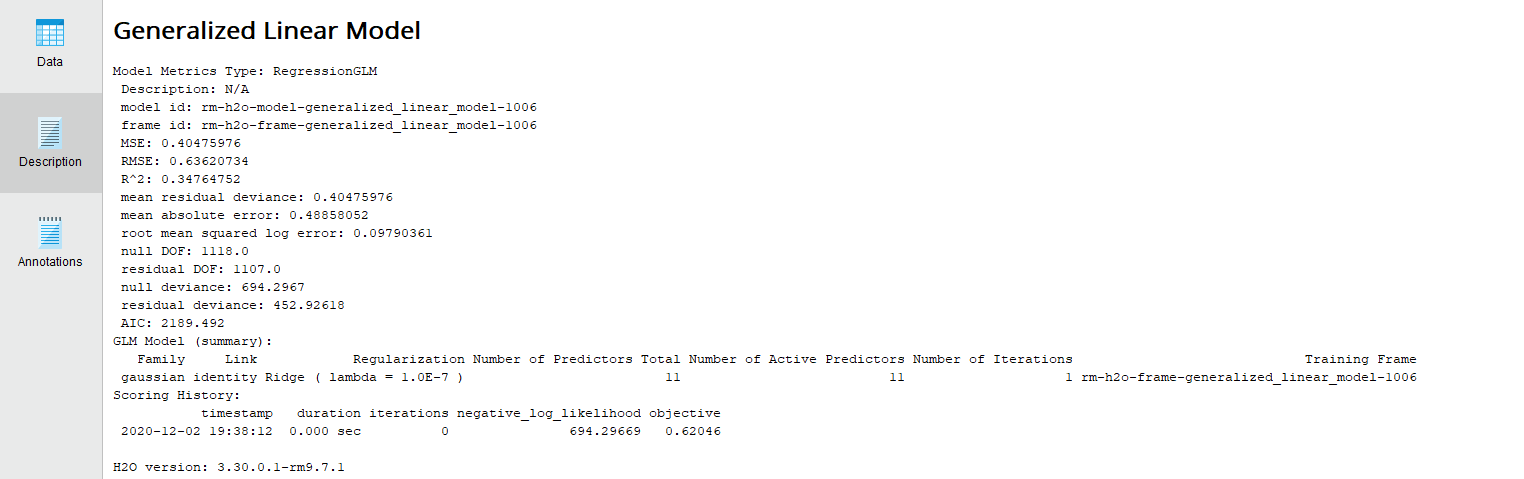


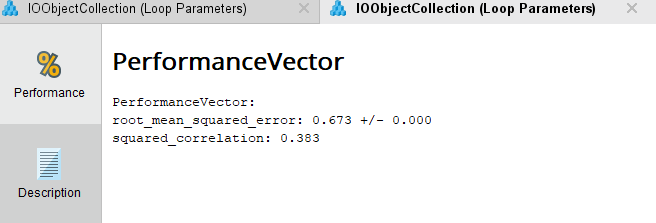
Multi-Linear Regression Results and Analysis

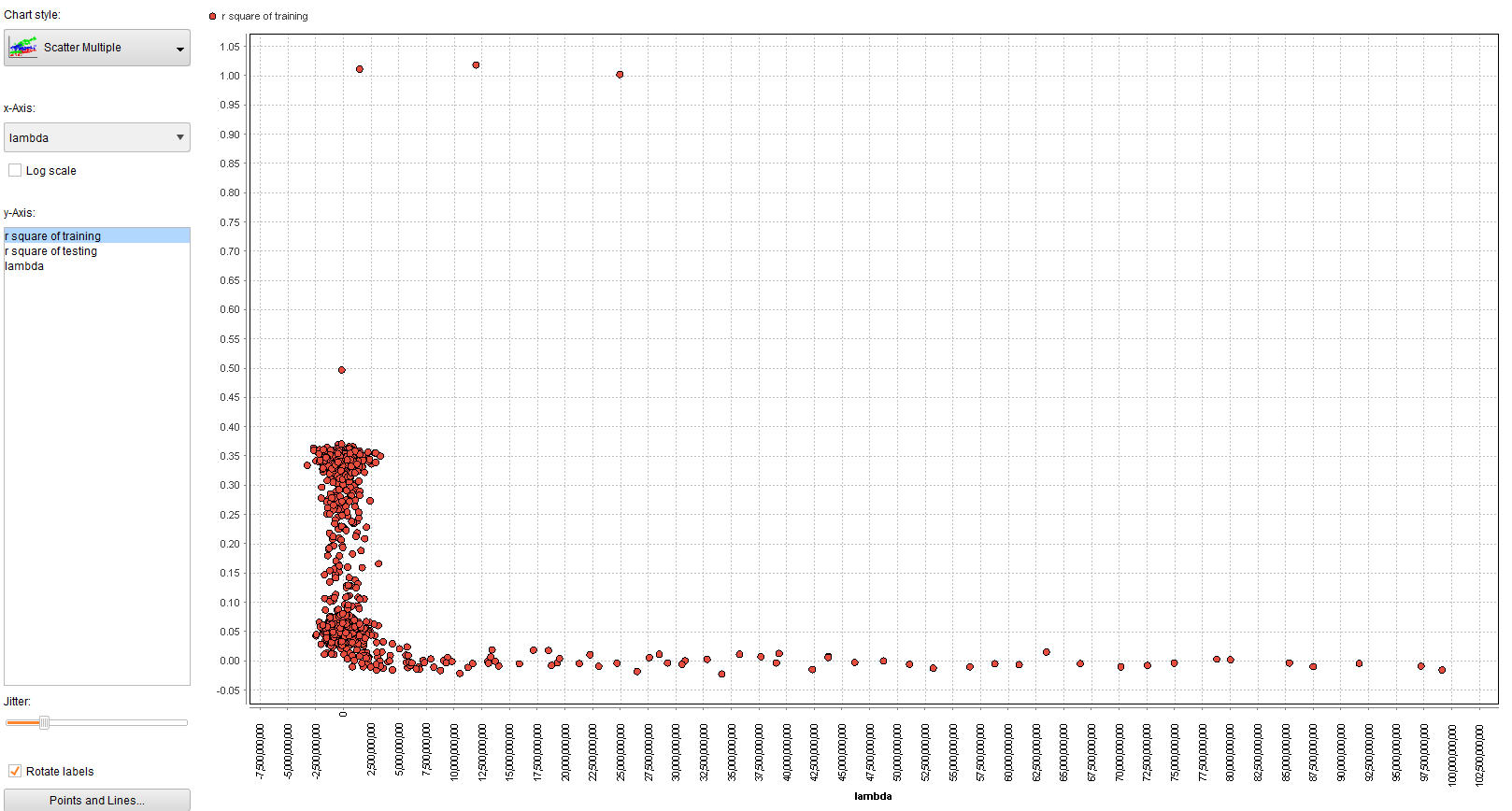
This visual is given since we’re dealing with multiple linear regression models, so the coefficients are given. These positive and negatives values multiply the predictor values, indicating the direction of the relationship between a predictor variable and response variable. No sign indicates a positive proving that as the predictor variable increases, the response variable also goes up vice versa for negative signs. Logistic doesn’t have this since it’s “S” shaped!

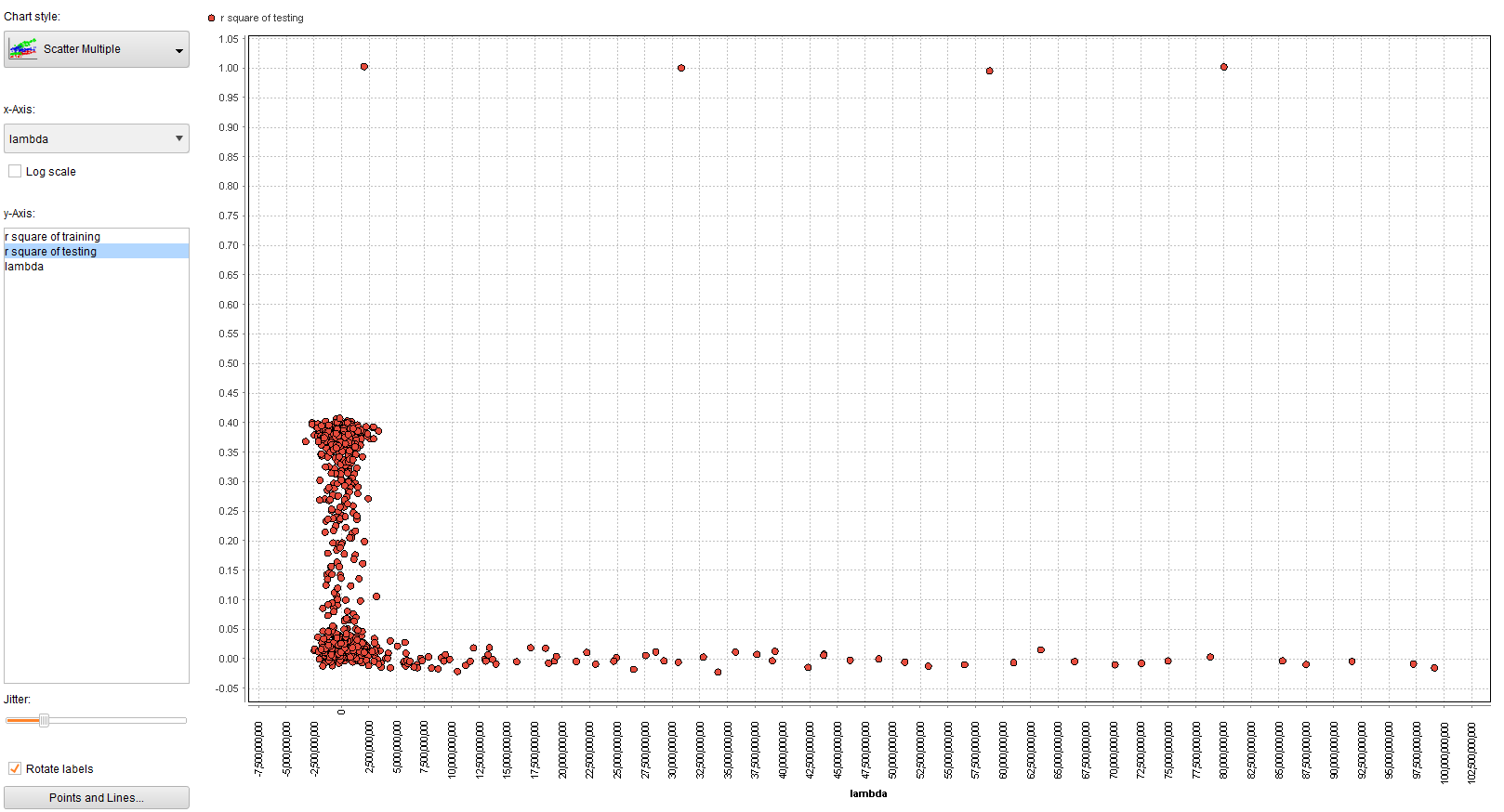


Here we can analyze how the model performed and some more statistical analysis. This wasn’t provided in the Logistic Regression modeling. Here the root mean squared error is given which is key to comparing the model performance.









Graphical user interface

Description automatically generated

BONUS:

Here we can use the cool and unique AutoModel tool that RapidMiner Studio has a built-in function. We can compare other models that RapidMiner Studio to the two models we’ve built. All of these models are built around the red wine quality data set from UCI with the same target variable, quality, in each. This offers really insightful details on what models perform the best, statistics relating to those models, and how we can deploy them. We see from this that our models, the Logistic Regression and Multi-Linear Regression (Generalized Linear Model) performed the same in every category.

We see based off of the accuracy score of the logistic regression model that it performed about ~68% in predicting a quality variable, high or low, based off of the spread of another dependent variable. This is the accuracy score, which is key in understanding a model’s performance. Now the multi-linear regression model doesn’t have an accuracy score, however, it has a root mean squared error score of ~67.3%. This is very kind of like our logistic regression accuracy model score. It’s good to understand that the basis mean squared error may be a good measure of accuracy, however, we only use it to match prediction errors of various models for a selected variable and not between variables. this can be because it’s scale dependent. It seems that our models performed relatively the same on the same data set, despite the differing model building processes.