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# **TEXT ANALYSIS OF AIRLINE TWEETS**

by

**Essa ALTamimi**

**A Capstone Submitted in Partial Fulfilment of the Requirements for  
the Degree of Master of Science in Professional Studies:**

**Data Analytics**

**Department of Graduate Programs & Research**

**Rochester Institute of Technology**

**RIT Dubai**

**April 2022**

# RIT

**Master of Science in Professional Studies:  
Data Analytics**

**Graduate Capstone Approval**

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Graduate Capstone Title: **TEXT ANALYSIS OF AIRLINE TWEETS**

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**Date:**

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## Abstract

By acting as a succinct summary, keywords and key phrases can be a useful tool for swiftly assessing enormous amounts of textual material. A "keyword" is defined as a "word that briefly and accurately characterises the subject, or an aspect of the subject, presented in a text," according to the International Encyclopaedia of Information and Library Science (Bolger et al., 1989) (Feather et al., 1996). People are more likely to complain when they are anxious, according to research (Bolger et al., 1989)(Meier et al., 2013), and moods are affected by time (Ryan et al., 2010). Due to this study, airlines will have a tool to calibrate and judge the positivity/negativity of tweets based on the day of the week, which is a topic that has yet to be researched. We want to do text and sentiment analysis on extracted airline travel tweets, taking into account when the tweet was 'tweeted' and if it had a good or negative impact.

**Keywords:** social media, customer experience, supervised learning, airline tweets, text analysis, classification.

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# Chapter 1

## 1.1 Background

Social media is a powerful source of communication. Information extracted and analysed from social media offers valuable insight for companies regarding their products and services. A customer's experience is an important concern for the air-travel industry in particular, and Twitter has become a popular platform for travellers to share feedback. Airline companies invest time and resources to enhance customer loyalty. By exploring customer feedback, airlines can allocate resources to the weak areas of customer satisfaction, increasing economic and social development of the company. Without the use of machine learning and artificial intelligence, orthodox businesses spend hours of human effort completing manual annotations of tweets to group them into positive/negative sentiments, thus increasing the Time to insights.

Moreover, errors that occur from humans can affect the manual text tagging accuracy, such errors can result from fatigue or overconfidence. However, computer aided Text Analysis (NLP) can reduce this time to a few minutes.

## 1.2 Statement of problem

Interpreting and classifying opinions and emotions in subjective data (like tweets) is referred to as sentiment analysis. Sentiment analysis of customer experience is a hot topic and is applied in various industries, such as finance, business, politics, and risk assessment. Some researchers (Kandasamy et al., 2020) (Rezaeinia et al., 2019) (Yadav et al., 2020) have discussed various machine learning, artificial intelligence, and deep learning, and other techniques for sentiment analysis such as Word embedding, Deep Belief Network, Recursive Neural Network, Recurrent Neural Network, and approaches involving Refined Neutrosophic Sets.



While general frameworks have been explored, we will be utilizing these in conjunction with machine learning methods on a twitter sentiment analysis for this project.

Keywords and key phrases can be a useful tool for analysing large amounts of textual material quickly by serving as a concise summary. International Encyclopaedia of Information and Library Science (Bolger et al., 1989) defines a “keyword” as a “word that succinctly and accurately describes the subject, or an aspect of the subject, discussed in a document.” (Feather et al., 1996). Research suggests that people tend to be more willing to complain when they are stressed (Bolger et al., 1989) (Meier et al., 2013), and moods are affected by time (Ryan et al., 2010). Therefore, this project will provide airlines with a tool to calibrate and judge the positivity/negativity of the tweet based on the weekday (Sunday, Monday, ...), which is an issue that has yet to be studied. We aim to perform text & sentiment analysis on extracted airline travel tweets while also taking into consideration when the tweet occurred, and whether it has resulted in a positive or negative effect.

### 1.3 Project goals

- (a) To scrape the tweets mentioning the top airlines of interest
- (b) To identify the sentiment of the above scraped tweets
- (c) To analyse the relationship, if any, between time of the tweet and the sentiment of the tweet

#### **Research questions we aim to answer**

- 1) What causes negative sentiments in a tweet?
- 2) What causes positive sentiments in a tweet?
- 3) What is the effect of time on the sentiment of the tweet?

## 1.4 Methodology

List of innovations and why the method and visualization are better than state of the art:

- Comparing the accuracy of the results for both logistic regression and SVM.
- Making it possible to create a good classification model with greater than 65% f1 score after manually labelling as few as 10 samples per class
- Creating a new list of better stop words and processing the text based on these custom stop words to avoid changing the meaning when filtering the tweets while ensuring that the words that do not contribute much to the meaning of the text are removed.
- Studying the behaviour and correlation of sentiment with day of week.

Steps and algorithm:

### 1) Gathering data:

To gather data quickly and efficiently, we planned to use the web scraping software, Octoparse. Octoparse takes in a given URL and scrapes selected data. We spent some time testing this method and found that even if every team member commits to scraping data for a week, Octoparse would still fail to provide a large enough dataset. So, we explored other methods, and decided to use ScrapeHero.

To determine the airlines we want to analyse, we used those that have the largest revenues and most passengers carried, thus selecting Delta, American, Lufthansa, United, Air France, Southwest, China Southern, and Ryanair. Since COVID-19 disrupted the airline industry, we took tweets that mentioned these airlines prior to the pandemic, from August 2019 to December 2019. Using the advanced search provided by Twitter, we got a url for all the tweets meeting these criteria. ScrapeHero used this url and scraped the webpage, capturing the user's handle, the user's name, the tweet, the number of

retweets, replies, and likes, and the time and date of the tweet (unix timestamp). We exported this data as a csv file.

While cleaning this data, we found that ScrapeHero included tweets from outside the date range we specified, and some tweets that did not mention any airline. After excluding these, our data reduced by about 1,000 data points.

## 2) Collecting external resources/data:

While the above data was being labelled, we looked for a representative dataset and found the airline tweets dataset of “Crowdfower's Data for Everyone library” to train our sentiment classification model and build our model for few shots classification. We then applied these models in the relevant sections on our scraped dataset. This dataset (Crowdfower, 2019) was scraped in February 2015 and the tweets were classified into positive, negative, and neutral.

## 3) Building a machine learning model:

Several machine learning methods can be used to classify tweets. We explored two methods: logistic regression and support vector classifiers (SVC).

### 3.1) Logistic Regression model:

In this project, we train and test logistic regression that classifies tweets into positive and negative using the following algorithm, Python 3 and its relevant libraries:

First, we import the “Crowdfower’s airline tweets” dataset and identify relevant features (tweet text and airline sentiment). This dataset doesn’t include missing values. Then, we extract two subsets: one for positive tweets and the other for negative tweets. After that, each subset is further divided into training and testing sets. Then, the positive and negative sets are combined to form a training and test datasets. This ensures that each set has an equal number of positive and negative tweets.

Then, we process the tweets. This includes the removal of stop words, hashtags, username mentions, old RT style, hyperlinks, signs (such as \$). After cleaning the tweets, we split them into a list of tokenized words. Since negative stop words (non, not, nor, no, ...) can change the meaning and sentiment if removed, they are not included in the stop word list. Moreover, duplicate words are removed. Next, a dictionary is constructed counting the number each word appeared in positive and negative tweets. This dictionary is used to build a logistic regression model. Gradient descent is used to reach convergence. A cutoff of 0.5 is used to classify the tweets and predict the outcome. Finally, the test dataset is used to test the model and calculate the accuracy. In our model, the accuracy is around 82%.

### 3.2) SVC model with word embeddings:

SOTA techniques use word embeddings along with Machine learning models to increase accuracy. Word embeddings which convert text into numbers to create a dictionary decrease the amount of training data set and increase the performance of the Machine Learning model. For the prediction of sentiments, we had explored a combination of Word2Vec with SVC and FastText embeddings with SVC. From the crowdflower dataset, we had filtered and kept only the data instances whose confidence is 1 for training the model.

After applying the preprocessing steps on the tweets as we had done during logistic regression, we used the language model for generating the word embeddings of the clean tweets. These word embeddings then became the training feature for the Support Vector Classifier which could then give the output of sentiment. For the FastText approach, we used gensim to load the vector file from the common crawl models downloaded from fasttext (FastText, 2020) and converted it to a bin model because the loading time of the vector was more. We then continued to use gensim to load the bin model which helped in converting clean and processed tweets into embeddings of size 300. Such embeddings were generated on each tweet of both, crowdflower dataset as well as our crawled dataset. We trained the SVC model on the embeddings of tweets from crowdflower

dataset and we used the embeddings of each tweet from our crawled dataset as input features to give sentiment predictions on our crawled dataset,

#### 4) Correlation of tweet sentiment with day of the week:

We extracted the day of the week from the `date_stamp` of each tweet using Python's `datetime` module. Once the sentiment was predicted, we then gave a score of +1 to positive, -1 to negative and 0 for the neutral sentiment. After some missing value imputations and handling outliers, we then calculated the mean sentiment score for each day of the week in our crawled twitter dataset which we crawled using the mentioned tools.

After some further analysis, we got a correlation of -0.44 between day of the week and sentiment which means people were more negative towards the weekends than the weekdays. We also plotted the mean sentiment vs day of the week and also vs dates (August 1st to December 31st)

## 1.5 Limitations

In the past few years, the world of travel has seen a drastic change due to the pandemic, which led to various crests and troughs in the travel seasons. Due to this, there was a quick change in airline ticket fees which will definitely have an impact on the actual study of the airline tweets. Therefore, a model will be built based on the data from the pre pandemic era which would be the ideal solution.

## Chapter 2 – Literature Review

There have been several studies in the past which analysed the airline travel tweets across the globe. They had employed the usage of various methods and pipelines. They achieved varying reports of accuracy ranging between 50% to 90%.

Several papers available in literature have analysed social media complaints such as (Tsakalidis et al., 2018). They proposed an unsupervised method, utilizing information from the network and time sensitive text. In comparison to simply text-based models, their examination in a real-time simulation environment revealed the efficacy and resilience of their technique versus competing baselines, attaining a substantial 20 percent boost in F-score.

The research in (Suryotrisongko et al., 2018) used a tweet dataset of 3000 rows which was of the feedback for Surabaya's City Government. It was classified as a complaint or non-complaint tweet, and it resulted in systems that can categorise tweets automatically with an accuracy of 82.5 percent.

The fuzzy system which was proposed in (Vashishtha et al., 2019) integrated NLP techniques with Disambiguation of Word Sense leveraging a new unsupervised 9 fuzzy rule-based system which classifies the post into either of positive/ neutral or negative sentiments. Their results helped in choosing which lexicons are best for the use case of social media. Their method of fusion of fuzzy logic with lexicons for sentiment classes can be adjusted to any lexicon. They can also be adjusted for any dataset.

Recently, some papers have also analysed tweets of airline travel such as (Kumar et al., 2019), which used Python to retrieve tweets about airlines using twitter API and then used support vector machines and artificial intelligence networks methods to analyse those tweets. It demonstrated how to use ML to analyse tweets in order to improve the user experience. Word embedding with Glove dictionary technique and n-gram approach were used to extract features from tweets. CNN outperformed ANN and SVM models in this study, and it used association mining to map the link between tweets and sentiment categories.

In contrast, (Tiwari et al., 2019) proposed using machine learning to identify passenger tweets about aircraft services in order to better understand the emotional trend. On an actual dataset, they were able to reach an accuracy of around 80% using Random Forest (RF) and Logistic Regression (LR) to categorise each tweet into positive, negative, and neutral sentiment.

In (Khan et al., 2018), the paper's major goal was to analyse tweets about airlines from four different regions: Europe, India, Australia, and America, with the goal of predicting consumer loyalty. The TextBlob analyzer was used to do the sentiment analysis. The positive and negative mean sentiment ratings were then calculated and visually shown using the tweets. Random Forest, Decision Tree, and Logistic Regression were the three classifiers used. Random Forest has a maximum classification accuracy of 99.05 percent after 10-fold cross validation.

There were other models based on Transformers. Like, for example, for Twitter sentiment analysis, (Naseem et al., 2020) employed Transformer-based Deep Intelligent Contextual Embedding. In this, Deep intelligent contextual embedding was used to improve the quality of tweets by reducing noise and taking into consideration word sentiments, polysemy, syntax, and semantic knowledge.

(Jain et al., 2020) compared Random tree and Decision tree ML techniques to provide recommendations to customers using airline reviews. People are more likely to complain when they are anxious, according to research in (Meier et al., 2013).

An examination of the temporal effects of weekend and weekdays was required. We found (Ryan et al., 2010) which does exactly that in addition to exploring work versus nonwork experiences on mood and other well-being indicators too.

(Utama et al., 2019) did Sentiment classification on Airline Tweets. They used Mutual Information for Feature Selection. Despite recent advances in text analysis, many approaches have limitations for tweets (Wang et al., 2017). They proposed using convolutional neural networks framework. It combined implicit as well as explicit representations of short text for classification. They obtained the short text embedding by

joining the words and relevant concepts on top of pre-trained word vectors and further incorporating character level features into the model.

Text from twitter (tweets) fall under the category of short-texts since Twitter allows a maximum character length of 280 characters only and using supervised and unsupervised natural language processing methods, they performed analysis on approximately 350,000 tweet replies to U.S. politicians in (Jaidka et al., 2019). Therefore, unlike large paragraphs or documents, tweets might not observe the syntax of natural language thus including heavy usage of abbreviations and internet slangs (eg: LOL, ROFL, ...).

(Rezaeinia et al., 2019) utilised techniques such as POS tagging, lexicon-based approaches, and Word2Vec/GloVe methodologies in their method. They discovered that Improved Word Vectors (IWV) are particularly successful for sentiment analysis after comparing the method's accuracy with several deep learning models. (Yadav et al., 2020) looked at more of these methods.

Research in (Gautam et al., 2020) presented a semi-supervised bootstrapping approach that calculated transportation services related complaints on social media platforms and their main strategy began with a limited set of annotated samples, which were used to establish a preliminary set of language indicators relevant to complaints, which were then used to supplement data. This enriched data is then utilised to extract other indications using the same procedure, which is done until no more indicators can be located.

From 1961 to 2021, a survey publication (Li et al., 2020) was valuable in assessing state-of-the-art methodologies, concentrating on models ranging from classical models to deep learning. This study concluded with a summary of significant implications, future research directions, and issues facing the research area, as well as a complete comparison of different approaches and outlining the benefits and downsides of various assessment measures.

In summary, after studying through all the papers mentioned in the literature review, we feel inspired by the psychology paper and also found that there is a lack of papers which study the weekend effect on the emotional state and mood of the travellers thereby



affecting the sentiment of the tweets that they are posting. For this, we will have to scrape twitter for tweets and build a machine learning model that predicts the sentiments for us and execute the analysis for this. The literature papers referenced the use of traditional machine learning algorithms like Support Vector Classifiers and Random Forest Classifiers. We also got some insights into special cleanings and pre-processings that are required for a dataset involving social media and short texts. Finally, the survey paper (Li et al., 2020) was instrumental in providing a comprehensive list of different techniques so that we could design our experiments accordingly.

# Chapter 3 – Project Description

## 3.1 Airline Tweets

Companies can gain important information into their products and services by extracting and analysing data from social media. The air travel business, in particular, is concerned about the consumer experience, and Twitter has become a popular venue for travellers to communicate their thoughts. Without machine learning and artificial intelligence, traditional firms waste hours of human work manually annotating tweets to categorise them as good or bad, lengthening the time to get insights. Airlines devote time and resources to improving consumer loyalty. Airlines can direct resources to the weak areas of customer satisfaction by analysing customer input, resulting in increased economic and social development for the organisation.

Furthermore, human mood influence such as tiredness and skills might affect the manual text tagging accuracy. Computer-assisted Text Analysis, on the other hand, can cut this time in half. Sentiment analysis is the process of interpreting and classifying opinions and emotions in subjective data (such as tweets). Customer sentiment analysis is an important issue that is used in a variety of areas, including banking, business, politics, and risk assessment. Word embedding, Deep Belief Network, Recursive Neural Network, and approaches incorporating Refined Neutrosophic Sets are some of the machine learning, artificial intelligence, and deep learning technologies that can be utilised for sentiment analysis, according to some researchers.

While broad frameworks have been investigated, for this project, we will be using them in combination with machine learning approaches on a twitter sentiment analysis.

By acting as a succinct summary, keywords and key phrases may be a valuable tool for swiftly assessing enormous volumes of textual content. A "keyword" is defined as a "word that briefly and accurately represents the subject, or an element of the subject, covered in a document" by the International Encyclopedia of Information and Library Science.

People are more likely to complain when they are worried, according to research, and moods are impacted by time.

As a result of this study, airlines will have a tool to calibrate and assess the positivity/negativity of tweets based on the day of the week, which is a topic that has yet to be researched. We want to do text and sentiment analysis on extracted airline travel tweets, taking into account when the tweet was made and if it had a good or negative impact.

## 3.2 Machine learning

The purpose of machine learning (ML) is to use mathematical models of data to assist a computer in learning without being explicitly directed to do so. Machine learning is a subset of artificial intelligence (AI). Algorithms are used to analyse data and find trends, which are then utilised to develop prediction models. Machine learning, like humans, improves with more data and experience.

ML can be subdivided into further 2 subcategories:

1. Supervised Learning
2. Un-supervised Learning

The most popular methods of learning are supervised and unsupervised, with reinforcement being a sequential decision maker technique. Until now, machines have been unable to make decisions without being trained (Matthew Botvinick, May 2019).

Supervised learning is derived from the word supervisor, which meaning teacher. The class will be categorised or predicted in this scenario. The right answers were already marked with the matching class labels during what is called algorithm training. Support Vector Machines (SVMs), Random Forest Trees (RFTs), and Decision Trees (DTs) are common supervised machine learning techniques (Singh, Thakur, & Sharma, 2016). When there are no class labels on the input data, unsupervised learning happens. We wish to model the data's underlying structure in order to learn more about the data.

Association and clustering are the two main forms (Ceriottia, 2019). K-means clustering, affinity propagation, and other unsupervised methods are well-known.

### 3.2.1 Supervised Learning

The following are the workings and specifics of some well-known supervised machine learning algorithms that were employed in this project:

#### **Logistic Regression:**

When the output variable is discrete (categorical), and the class should be predicted rather than categorised, the logistic regression technique should be abandoned. When it comes to machine learning techniques for categorising binary data, logistic regression is frequently used. The purpose of Logistic Regression is to enhance outcomes by combining data from several sources (Swaminathan, 2018). The default label class is always used to predict outcomes, but the results and probability are always determined after all categorical values have been changed to numerical values and all data has been normalised.

In ecological study, logistic regression, also known as sigmoid regression, was developed by statisticians to explain the characteristics of a population that was rapidly growing and depleting its ability to wear out the environment. An S-shaped curve may translate any real-valued range into a number between zero and one, but not precisely at the limit of one.

$$\frac{1}{1 + e^{-x}}$$

*Equation 1 Sigmoid equation*

Where e is the logarithms' base (Euler's broad variety or the EXP () function on your spreadsheet), and price is the true numerical price to be changed.

While the following is the regression equation in which the intercept and slope are combined:

$$y=mx+c$$

## Equation 2 Regression equation

A generalised equation for a multivariate regression model is given below:

$$y = \beta_0 + \beta_1.x_1 + \beta_2.x_2 + \dots + \beta_n.x_n$$

The regression is created in a few steps, starting with feature selection, normalising features, choosing a loss function and hypothesis, setting hypothesis parameters, minimising the loss function, and lastly testing the data's function.

### **Random Forest Regressor:**

Random Forest has previously demonstrated that it creates a forest before randomising it. It builds the forest with an collective of Decision Trees and trains it with the Bagging Method for the most part. Because the ensemble approach is used, the result is improved.

The steps below will help us understand how Random Forest works:

To begin, select random samples from the dataset.

After then, each sample will be given a decision tree to work with. It will generate a projected final outcome based on those options.

Voting may take place in this phase for each expected outcome.

Finally, because it is the very final prediction outcome, the prediction output which gets the maximum votes gets chosen.

### 3.2.2 Unsupervised learning

Unsupervised learning algorithms are taught on data that hasn't been classified or labelled, allowing them to operate on it without supervision. Dispersed data is organised with patterns or similarities and differentiations using this approach, which requires no prior training.

The algorithm didn't get any training from a training dataset, unlike supervised learning. As a result, the algorithm concentrates on us uncovering the hidden pattern in unlabelled facts.

### 3.3 Dataset description

Utilization of a product called Octoparse, which is a web scraping platform, to collect data rapidly and effectively was the plan. So, we put Octoparse to the test and discovered that even if every team member committed to scraping data for a week, Octoparse would still fall short of providing a large enough dataset required for our task. We decided to use this strategy on other platforms as well. After experimenting with others, another product called ScrapeHero was selected.

The airlines we wanted to look at were those with the highest revenues and the most passengers with an active twitter timeline. Delta, American, Lufthansa, United, Air France, Southwest, and China Airlines were among the airlines that carries highest passengers. Southern and Ryanair are two of the most popular airlines too. Since COVID-19 wreaked havoc on the aviation sector, we compiled a list of tweets that highlighted it prior to the pandemic, that is, from July 2019 to December 2019.

Twitter provides an advanced search option. Using that, we obtained the url for all tweets meeting the above criterias. Then, ScrapeHero used this url & scraped the webpage, capturing user's handle, user's name, tweet, number of retweets, replies, & favorites, and time and date of the tweet (unix timestamp). We exported this data as a csv file. This will act as our main master data from Twitter and act as the test data too.

We got our training dataset of airline tweets from Kaggle which originally came from Crowdfunder's "Data for Everyone library". Crowdfunder has a large library of 'Off-the-Shelf' datasets that are meant to increase accuracy, overall performance, and supply high-quality datasets at scale for specific AI programme requirements. They're continually creating fresh datasets to fulfil the demands of their worldwide clientele.

### 3.4 Exploratory Data Analysis (EDA)

After cleaning, the master dataset had about 629k rows while crowdfunder dataset had about 15k rows.

We performed some exploratory data analysis on the master data, looking at word lengths in the tweets, number of words used in the tweets, mentions (@), hashtags (#), tweet sentiments, and airlines mentioned.

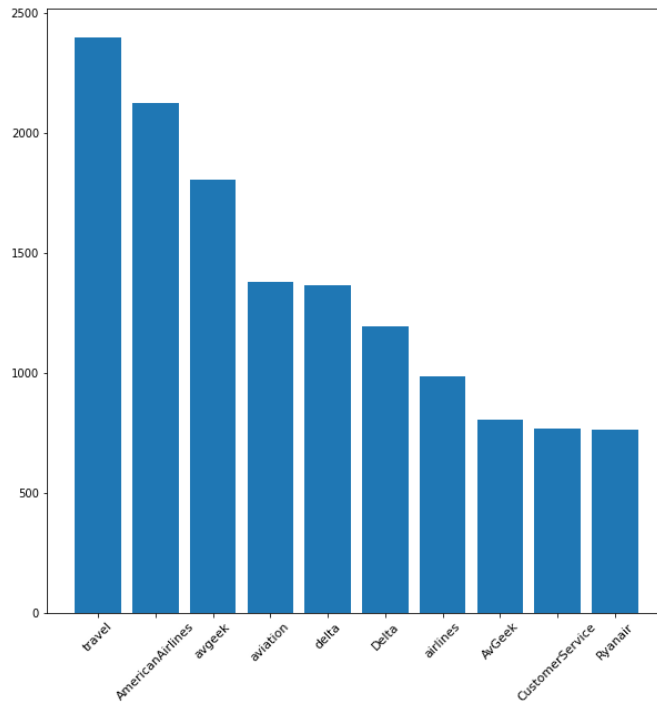


Figure 1: Top 10 Hashtags

Most tweets used words that are 4 characters long, and the average word length in the dataset is 5 characters long.

# Wordcount distribution

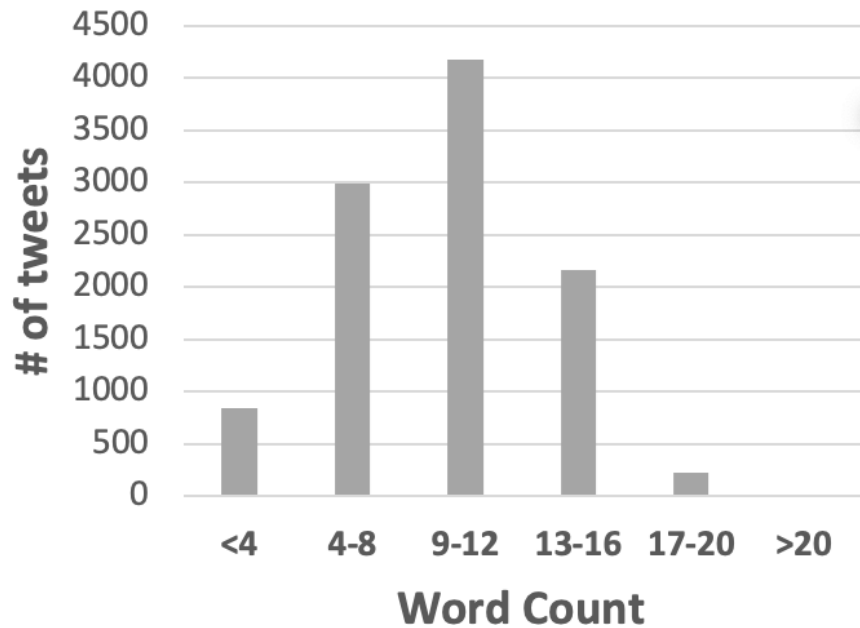
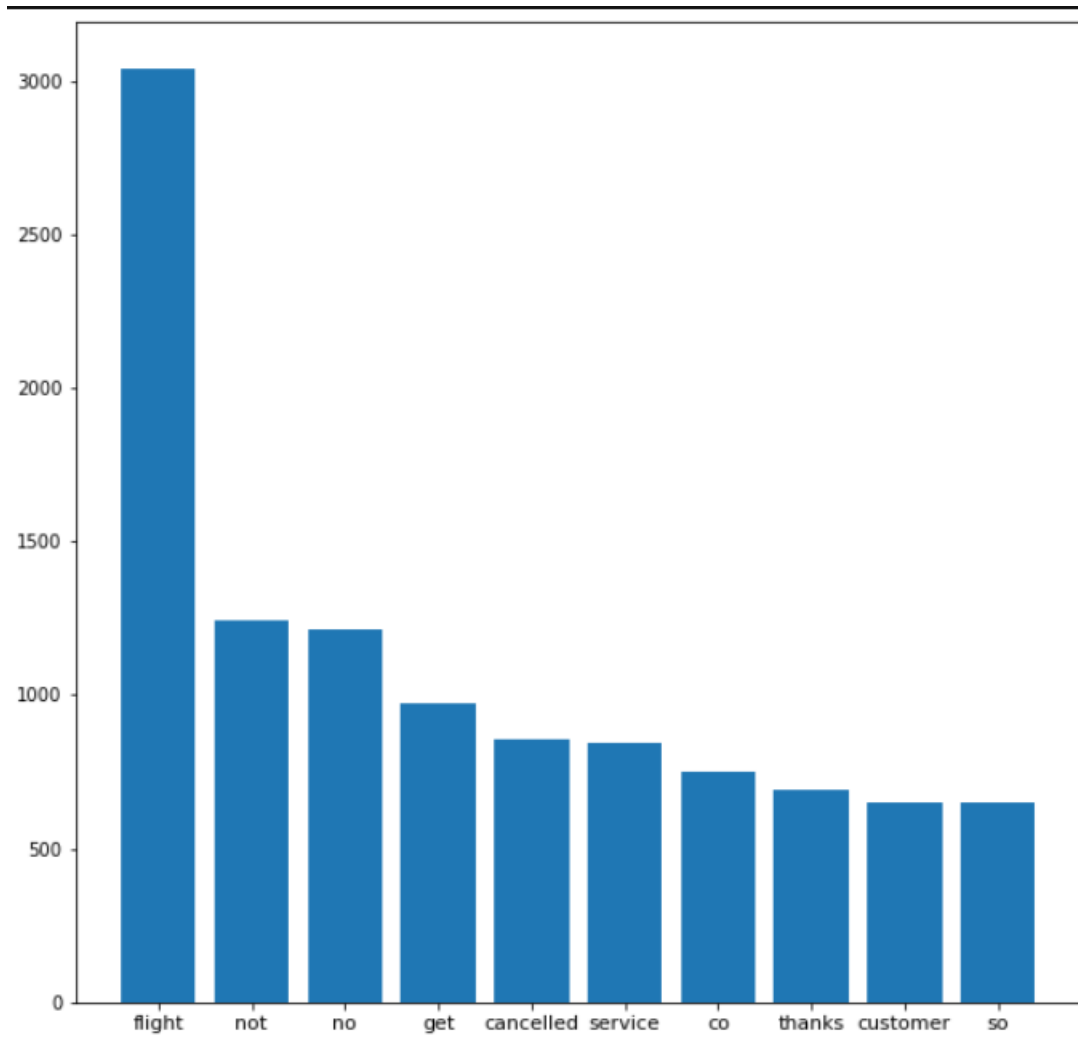


Figure 2: Word count distribution

Maximum tweets, that is approximately 4200 tweets, had a word count in the range of 9-12 words.

The top 10 most frequently used words are (in order): 'flight', 'not', 'no', 'so', 'get', 'time', 'service', 'one', 'plane' and 'like'.





*Figure 3: Most Frequently Used Words*

Tweets with a negative sentiment have an average of 14 words, while both neutral and positive sentiment tweets have an average of 9 words.

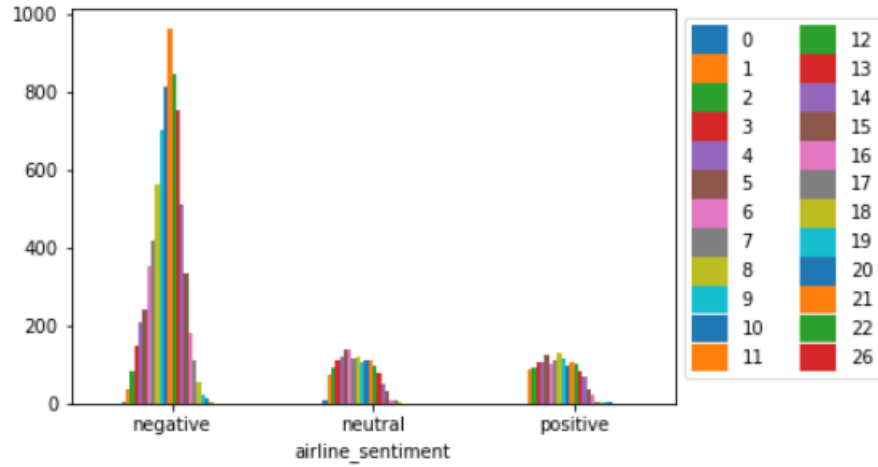


Figure 4: Sentiment wise word count

The two graphics below show the relationship between time and airlines mentioned. The figure 5 shows the airlines mentioned by month number.

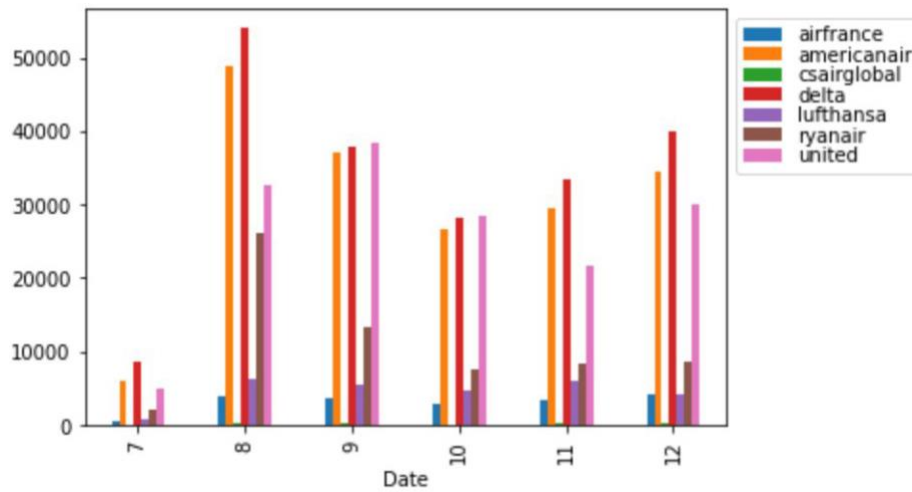


Figure 5: Airlines companies mentioned by month number

## 3.5 Dataset pre-processing

When we convert raw data into an understandable and clean form it is called Pre-processing. Real data is often unclean and filled with incorrect data points. It can be caused due to poor data collection. And in case of data models, it is said that if we feed models unclean data, the models are inaccurate. Preprocessing the data solved the problem.

We perform the following steps to clean and preprocess the training dataset.

1. We remove the duplicates or Nan values

```
[34]: # Remove duplicate and nan values if any
data_twitter['airline_sentiment'].replace('', np.nan, inplace=True)
data_twitter = data_twitter.drop_duplicates()
data_twitter = data_twitter.reset_index(drop=True)
```

Figure 6: Pre-processing of airline attribute - Sentiment of training data

2. Only selecting the rows where the data tagger was 100% confident of the sentiment

```
[36]: # To be safe, I'll only consider sentiments with confidence as 1
data_twitter = data_twitter[data_twitter.airline_sentiment_confidence == 1]
print(data_twitter.shape)

(10409, 15)
```

Figure 7: Selection of rows in training data

The dataset becomes smaller with 10409 rows instead of 14640 previously.

3. Since it is tweets dataset, there can be encoding problems or htmls. So, we convert the text forcefully to ascii characters

```

•[37]: # Cleanings of the tweet
data_twitter['clean_text'] = data_twitter['text'].apply(lambda x: str(x.encode("ascii", "ignore"))) # Handling the encodings
data_twitter['clean_text'] = data_twitter['clean_text'].apply(lambda x: html.unescape(x)) # Unescaping the HTMLs
data_twitter['clean_text'] = data_twitter['clean_text'].apply(lambda x: str(x.strip('b').strip("'").strip('')))

```

Figure 8: Handling encodings and htmls

4. Text might contain characters like ‘\r’ and ‘\n’ for tabs and newlines. We remove such special characters.

```

data_twitter['clean_text'] = data_twitter['clean_text'].str.replace("\r", " ")
data_twitter['clean_text'] = data_twitter['clean_text'].str.replace("\n", " ")

```

Figure 9: Removal of tabs and newlines

5. Since it is a social media text, there will certainly be emojis, emoticons etc. We handle them using the function below which uses a python library named emot

```

def convert_emoticons(text):
    """
    Function for converting emoticons into word
    """

    # Added these common symbols since the dictionary from the library did not have it
    EMOTICONS_EMO["<3"] = "Love"
    EMOTICONS_EMO["</3"] = "Broken Heart"
    for emot in EMOTICONS_EMO:
        # Some emots like :-) or :-( create problems with RE
        if ')' or '(' in emot:
            continue

    text = re.sub(u'('+emot+')', "_".join(EMOTICONS_EMO[emot].replace(",","").split()), text)
    return text

```

Figure 10: Emot and regex based emoticon handling

6. Finally, we do all the basic text cleanings like removal of user name mentions, hashtags, numbers etc using the function below

```

def clean_tweet(txt):
    """
    Basic tweet cleanings like removing username mentions, numbers, and removing pounds (#) from hashtag mentions
    """

    txt = re.sub(r'@[A-Z0-9a-z_]+', '', txt) # replace username-tags with space
    txt = re.sub(r'^[RT]+', '', txt) # replace RT-tags with space
    txt = re.sub("#[a-zA-Z]", " ", txt) # replace hashtags with space
    txt = ' '.join(re.findall(r'\b[a-zA-Z]+\b', txt)) # Include only alphabets and important punctuations in the tweets
    words = txt.lower().split()
    meaningful_words = [w for w in words if not w in sw_final]
    return " ".join( meaningful_words )

```

Figure 11: Basic final text cleanings

7. We combine 3 columns related to date into a single 'Date' column

```

#add date column and convert to datetime
data_df['Date']=pd.to_datetime(data_df[['Year', 'Month', 'Day']])

```

Figure 12: Addition of data column

It is evident from the EDA of the training data that number of tweets that are tagged as negative are the highest. The numbers are very unbalanced. We need to take care that this bias does not creep into our model.

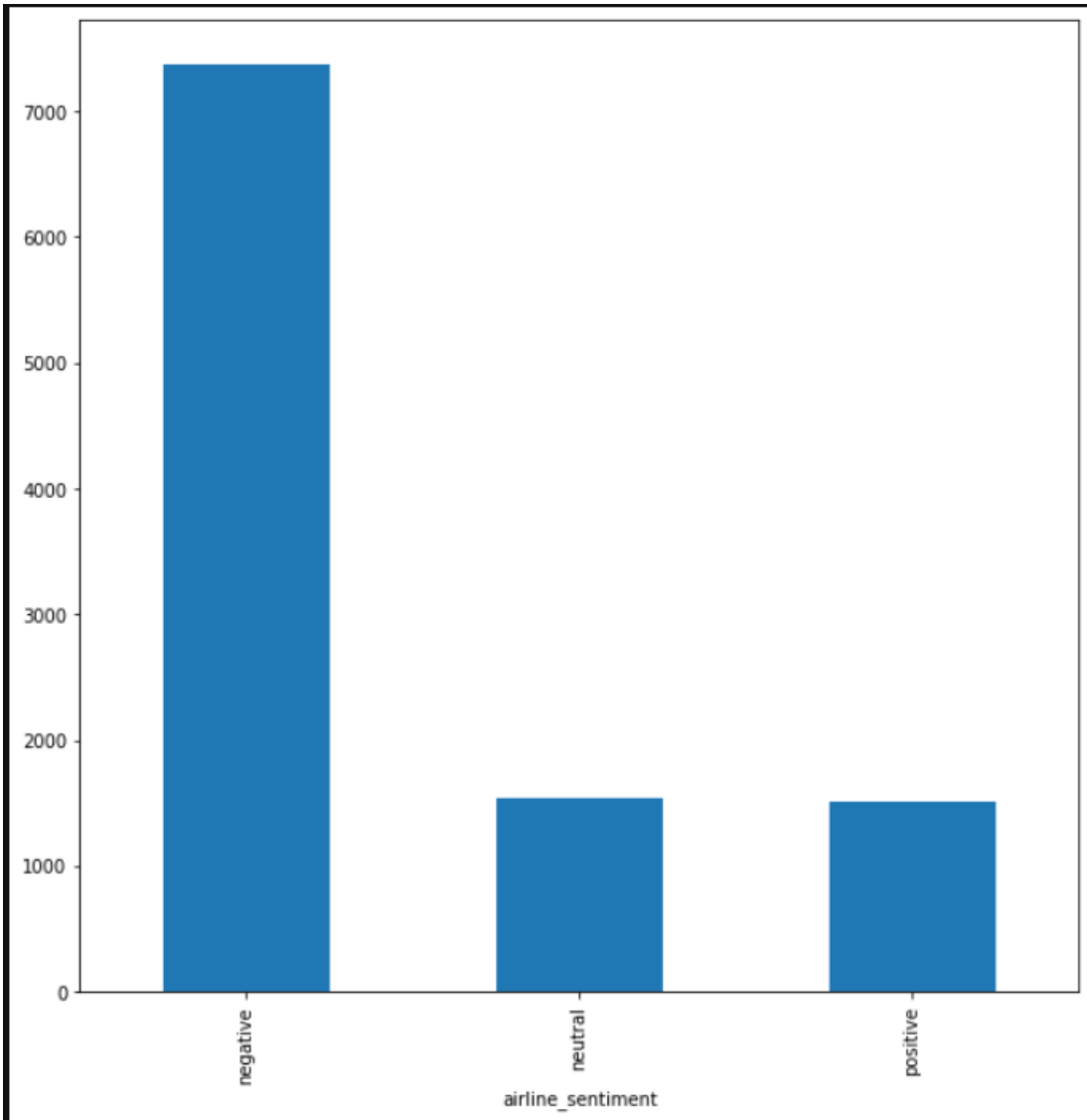


Figure 13: Bias of Sentiments

## 3.6 Parameters for Model Evaluation

To evaluate the classification model, the following metrics can be analyzed:

### 1. 10-fold cross validation:

Cross-validation is a resampling technique for evaluating machine learning models on a small sample of dataset.

The following is the usual procedure for performing a 10-fold cross validation:

- a) Shuffling the dataset.
- b) Divide the data into k groups.
- c) For each distinct group:
- d) Use the group as a holdout or test data set. e) Use the remaining groups as training data sets.
- f) Fit a model to the training data and test it on the test data.
- g) Save the evaluation score but reject the model. h) Summarize the model's skill using the sample of model evaluation scores.

The mean of the model skill scores is frequently used to describe the outcomes of a 10-fold cross-validation run.

### 2. Confusion Matrix:

The confusion matrix is an  $N \times N$  matrix, that is used to evaluate the performance of a machine learning classification model,  $N$  represent the output classes number. The matrix cross check how the model been able to correctly classify each output correctly or not. Moreover, then we can observe certain metrics from the matrix such as accuracy, which can let us know how good is the model.

### **3. Classification Report:**

The classification report displays the model's accuracy, recall, F1 score, and support score.



# Chapter 4 – Project Analysis

## 4.1 Experimental results & Analysis

Following deep learning models and ML models are implemented.

1. FastText
2. Linear SVC

### 4.1.1 FastText

FastText is a library for quickly learning word representations and categorizing sentences. It's the result of a Facebook study. 294 languages on Facebook are available in pre-trained model.

For English language, we will be utilizing the pre-trained model.

### 4.1.2 Linear SVC

Support vector machines (SVMs) or Support Vector Classifiers (SVCs) are supervised machine learning models that are commonly used for classification and regression.

The basic blocks of SVC or SVM are :

The closest datapoint to the hyperplane are known as Support Vectors.

The **Margin** is the space between two lines on the nearest data points of distinct classes.

The **HyperPlane** is a decision plane or space that splits a set of objects into multiple classes.

The fundamental purpose of SVMs is to partition datasets into various groups so that a maximum marginal hyperplane (MMH) may be found.

This may be accomplished in two steps:

1. Support Vector Machines will first iteratively construct hyperplanes that best divide the classes,
2. and then it will pick the hyperplane that best separates the classes.

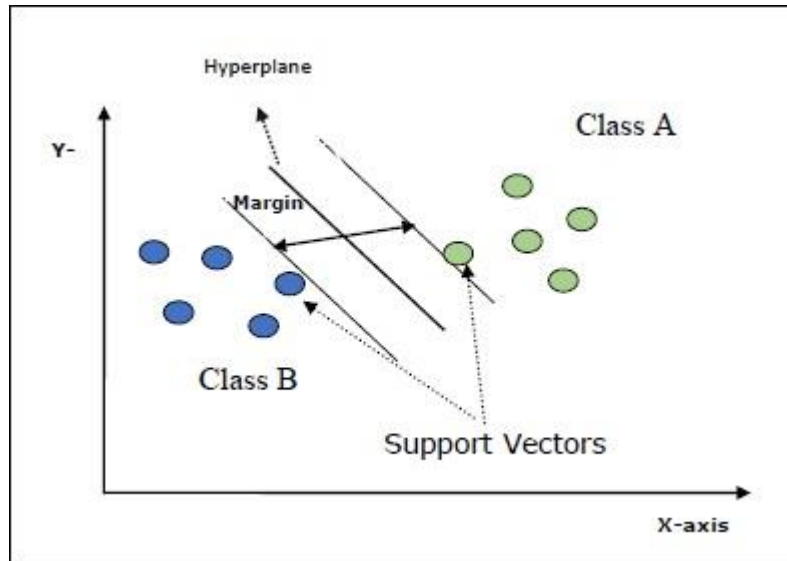


Figure 14: SVC Model explanation

## 4.2 Results

We got a 10-fold cross validation of 85% on our training dataset of tweets which we sourced from Kaggle.

```
print("10 fold cross validation score is ", cross_val_score(clf, list(trainX), trainy, cv=10).mean())
```

```
10 fold cross validation score is 0.8533965122293653
```

Figure 15: Cross validation

Given the evaluation parameters defined above, we checked the confusion matrix and it looked like:

```
print(confusion_matrix(list(data_df[~data_df["actual_sentiment"].isna()]["predicted_sentiment"]), list(data_df[~data_df["actual_sentiment"].isna()]["actual_sentiment"])))
[[26  5  1]
 [ 0  2  1]
 [ 0  0  2]]
```

		Predicted		
		NEGATIVE	NEUTRAL	POSITIVE
TRUE	NEGATIVE	26	5	1
	NEUTRAL	0	2	1
	POSITIVE	0	0	2

Figure 16: Confusion Matrix on the crawled testing data

We see that from the confusion matrix, there were total 37 (26 + 5 + 1 + 0 + 2 + 1 + 0 + 0 + 2) tagged samples from our crawled dataset. Out of this 37, there were 32 (26 + 5 + 1) which were truly in NEGATIVE class. Our model predicted 26 correctly.

In a similar way, out of 2 tweets that were tagged as POSITIVE, our model predicted both correctly.

We now check the classification report for further details.

	precision	recall	f1-score	support
negative	1.00	0.81	0.90	32
neutral	0.29	0.67	0.40	3
positive	0.50	1.00	0.67	2
accuracy			0.81	37
macro avg	0.60	0.83	0.65	37
weighted avg	0.92	0.81	0.84	37

Figure 17: Model Classification Report

Our model has a good weighted average f1 score of 84% on our crawled dataset.

From this, it can be inferred that the errors of Support Vector Classifier when used with FastText embeddings for English are more than 65%. Hence, we use SVC for predicting on all the tweets.

When we analyze the results with days of the week, we observe a significantly higher number of negative tweets on Fridays and Mondays and very low on Saturday and Sunday.

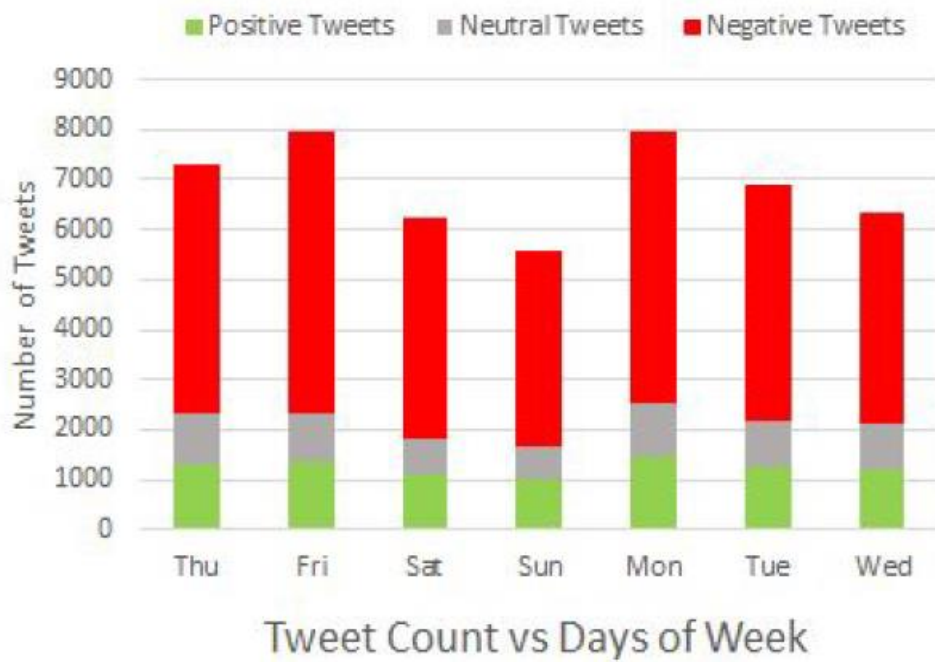


Figure 18: Weekend effect on sentiment of tweets



Figure 19: Word cloud - Positive and Negative Tweets

We observe from the word cloud that tweets related to “bags” are causing the most negative tweets. It means the airlines need to focus the most on their luggage problems

like bags being lost, allowed baggage limits. Other complaints were related to getting no response, layover, flight times and bills as seen in the word cloud.

We also see that people are complaining mostly about crews, wifi, cost etc.

For the positive side, people were happy with the experience “great experience”, however the number is very less as seen by the size of the word in the word cloud.

# Chapter 5 – Conclusion

## 5.1 Conclusion

Deep learning embeddings and machine learning approaches

This project proposed an approach to analyze the airline tweets using 3 class sentiments by utilizing deep learning embeddings and machine learning. Twitter was scraped using third party tools and we used training data from a dataset in Kaggle which was tagged with 3 class sentiments. An effective machine learning model was built by training, testing, and evaluating Support Vector Classifiers along with FastText embeddings. After several steps of cleaning and pre-processing, Linear SVC gave a weighted average f1 score of 84%.

Since the sentiments clearly differ by the days of the week, the airline industry may have to consider business decisions which take this analysis into account. For example, having a varied work force of customer service representatives depending on the day of the week may prove beneficial. Digging deeper down into the causes of negative sentiments may also reveal some pain points, helping the airline industry in forming a plan of action to mitigate these issues.

## 5.2 Recommendations and Future Work

More data can be scraped from Twitter using the third-party scraping tool and more machine learning models can be tested.

To crystallize the analysis, all one has to do is take airline tweets from a larger duration of choice and use this same approach of tagging the tweets, training using machine learning models and predict the sentiments using our model. Further statistical analysis can be done to check the correlation between the sentiment with the day of the week.

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