# 40.016 The Analytics Edge: Data Competition

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# Introduction

This report served to document the approach and results of the model(s) used in the [40.016 TAE Data Competition](https://www.kaggle.com/competitions/2022tae/overview), which is about Twitter Sentiment Analysis. This competition aims to develop a model that accurately classifies tweets (The categories are; 3: Positive, 2: Neutral, 1: Negative) in any dataset. This report will briefly cover some of the data cleaning processes, models tested, and finally our best model which we adopted during the competition.

To make things easier for our understanding, we mirrored the sentiment values to **1: Positive**, **0: Neutral** and **-1: Negative** in our model.

# Approach

## Data Cleaning

In the data cleaning process, a separate script “clean.R” is written to clean and save both train and test data as separate data files to be used for the training and testing of the model. In this script, the function **clean\_data()** is executed to clean each data set. This function utilizes the **Corpus Library** and includes a step to clean the tweets in the data set to remove discrepancies while preserving information from the punctuations. In this step, the tweets from each row are passed into **clean\_punc()**, a function that takes in a string and outputs **“out$words” and “out$punc”** which are the cleaned words and punctuations respectively. The **clean\_punc()** function does the following in the cleaning process:

### Extract emotions/emoticons from the punctuations

To preserve information from the punctuations, 5 categories are created to represent a certain type of emoticon or emotion. Each category saves a binary value of whether the string contains the emotion or emoticon, which would be useful in the training and testing of the model. The 5 categories are defined as such:

* “excl” : indicates 1 when the string contains an exclamation mark “!”, 0 otherwise
* “qsnm” : indicates 1 when the string contains a question mark “?”, 0 otherwise
* “dott” : indicates 1 when the string contains at least 2 consecutive dots “..”, 0 otherwise
* “smle” : indicates 1 when the string contains an emoticon of a happy face (eg. “:)” ), 0 otherwise
* “sadd”: indicates 1 when the string contains an emoticon of a sad face (eg. “:(“ ), 0 otherwise
* In determining whether the string contains happy or sad emoticons, a dataset was found online which contains the most relevant emoticons from Wikipedia and conveniently assigns a sentiment value to them.

The data was saved as **“emoticons\_long.csv”** and is sourced in the R script. As can be seen in Figure 1, the first 4 emoticons are smiley faces and have a score of 1, indicating a positive sentiment. Inversely, emoticons that are sad faces have a score of -1. In the clean\_punc() function, the positive and negative emoticons, which are extracted from the dataset, are compared to the extracted punctions from the tweets. The clean\_punc() function then assigns the 0 or 1 to the categories “smle” and “sadd” depending on whether the string contains the respective emoticons.

Figure First 5 rows of emoticons\_long.csv

The binary values of the 5 categories are then saved as a single row data frame and is outputted from the function as “out$punc”. These out$punc from each row of the data set are then compiled and finally added to the columns of the data before being exported and used for the model.

### Remove URLs and links

Many of the tweets in the datasets have website links in them. These links would naturally be filtered out as sparse terms are removed from the Corpus functions. However, in the process of detecting happy or sad emoticons, the website links may contain punctuations that lead to a false assignment of “sadd” or “smle” categories. For example, “http://www.empireonline.com/100greatestgames/” contains the emoticons “:/” which would be detected by the function as a negative emoticon and assign 1 to the “sadd” category in the out$punc output. Therefore the **URL and links are removed** to **prevent false detection** of emoticons.

This is done by checking if the separated words in the string that contains characters such as “http”, “.com” or “.net” would be a clear indicator that the separated words are a website link.

### Correct spelling of misspelt words with three or more consecutive letters.

As there were many misspelt words in the dataset, they would not be detected by the model. Therefore, the **“spellcheckr” library** was used to correct the spelling of words in the dataset. However, correcting all the words in the dataset would take a very time. To speed up the process, only words that contain three or more consecutive letters are corrected (eg. “awwww” , “happyyyy”, “heyyyy” ). Such words occur very frequently in the data set and would significantly improve the model when their spelling is corrected.

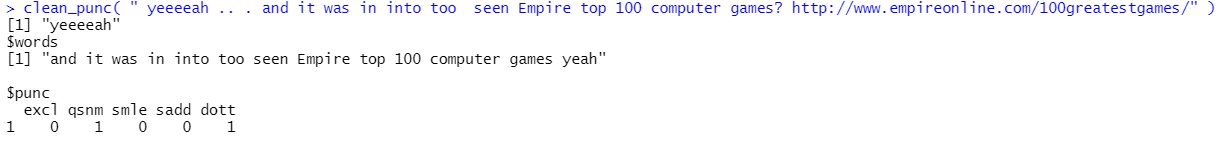
With all the above features of the clean\_punc function, each row in the clean and test datasets are cleaned effectively as such: 

Figure clean\_punc() example

Utilizing the outputs from clean\_punc, out$words is updated to each row in the corpus variable, while out$punc from each row is compiled and saved to punc\_df, which is eventually appended to the columns of the final dataframe. Stopwords and punctuations are then removed from the corpus variable before it is stemmed. Afterwards, sparse terms are only removed from the training dataset. This is so that all the words from the testing dataset are preserved to maximize the amount of information from the test data to give the best results when its sentiments are predicted from the model.

## Data Classification

![Diagram

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4ShiRXhpZgAATU0AKgAAAAgABgALAAIAAAAmAAAIYgESAAMAAAABAAEAAAExAAIAAAAmAAAIiAEyAAIAAAAUAAAIrodpAAQAAAABAAAIwuocAAcAAAgMAAAAVgAAEUYc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFdpbmRvd3MgUGhvdG8gRWRpdG9yIDEwLjAuMTAwMTEuMTYzODQAV2luZG93cyBQaG90byBFZGl0b3IgMTAuMC4xMDAxMS4xNjM4NAAyMDIyOjA4OjE0IDEzOjA1OjU1AAAGkAMAAgAAABQAABEckAQAAgAAABQAABEwkpEAAgAAAAM2MAAAkpIAAgAAAAM2MAAAoAEAAwAAAAEAAQAA6hwABwAACAwAAAkQAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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a model to predict three different kinds of sentiments requires multiple steps to split the data into different categories. As such, our Data Classification Process utilizes two models, a **neutral model**, and a **non-neutral model** (refer to Figure 3) to predict Neutral, Positive and Negative Sentiments.

Doing so allows us to separate the neutral tweets from the non-neutral tweets first before predicting whether they are positive or negative. The intuition behind this is that sentiments that are more likely to be positive are less likely to be negative. For example, if a tweet is “I am feeling happy today”, the model should predict that it is more likely to be positive and less likely to be negative. Therefore, by filtering out the non-negative data in the first model, we are best able to predict negative and positive sentiments in the second model.

We decided to classify the sentiments we gathered by passing them through the neutral model where it would be tested for whether the sentiment is neutral or non-neutral. However, there may be some rows from the predicted non-neutral data that are neutral in sentiment. This may lead to more inaccuracies when it is passed to the second model. To address this, we filtered out rows that may be neutral from the predicted non-neutral data. To do this, the predicted non-neutral data is screened to see if it contains the significant predictors from the non-neutral model. If a tweet does not contain the significant predictors from the second model, it should more likely have a neutral sentiment. For example, given a tweet, “I am feeling bored today”, is predicted as non-neutral data, but does not contain any words that are significant predictors from the second model, it is more likely to be a neutral data.

Figure 3 Data Classification Diagram

Upon filtering the neutral data from the non-neutral data, we then passed the non-neutral data through the non-neutral model which will determine whether the sentiment is positive or negative.

### Models Tested

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| --- | --- | --- |
| Model 1: Logistic Regression | Model 2: Random Forest | Model 3: Logistic Regression and Random Forest |
| We used this model to filter columns with a p-value of 0.1.  Test Accuracy was 0.6950163 and 0.8267831 for the neutral model and non-neutral model, respectively. | We used the random forest function to classify words.  Test Accuracy was 0.6862365 and 0.823225 for the neutral model and non-neutral model, respectively. | Using this model, we shortlisted the best predictors using a logistic regression by p-value 0.1, and applied the predictors onto a random forest model.  Test Accuracy was 0.6933527 and 0.8245188 for the neutral model and non-neutral model, respectively. |

### Final Model Used

Despite the higher accuracy values in Model 1, we prioritised Model 3. This is because Random Forest uses no statistical assumptions and can handle multicollinearity better. Moreover, unlike Logistic Regression, Random First is more robust to overfitting and outliers.

### Leaderboard Results

We achieved a test accuracy of 0.63477 on the Private Leaderboard and 0.65672 on the Public Leaderboard.

# Model Interpretability

A classification model using Random Forest is more comprehensible when compared to using more complicated neural networks or any deep learning algorithms. The costs involved in an improved model performance are much lesser too. Thereby, more focus can be prioritised on the data cleaning instead of training the model. The downside of this model is its accuracy level when compared to neural networks.

# Conclusion

Throughout the TAE data competition, our group prioritised data cleaning over training a complicated model. We felt that with a better-cleaned dataset, any model would have performed well as the necessary words have already been classified.

Our group also prioritised data pre-processing using libraries and other functions, instead of manually adding common words used in the dataset. This is because we felt it was important to build an algorithm that can be used in any given test dataset and not a specific one. Some of the possible improvements our group could have done were to maybe train a slightly more complicated model to attain a higher accuracy.

# Project Limitations

* Words classified as positive and negative might not always be associated with only positive or negative sentiments, respectively. Such models may fail to classify sarcastic tweets.
* Words may not be corrected correctly in the data cleaning process. For example, “seeed” would be corrected as “see”. Examples like this make it difficult for the clean\_punc function to extract the correct information from the tweets correctly.
* With a wide range of words extracted from the training dataset, we were unable to find the optimal subset of the dataset using K-fold cross-validation.
* One weakness in our model is that whatever inaccuracies from the model in phase 1 would transcend into phase 2 and that would lead to even greater inaccuracies.
* We used the data file of emoticons\_long.csv which has emoticons in it where values may be incorrectly assigned which may then affect the accuracy of our data gathered.

# Project Repository

* <https://github.com/chiragshiva99/TheAnalyticsEdge-DataCompetition.git>

# References

* Matbun, Matbun/Emoticons-Dataset. *GitHub*. Available at: https://github.com/matbun/Emoticons-dataset [Accessed August 10, 2022].