Sentiment Classification of Current Public Opinion on BREXIT: Naïve Bayes Classifier Model vs Python's TextBlob Approach

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Bhupender Singh Shekhawat
Student ID: X17170214

School of Computing
National College of Ireland

Supervisor: Prof. Vladimir Milosavljevic

National College of Ireland

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School of Computing

Student Name: Bhupender Singh Shekhawat

Student ID: X17170214

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Sentiment Classification of Current Public Opinion on BREXIT: Naïve Bayes Classifier Model vs Python’s TextBlob Approach

Bhupender Singh Shekhawat
X17170214

Abstract

Sentiment Analysis is playing a crucial role in technological world due to tremendous growth in the field of social media. The motivation regarding sentiment analysis comes from the fact that social media platforms like twitter provide a great platform which is used by general public to express their opinions about a product or an event. Such opinions provide an opportunity to researchers to work on data mining based on public reviews and opinion and provide critical insights helpful for organizations in better decision making. This paper discusses comparison in performances of Naïve Bayes Classifier Model and Python’s TextBlob library by carrying out sentiment classification on current public opinion on BREXIT. In order to achieve the objectives, natural language processing, concepts including regular expression library and count vectorization have been used. Also, Natural Language Toolkit library along with TextBlob library are used to clean the data and provide polarity score to the tweets respectively. Naive Bayes Classification algorithm is then introduced into the model after training it on Sentiment140 Twitter dataset to provide an accuracy comparison to that of the TextBlob. Therefore, useful insights are produced considering visualizations obtained from Tableau. Moreover, the results of this research provide an insight about public opinions of different countries about BREXIT. Also, the results will help British and Irish governments to formulate their foreign policies and internal policies in order to maintain their relationship with their major business friendly countries.

1 Introduction

The exit of Britain from European Union is termed as BREXIT. However, since March 2019, the uncertainty over BREXIT deal has been pushing the BREXIT date further. Now, the United Kingdom has been provided an opportunity to work upon the BREXIT deal until 31st Oct 2019 before BREXIT happens. (United Kingdom - European Commission, 2019)

Moreover, there have been a lot of speculations on the aftereffects of BREXIT deal. It is expected that such speculations along with many other political and social events associated with BREXIT happened in the recent past will play an important role on present public sentiments about BREXIT. Hence, this research aims at discovering the variation in the public mood swing since 2016 using social media platform. Twitter and producing visualizations based on insights obtained from sentiment analysis of the retrieved dataset. Also, it is considered that BREXIT will certainly impact the United Kingdom’s economy and the associated countries with it. Therefore, it becomes extremely important to determine the public reaction in the countries which plays an important part in positively contributing towards the United Kingdom's economy. Such analysis will provide critical insights to United Kingdom for deciding their internal as well as foreign policies. Until now, only a few researches have been done on BREXIT and they have been mainly focussing on determining the public's opinion about it. Therefore, this research will focus on identifying the impact of BREXIT on countries playing an important part in the United Kingdom's economy. For it, data mining techniques Naive Bayes Classifier algorithm, NLTK library along with natural language processing concepts are used to carry out sentiment analysis. In order to fetch real time tweets, Twitter streaming API has been used, once sentiment analysis was carried out then insights related to the retrieved dataset were visualized using Tableau.

1.1 Motivation and Background

With surge in number of users of social media platforms like Twitter, it has now become very common for people to express their opinions about certain event, product or organization on such platforms. This has brought sentiment classification at the centre of interest for many researchers and scholars. Sentiment classification or sentiment analysis in text classification on social media platform like Twitter is defined as a process of finding out public opinion about an event, product or topic using techniques like machine learning. In it, public opinions are classified into categories like ‘Positive’, ‘Negative’ and ‘Neutral’. Sentiment classification helps organizations to gain insightful knowledge from retrieved data for swift decisions on crucial moments. Sentiment Analysis on BREXIT has been an interesting topic for research. However, so far very few researches have been done on this topic and previous researches have mainly been focussing on identifying the opinion swing among public. As the BREXIT date (31st Oct 2019) is approaching closer, there are a lot of speculations and discussions going on about it on social media platforms like twitter. A lot of organizations are also interested to have an idea about BREXIT impacts globally, Walker-Osborn and Barry (2016) published article about possible impact of BREXIT on Information Technology Industry. Therefore, it is expected directly or indirectly BREXIT will have certain impact on businesses. This brings a need for sentiment analysis about BREXIT on social media platform like Twitter and in order to make an effort to gain insights from public opinions from residents of major business partner countries to United Kingdom. Therefore, conducting real time sentiment analysis on BREXIT for public based in major business partners countries of UK will provide an opportunity to the United Kingdom government to gain some useful insights in order to formulate their business and foreign policies in a better sense.

1.2 Research Question

Can sentiment classification on BREXIT using Naive Bayes Classifier Model and Python’s TextBlob approach assist/support United Kingdom and Irish governments in gaining important insights from real time sentiment analysis of their major business partner countries.

In order to solve the research questions, certain objectives have been formulated, implemented, evaluated and finally results are illustrated.

1.3 Objectives

1. Literature search on sentiment classification based on Naïve Bayes Classifier Model and Python’s TextBlob approach.
2. Implementation, Evaluation and Results on Naïve Bayes Classifier Model.
3. Implementation, Evaluation and Results on Python’s TextBlob approach.
4. Comaprison of Naïve Bayes Classifier Model and Python’s TextBlob approach .

2 Related Work

In order to discover the topic to perform research on sentiment analysis, the papers related to sentiment analysis were initially studied which further provided the basis for deciphering text classification and opinion mining that helped in forming the core foundation of text understanding about BREXIT using twitter as the topic for this research. Also, these papers have helped to explore Naïve Bayes Classifier Algorithm, python's textblob library, along with concepts from Natural Language Processing such as tokenization, Count Vectorization and Python's regular expression library as the machine learning technique to carry out this research. Moreover, special credit goes to the online research paper-based libraries such as IEEE explore and Research Gate for providing an abundance of literature resources. As far as sentiment analysis is concerned, there have been numerous researches being done in this field. Therefore, it becomes extremely important to throw some light on key previous work which have been done in this field and then proposing a new solution at the end of the discussion.

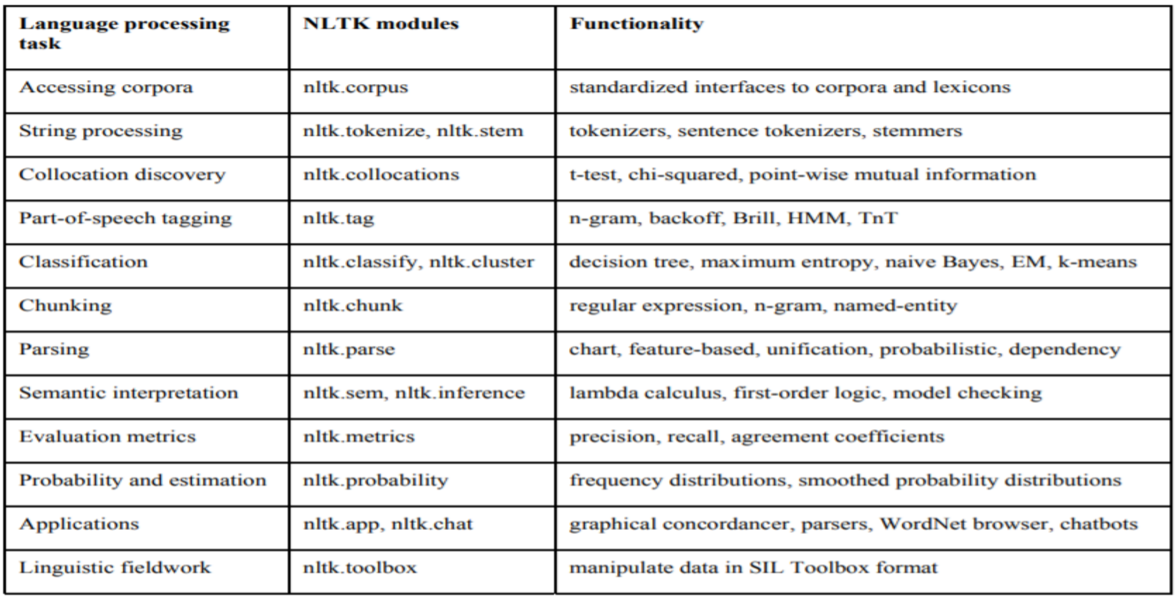
2.1 A Review on Sentiment Analysis on Twitter Data

As shown by Ramanathan et al. (2019), Sentiment analysis is playing a crucial role in the technological era because of presence of wide range of applications supporting business and platforms like social media. The advantage of sentiment analysis is, it helps in determining the present opinion of public about a product or field. The insights retrieved from such analysis on public opinion assists business to work upon improving their product quality. Domain specific ontology is a type of analysis done using common sense. The part of speech (POS) tagging turns out to be crucial in identifying the entities, this is further supported by comparing entities based on knowledge gained from domain specific ontology. Sentiment lexicon approach is a branch of sentiment analysis which is used for determining the sentiment scores of entities. Semantic orientation is combined belonging to respective domain specific features. Also, as one of the advantages it is found that using machine learning algorithms along with features as conceptual semantic improves overall performance of the model. However, as an improvement contextual and conceptual semantic sentiment analysis can be utilized to improve the performance of model. This paper has helped in understanding on how part of speech tagging could be used along with conceptual semantic sentiment analysis can assist in improving overall performance of the selected machine learning algorithm. Although, automatic sentiment analysis is a very good way to analyze sentiments of public about a product or topic. But, at the same time another challenge related to sentiment scores comes up. As sentiment scores allocated to all words stay same irrespective of domain of the research. There is possibility for obtaining less accurate results because in lexicon-based approach performs differently in different domains. Ikoro et al. (2018) resolved this problem and accuracy of the research is improved by using two sentiment lexicons altogether. As a part of it, initially a lexicon is used to obtain the words containing sentiments and negative words. Later, another lexicon is used to classify remaining data. However, use of machine learning algorithm would have given more accurate results. This approach helped in understanding how accuracy of the final model is improved by using two lexicons together instead of going for traditional single sentiment analysis approach. In automatic sentiment analysis vocabulary is built based on set of words being assigned.In order to improve user experience, artificial intelligence assistance is an emerging technology being used for carrying out sentiment analysis. It focuses on evaluating user experience and emotions while understanding user tendency through opinion mining. The author Park and Seo (2018) tried to identify which artificial intelligence assistant statistically performs well among the three chosen artificial assistants. Users opinion regarding the chosen three artificial intelligence assistants were divided into three categories positnive, negative and neutral by using lexicon Valence aware dictionary along with VADER (sentiment reasoner). In order to identify the statistical stability of the three artificial intelligence assistants test like Mann- Whitney, independent sample T test, Krushal Wallis test were used. Improper optimization of natural language processing turned out to be a limitation of this work. This work has provided knowledge of another lexicon approach to carry out sentiment analysis. In Rahman et al. (2019), the authors have taken a different approach to perform sentiment analysis on retrieved unstructured data from twitter. Supervised and unsupervised algorithms are used for performing sentiment analysis. Initially, data is retrieved using twitter API which is then pre-processed. In the next step data is pre-processed and cleaned. In the model building phase first unsupervised lexicon model was used to classify collected tweets data as pre-processed data did not had class labels assigned to it. Tweets were classified in positive, negative and neutral categories by matching the words of the tweets with a predefined library. In order to classify the tweets 1,0, -1 sentiment scores were assigned to them. In the next step, supervised models were implemented for training purpose. The used supervised models are Naïve Bayes Classifier Model, Support Vector Machine, Maximum Entropy Classifier, Decision Tree and Bagging. As an advantage the use of multiple machine learning algorithms have improved the performance of model over other machine learning models. This model was unable to classify tweets automatically which turned out to be its limitation. This work has provided very critical knowledge regarding the models which can be incorporated for performing sentiment analysis.

After a thorough literature review on sentiment analysis using different techniques. These papers helped in deciding Natural language processing, NLTK library, Naïve Bayes Classifier algorithm, and TextBlob approach as core foundation to carry out work in this paper.

2.2 A Review on Sentiment Classification Using Natural Language Processing (NLP)

As articulated by Lobur (2011), the natural language processing (NLP) is the domain in machine learning which is used in text analytics. NLTK which is called Natural language toolkit is a part of python’s library belonging to natural language processing. Natural language processing not only deals with text analytics, but it also plays an important part with research based on analysis on human languages. Preparing models for research based on human languages comes in computational linguistics. The major advantage of using NLTK is that it allows even a beginner programmer to understand concepts of natural language processing saving a lot of time from gathering information about it. Numerous advantages associated with using NLTK are it contains 60 corpora belonging to real world data, collections of grammar, models which have been trained, functions which provides a path for performing general natural language processing tasks.



Language processing task	NLTK modules	Functionality
Accessing corpora	nltk.corpus	standardized interfaces to corpora and lexicons
String processing	nltk.tokenize, nltk.stem	tokenizers, sentence tokenizers, stemmers
Collocation discovery	nltk.collocations	t-test, chi-squared, point-wise mutual information
Part-of-speech tagging	nltk.tag	n-gram, backoff, Brill, HMM, TnT
Classification	nltk.classify, nltk.cluster	decision tree, maximum entropy, naive Bayes, EM, k-means
Chunking	nltk.chunk	regular expression, n-gram, named-entity
Parsing	nltk.parse	chart, feature-based, unification, probabilistic, dependency
Semantic interpretation	nltk.sem, nltk.inference	lambda calculus, first-order logic, model checking
Evaluation metrics	nltk.metrics	precision, recall, agreement coefficients
Probability and estimation	nltk.probability	frequency distributions, smoothed probability distributions
Applications	nltk.app, nltk.chat	graphical concordancer, parsers, WordNet browser, chatbots
Linguistic fieldwork	nltk.toolbox	manipulate data in SIL Toolbox format

Table 1: Functions of NLTK Library

The table1 depicts the common functions performed in natural language processing. The corpora used in NLTK are generally divided into different categories for assisting its users. Though in other programming languages, natural language processing tasks can be accomplished. The major points which takes python apart from other languages is as follows.

- Better reading ability.
- User-friendly object-oriented technique.
- Ease of extensibility.
- Better Unicode assistance.
- A functionality rich library.

NLTK has vast source of libraries which are being updated with new functionalities over the period. This paper has provided deep understanding regarding functioning of NLTK library.

Tasks such as summarization of text, extraction of information, machine translation are performed by NLP as depicted in work from Zitnik et al. (2017) here, the author has carried out sentiment analysis using natural language processing toolkit nutIE in order to detect the language of text and extract meaning out of it. For it, first the language dataset has been cleaned in the pre-processing stage which was then followed by language detection and evaluation of results. Though, this natural language toolkit library. Major limitation of this work is that it does not compares performance of this library with other natural language toolkit libraries. Though, as an advantage this library can be used for natural language processing courses for educational purpose. Moreover, this work has provided understanding of use of natural language processing in language detection which is used in this research project.

2.3 A Review on Feature Extraction For Sentiment Classification

As stated by Zhang, Jin and Zhou (2010) in his work that one of the most important model utilized for categorization of object is Bag of Words (BoW). The concept behind Bow model is forming visual words by quantizing every extracted key point. After this each picture is shown using visual words histogram. Joachims (1998), also worked upon BoW model. He showed that BoW model depicts count of every word present in a textual data. Ma et al.

(2018) showed that a matrix depicting count of words in textual data is created in BoW model. Afterwards, frequency of occurrence of these words are used as features for the purpose of training the classifier. Thang Luong (2015) conducted a research where it is observed that BoW model performed considerably well in comparison with other models on Chinese English language translation data. All these works have helped in understanding the concept behind BoW Model for feature extraction. Janani (2016),emphasized on various steps being taken while preprocessing the dataset. Various steps which were taken for pre-processing dataset are stop words removal, determination of sentence boundary, tokenization and stemming. Tokenization is one of the most important steps while pre-processing a dataset. It works in a manner that textual data is divided into small tokens. Each token represents a word from the textual document or language. There are numerous libraries available in python such as NLTK word tokenize, Mila tokenizer, TextBlob tokenizer etc which are used for tokenization. This work has helped in understanding the in-depth functioning of TextBlob library for pre-processing phase.

2.4 A Review on Using Naïve Bayes Algorithm For Sentiment Classification

The Naïve Bayes Classifier is a probability-based algorithm which is mainly used for text classification purpose. It works on the concept of Bayes probability theorem. According to it the probability of presence of a specific component in a class is random as compared to presence of some other part. In Rana and Singh (2016), the authors have tried to carry out sentiment analysis on reviews on drama by using Naïve Bayes Classifier algorithm, Support Vector Machine and Synthetic words approach. Reviews were first pre-processed and then data mining is performed by using Naïve Bayes Classifier algorithm and Support Vector Machine which is followed by comparison of results. In results it is observed that Support Vector Machine gives better accuracy as compared to Naïve Bayes Classifier algorithm. The comparison among Naïve Bayes Classifier algorithm and SVM was an advantage as it brought up another approach for text classification over the traditional approach. However, the accuracy was obtained on reviews based on drama. Therefore, the major limitation of this work is, for reviews based on other topics the accuracies may vary and that can make Naïve Bayes a better model as compared to Support Vector Machines for text classification. This work has not only helped in understanding Naïve Bayes Classifier algorithm but also porter stemming algorithm which is used for removing suffixes from words as a part of pre-processing of text. Ibrahim and Yusoff (2017) tried to test the accuracy of Naïve Bayes Classifier algorithm on different size of datasets. Sentiments were classified in positive, negative and neutral categories and 5 different datasets with dataset size 5,10,25,50 and 100 tweets were used. In order to train the model five users were used to classify the words in positive, negative and neutral categories. The training results were then given to Naïve Bayes classifier algorithm which produced accuracy results of 46%,78%, 89%,87% and 79% for 5, 10,25,50 and 100 tweets dataset respectively. The advantage of this work is that it removes the confusion that the Naïve Bayes Classifier is a weak model as compared to Support Vector Machine. However, the fact that this work was done on small groups of datasets, it turns out to be its limitation as works done on bigger datasets produces more accurate results. It has provided an understanding about functioning and performance of Naïve Bayes Classifier algorithm while choosing different amount of dataset for this research. Most work done on sentiment analysis have been mainly focussing on documents or datasets from English language. Therefore, the advantage of the work done by Sarkar(2018) is that it resolved the limitation of no work on a different language. Here, the author has used combined supervised and unsupervised techniques to determine sentiment scores from Bengali language.

Multinomial Naïve Bayes and Character n gram approach together have been implemented. In order to remove noisy data, the characters from every tweet have been tokenized using character n gram approach which are then used in multinomial Naïve Bayes Classifier for classifying the tweets. It is observed that multinomial naïve Bayes with character n gram possess better accuracy as compared to multinomial naïve Bayes with word n gram. Less training data and wrongly labelled parts of the data was limitation of this work which can be work upon to improve performance of the model. This work provided understanding to deal with tweets written in different languages on BREXIT and in-depth functioning of Multinomial Naïve Bayes Classifier algorithm. Permatasari et al. (2018) proposed a new approach in which just Bag of words were not used in feature selection. Apart from it, they used ensemble features which included bag of words with lexicon-based features, twitter specific features, textual features and part of speech feature. In order to implement the model first extraction of ensemble features was done from training and test data after which features results were then fed into Naïve Bayes Classifier Model which then labelled the tweets in Positive and Negative classes. In result it is observed that Naïve Bayes Model with bag of words feature performed well as compared to Naïve Bayes Model with ensemble features. The advantage of this work was that it has removed the misconception that ensemble feature always performs well. However, the only limitation of this work is that the author tested the model only on movie reviews, therefore, on different datasets ensemble features with Naïve Bayes Classifier algorithm may perform better than bag of words features with Naïve Bayes Classifier algorithm. This work has provided knowledge pertaining to bag of words features used for sentiment analysis. In Matharasi (2017), author has conducted sentiment analysis on twitter data using Naïve Bayes Classifier algorithm with unigram approach. Before using Naïve Bayes classifier firstly, the dataset was cleaned then the Naive Bayes Classifier model was first trained and then the stability of the output is tested by using cross validation, holdout method, k- fold cross validation and leave one out validation method. In these methods training dataset was divided into training datasets and validation datasets which were then used to evaluate performance of the algorithm. Later, Naïve Bayes classifier algorithm was used to calculate the sentiment scores which were classified in positive, negative and neutral categories. The classifier performed reasonably well but had some errors in output which turned out to be the limitation of this work. The major advantage of this work is that it deals with Naïve Bayes Classifier algorithm on categorical data. This work has also helped in understanding different validation methods. Moreover, the implementation of Naïve Bayes Classifier algorithm is understood with another approach.

2.5 A Review on TextBlob Approach Algorithm for Sentiment Classification

One of the python's library which uses API for accessing methods in order to perform Natural language processing is called as TextBlob. A common challenge for work based on sentiment analysis are miss spelled words. This problem is addressed by Manushree, Adarsh and Kumar (2017) Here, authors have compared TextBlob and SentiWordNet approach. Firstly, the dataset was pre-processed by removing stop words and unrequired data which could result added computational cost in performance of models. It was followed by aspect selection and based on it sentence extraction was done. Both the models were then used to calculate sentiment polarity and categorize the reviews in positive, negative and neutral categories. This work just focussed on sentiment analysis of miss spelled words in English language. The advantage of this work was that it performed sentiment analysis on miss spelled words in English language. However, limitation of this work is that it was unable to perform sentiment analysis on miss spelled words in other language using TextBlob.

Moreover, this work has helped in depth understanding regarding implementation of TextBlob approach for research project. Maniraj(2018), also carried out research work to perform sentiment analysis on twitter tweets using python's textblob library. Firstly, general process of fetching tweets using twitter streaming API has been used. It is followed by cleaning the tweets dataset in pre-processing stage. The authors have then performed feature extraction which is then followed by training the Naïve Bayes model. Afterwards, classifier is used for classifying tweets in positive, negative and neutral classes. The major limitation of this work is that it is unable to test sentiment score for slangs and short words in the form of abbreviations used in a text message. This work has also provided understanding of using python's textblob library. The pre-processing of the textual data is of very importance in sentiment analysis as it reduces the size of textual data which is given as input to the model. Various steps are followed while pre-processing the textual data. The various pre-processing tasks performed for cleaning textual data are determination of boundary of sentences, removal of stop words from natural language, stemming and tokenization. Tokenization involves splitting a sentence into tokens of each word belonging to the respective sentences. Janani et al. (2016) carried out work on certain tokenization tools including TextBlob in order to test the performance of selected tokenization tools. In the results it is observed that TextBlob performed significantly well in order to tokenize and read the tokenized words. Advantage of this work is that it compared various good tokenization tools and it distinguished TextBlob from them. However, it was unable to read tokenized special characters which turned out as its limitation. This work has helped in understanding major limitation of TextBlob.

2.6 A Review on Python's Regular Expression (REGEX/RE) Library

Stolee (2016), concentrated mainly on regex, which is also called as regular expression, it is reflection of specific words search which helps in identification of text through recognition of patterns in place of exact strings. REGEX library is commonly utilized for parsing textual data belonging to general language. Regex are also called as Python's module. Even though regex is considered as versatile and powerful library it could be difficult to understand, this is one of its limitations. According to Spishak, Dietl and Ernst (2012), The major advantage of python's regular expression library is that it has variety of applications as it has powerful ability to fetch meaningful information from given sentence. Regular expression is applicable in preprocessing the data, MY QL injection, generation of test cases and intrusion detection in networks etc. According to Ganesh (2012) and Yeole (2011), The major advantage of regular expression library is that it has fast processing speed in terms of code execution, and it has very compressed code which reduces efforts of writing long codes for pre-processing.
All these works have helped in understanding python's regular expression library for pre-processing of dataset. Advantage fast processing and compresses coding.

2.7 A Review on Sentiment Classification on Public Opinions About BREXIT.

So far there has been a very few researches done related to sentiment analysis based on BREXIT.
Lansdall-Welfare, Dzogang and Cristianini (2016) in their work carried out sentiment analysis on BREXIT by collecting data from twitter. They have categorized the tweets in positive, negative and neutral categories using LARS algorithm. This work was based on

comparing the public mood swing before and after BREXIT until early 2017. It could have been more informative if the authors would have considered a wider aspect into their analysis like possible impact of BREXIT on United Kingdom’s economy. Advantage of this work is that it has given a fair idea about variation in mood swing in public sentiments before and after BREXIT Moreover, this work has provided a case study-based understanding on BREXIT. European Union initiated a venture under the name of SSIX (Social sentiments financial indexes). McDermott (2016) used natural language processing to determine public sentiments on BREXIT by categorizing the retrieved tweets into positive, negative and neutral sentiments and assigning sentiment scores to them. The major advantage of using SSIX platform was that it was able to detect and understand text of other European languages. However, this work had certain limitations such that it was unable to retrieve location, age and gender gap bias associated to tweeter users. Moreover, This work has provided understanding of application of natural language processing for sentiment analysis on BREXIT. In Khatua (2016), the authors have collected over 2.7 million tweets before BREXIT referendum to carry out sentiment analysis. tweets were categorized in positive, negative and neutral categories. Hierarchical clustering analysis (HCA) was used to calculate sentiment scores. In the results they were successful to predict outcome of the referendum. The advantage of this research was that apart from public sentiments it was also able to find out the topics people were talking about like possible impact of BREXIT on UK and USA relation. The limitation of this work is that author did not researched on a broader scale using geographical location of twitter user to find out what are the sentiments of people living in business-friendly countries of UK. This work has also provided knowledge about scale at which sentiment analysis can broaden the research for topics like BREXIT.

2.8 Identified Limitations in Previous Work’s Based on Sentiment Classification on BREXIT

After a thorough literature survey on sentiment analysis of BREXIT, it is observed that there has not been much work done on this topic. There have been few researches on BREXIT and all of them were conducted in year 2016, as discussed in literature review. However, those researches were mainly focussing on analysing public mood swing based on sentiments before and after BREXIT referendum. There was just one research which focused on finding out trending topics related to BREXIT being discussed on social media platform like twitter. So far, there has not been any work done on analysing the public sentiments based on locations and finding out public sentiments and insights from major trading partners countries of United Kingdom. This problem is unique as it will assist United Kingdom and Irish government to formulate their business and foreign policies based on insights obtained from analysis. Also, so far there has not been any research done on sentiment classification comparing performance of Naïve Bayes Classifier model with TextBlob approach. Therefore, both these problems are unique.

2.9 Conclusion

Based on identified limitations, it is required to conduct sentiment classification using Naïve Bayes Classifier algorithm and Python’s TextBlob library, so that these techniques can be compared. The results will provide guidance to practitioners as well as scholars in order to make choice of a technique for a given problem.

3 Research Methodology

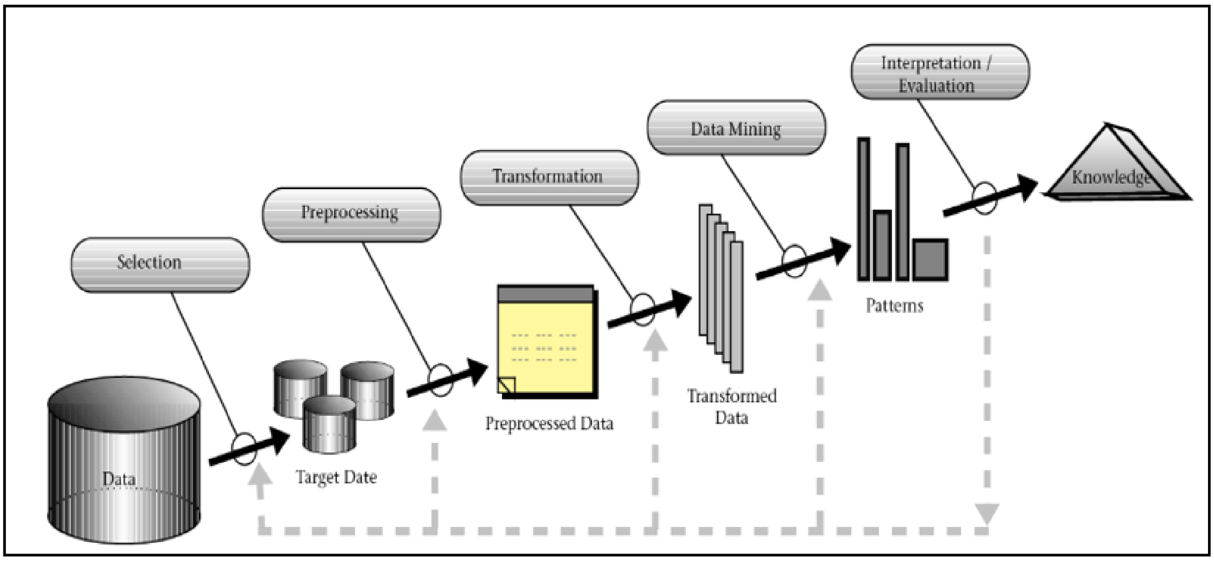


Fig 2: Knowledge Discovery and Data Mining

As articulated by Goebel (2014), this project uses modified KDD (Knowledge discovery and data mining) methodology. As depicted in Fig 1, the methodology explains the process and the KDD concept used for sentiment analysis on BREXIT data obtained from twitter.

- **Dataset Preparation**:- During this phase dataset has been collected and prepared for research.
- **Data Pre-Processing:-** In this phase different natural language processing (NLP) techniques have been used to clean dataset. This step is very important in order to prepare dataset for next steps.
- **Data Transformation:-** in this phase the pre processed dataset has been transformed in a format suitable to implement data mining techniques.
- **Data Mining:-** this phase is used to implement data mining models.
- **Interpretation/Evaluation:-**During this phase interpretation of patterns using visualizations is done. Also, performance of implemented model is tested using data mining concepts.
- **Knowledge:-** Using visualizations and model evaluation results, knowledge about dataset and model performance has been gained.

4 Design Specification

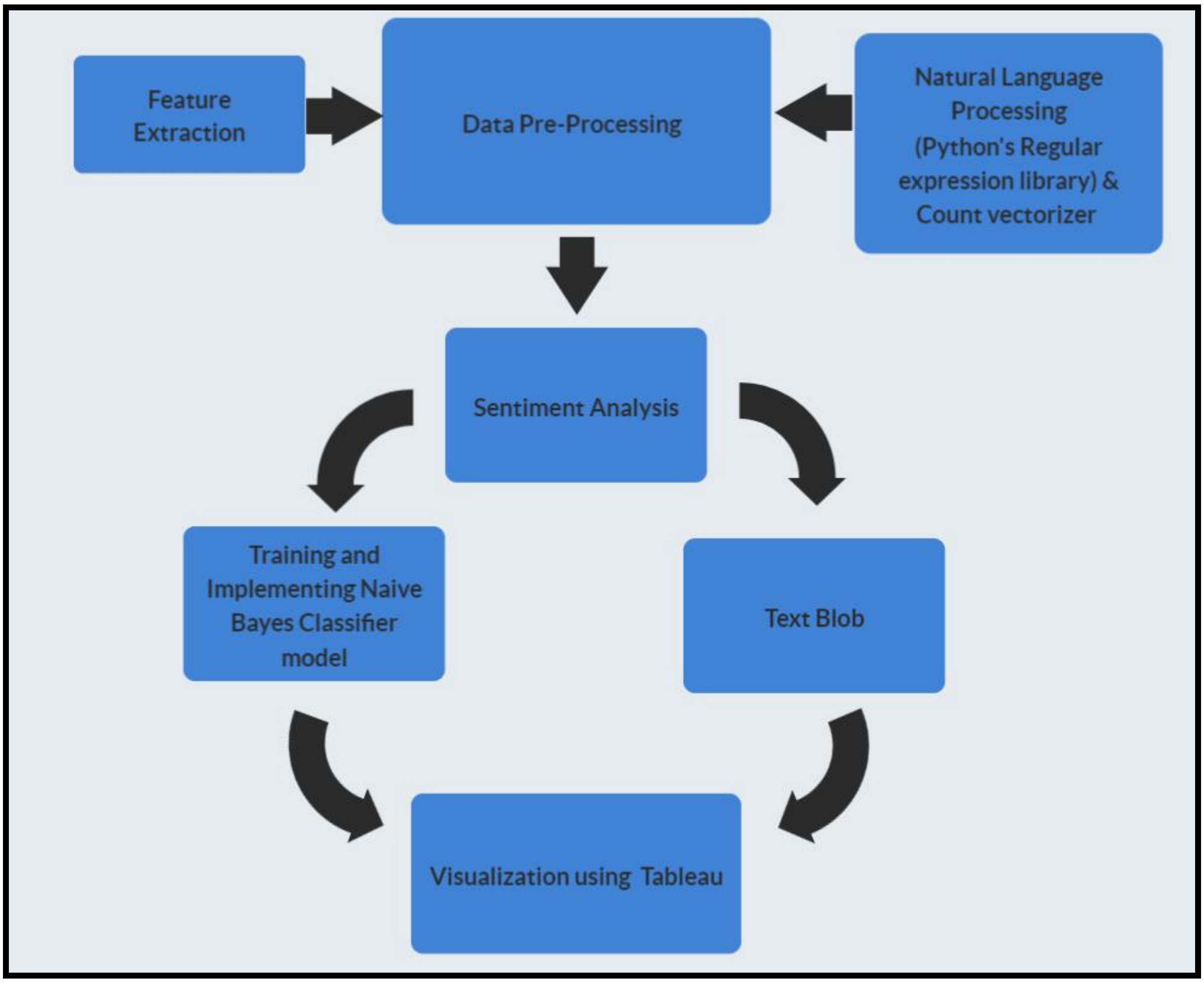

Feature Extraction
Data Pre-Processing
Natural Language Processing (Python's Regular expression library) & Count vectorizer
Sentiment Analysis
Training and Implementing Naive Bayes Classifier model
Text Blob
Visualization using Tableau

Fig 2: Project Work flow

This section explains the workflow of the research project using Naïve Bayes Classifier algorithm and Python's TextBlob approach. Two separate datasets have been used for training and testing Naïve Bayes Classifier Model. Also, for implementation purpose python 3.0 has been used. The workflow for this research is illustrated in fig 2.

- Creation of dataset using Twitter streaming API.
- Used natural language processing consisting python's regular expression library to clean the dataset and count vectorization to convert data in small pieces of tokens.
- Conducted sentiment analysis.
- Firstly, sentiment analysis was conducted using Naïve Bayes Classifier algorithm
- In the next step sentiment analysis was incorporated using Python's Textblob library.
- Finally, results containing insights from retrieved dataset were visualized using business intelligence tool Tableau.
- After implementation performances of both approaches were compared

5 Implementation

5.1 Data Preparation

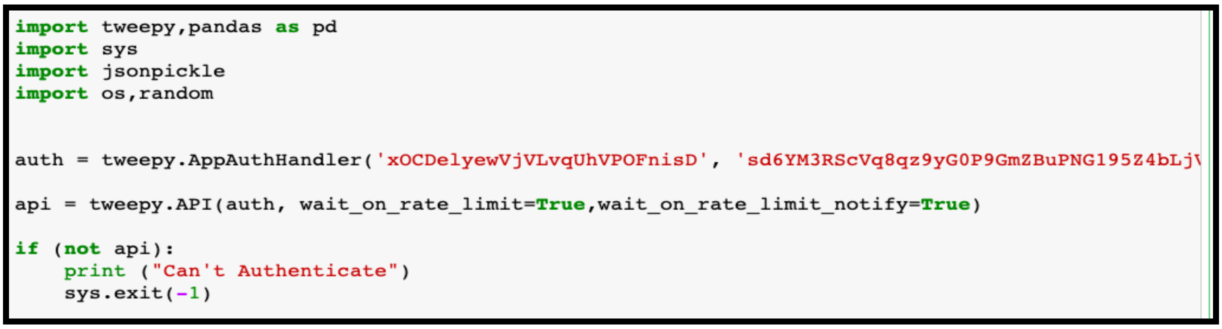
In order to prepare dataset for this research following data sources have been used.

5.1.1 Twitter

For fetching tweets data from twitter. Initially, an API request was made to twitter which was later approved. Afterwards, as explained by Shah et al., (2018) python's tweepy library which is specifically developed for retrieving tweets data from twitter is used along with twitter streaming API and authentication keys (Consumer_key, consumer token key , access token and access token secret.) provided by twitter.

For authentication purpose, the Tweepy library uses the OAuthHandler function for verification of authentication keys.. Once, authentication request is approved it starts fetching the tweets.

Python Tweepy Library:-



```
import tweepy,pandas as pd
import sys
import jsonpickle
import os,random


auth = tweepy.AppAuthHandler('xOCDelyewVjVLvqUhVPOFnisD', 'sd6YM3RScVq8qz9yG0P9GmZBuPNG195Z4bLj

api = tweepy.API(auth, wait_on_rate_limit=True,wait_on_rate_limit_notify=True)

if (not api):
    print ("Can't Authenticate")
    sys.exit(-1)
```

Fig 3: Python's Tweepy Library

Fig 3 shows use of python's tweepy library to retrieve tweets from twitter. Shah et al. (2018) explained the use of tweepy library in his work. Once API strategy is invoked, a tweepy class instance is sent back to the requester. It includes information sent back to us by twitter which was later used within our application.

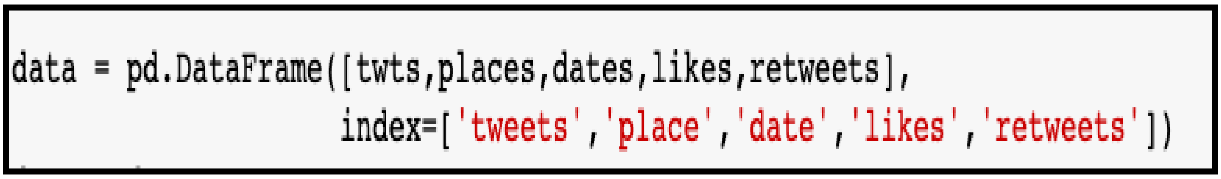
Tweets based on BREXIT were fetched by different user account by using.
tweets = api.home_timeline()
for tweet in tweets:
print(tweet.text)

The tweepy function user_timeline() was used to fetch recent tweets of users by using.

tweets = api.user_timeline()
for tweet in tweets:
print(tweet.text)

Pandas Libraray:-

Pandas is a python library used for analyzing data through manipulation. This library was used to provide final shape to the collected tweets dataset.



```
data = pd.DataFrame([twts,places,dates,likes,retweets],
                    index=['tweets','place','date','likes','retweets'])
```

Fig 4: Python's Pandas Library

The panda's library was used to fetch all the collected tweets in a data frame. As shown in figure 4.

5.1.2 UkTradeinfo.com

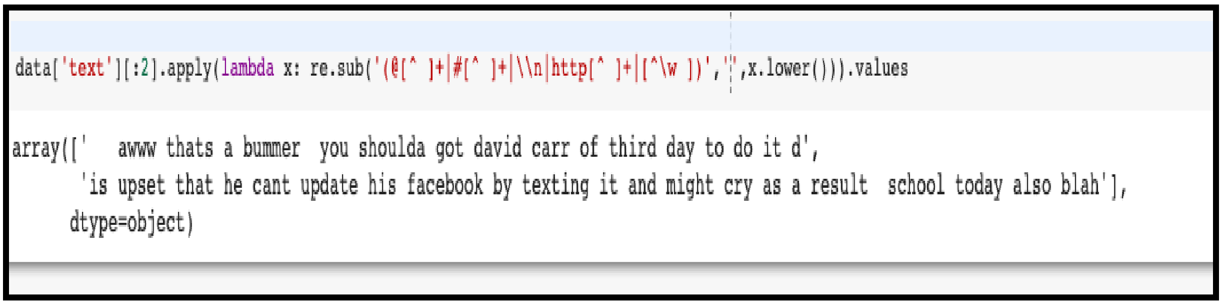
UKTradeInfo.com is an open data source. It is used to retrieve dataset showcasing the United Kingdom's (UK) economy statistics in terms of net contribution to GDP by major trading partners of UK. The collected dataset comprised of figures explaining net imports, exports and contribution to UK economy (in GBP) by respective countries.

5.2 Data Pre-Processing

The raw dataset retrieved from twitter is cleaned in the preprocessing stage using natural language processing concepts as stated by Jettakul et al. (2018) and Saha (2015). In order to calculate sentiment scores, it is essential to clean the dataset such that machine easily understands the text. Cleaning dataset using natural language processing involves a science. The detailed steps used while pre-processing the dataset is as depicted in fig 3.

5.2.1 Use of Natural language processing(Python's Regular Expression Library)

As explained by Goyvaerts (2006), python's regular expression (RE) library has been used to remove unnecessary data from text messages of tweet.



```
data['text'][:2].apply(lambda x: re.sub('(@[^ ]+|#[^ ]+|\\n|http[^ ]+|[^\w ])',' ',x.lower())).values

array(['   awww thats a bummer  you shoulda got david carr of third day to do it d',
       'is upset that he cant update his facebook by texting it and might cry as a result  school today also blah'],
      dtype=object)
```

Fig 5: Data Preprocessing using Regular Expression Library

Fig5, depicts pre-processing of a tweet using regular expression library. The unnecessary data removed from tweets involved.

- **URLS:** A lot of users use different hyperlink url's in their tweets. Removing such urls was necessary as they did not contribute towards calculation of sentiment score. Also, such urls brings in data redundancy which adds additional computational processing burden.

- **Removal of usernames:** In twitter usernames starts with '@' which is of no use in sentiment analysis. Therefore, such usernames starting with '@' were removed.
- **Removal of special characters:** There are various special characters being used by twitters users which needed to be cleaned to make dataset easily readable by the machine. The special characters removed were Stop(.), inverted commas(" ") , exclamation marks(!), special characters like '@' , commas(,).
- **Removal of hastags:** Many users twitter express their topic of discussion with #(eg:- #BREXIT, #ENGVsAUS). These '#' are of no use in calculating sentiment scores. Therefore, hash '#' were removed from the dataset.
- **White Spaces:** Many users on twitter leave unnecessary white spaces which were removed while cleaning.

5.2.2 Count Vectorizer

The process of processing textual data into numerical form is called as count vectorization. It is a type of encoding. It comes in the last stage of pre-processing.

- Depending on the size of vocabulary, different vectors are created.
- When a specific word is detected in the vocabulary then '1' is assigned as a count for that word.
- Every time when a word repeats in a vocabulary, its count is increased by 1.
- Zeros represent all those words which doesnot occur even once in vocabulary.

Count Vectorizer has also helped in performing tokenization.

- **Tokenization**

  One of the crucial steps performed as a part of natural language processing (NLP) is tokenization. As stated by Garg (2015) in this stage each word of a textual document is splitted from sentence in the forms of tokens and all the created tokens collectively forms a feature set.

  Sentences were tokenized into tokens of each word to form feature set.

  Eg:- Sentence:- "this is a sentence"

  Feature set after tokenization:- {'this' ,'is', 'a', 'sentence'

5.3 Sentiment Analysis

Once the dataset was pre-processed, in the next stage sentiment scores were calculated by using Naïve Bayes Classifier Model and Python’s TextBlob Library as follows.

5.3.1 Naïve Bayes Classifier Model

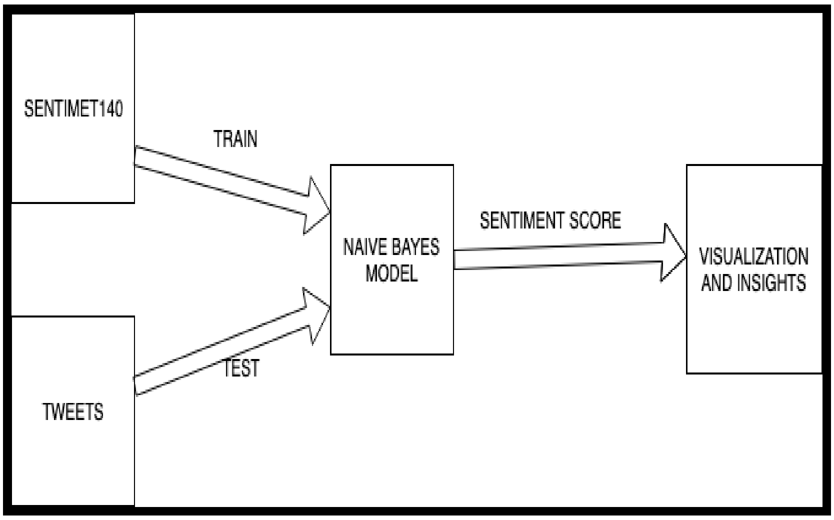


Fig 6: Naïve Bayes Classifier Model

The Naïve Bayes Classifier algorithm is a probability-based machine learning algorithm utilized for text analysis. its main concept follows Bayes theorem, which states that the ocuurence of a particular article within a class is randomto presnse of other components.

Mathematically Bayes theorem says that probability of A given that B has occurred is given by,

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Training Naïve Bayes Classifier Model

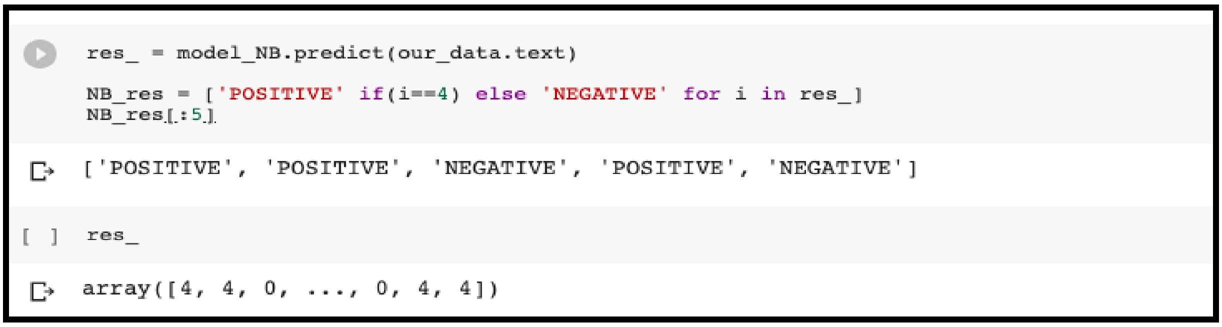
In order to train Naïve Bayes Classifier Model Sentiment140 dataset (Kaggle.com, 2019), has been used from open source data website Kaggle. Sentiment140 is a well-known dataset which comprises of tweets depicting reviews and opinions regarding different topics and products. It is comprised of over 1.6 million tweets. This dataset has helped in calculating sentiment scores of its tweets which helped in training the Naïve Bayes Classifier Model.

Initially, model was utilized to train on 15000 tweets. Afterwards, 50,000 tweets were used to train the model. Following numerical values were assigned to tweets while calculating sentiment scores.

- 0 for ‘Negative’ polarity tweets.
- 2 for ‘Neutral’ polarity tweets.
- 4 for ‘Positive’ polarity tweets.

Testing Naïve Bayes Classifier Model

The Naïve Bayes Classifier Model was tested on the collected dataset of 2.18 million tweets as shown in fig7



```
res_ = model_NB.predict(our_data.text)

NB_res = ['POSITIVE' if(i==4) else 'NEGATIVE' for i in res_]
NB_res[:5]
```

```
['POSITIVE', 'POSITIVE', 'NEGATIVE', 'POSITIVE', 'NEGATIVE']
```

```
[ ]  res_
```

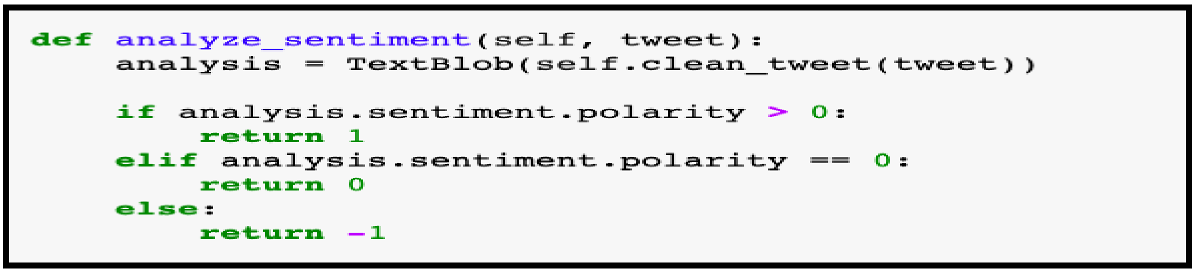
```
array([4, 4, 0, ..., 0, 4, 4])
```

Fig 7: Testing Naives Bayes Classifier Model

The sk learn library from python is used to implement Naïve Bayes Classifier model. In order to label collected tweets dataset, python’s predict() function has been used. Once, prediction was completed then newly labelled dataset along with sentiment scores of respective tweets were available.

5.3.2 TextBlob for Sentiment Analysis

One of the Python’s library to process data is called TextBlob. The functioning of TextBlob library is as shown in fig8. Once data was cleaned it was passed through TextBlob library in order to generate sentiment scores.



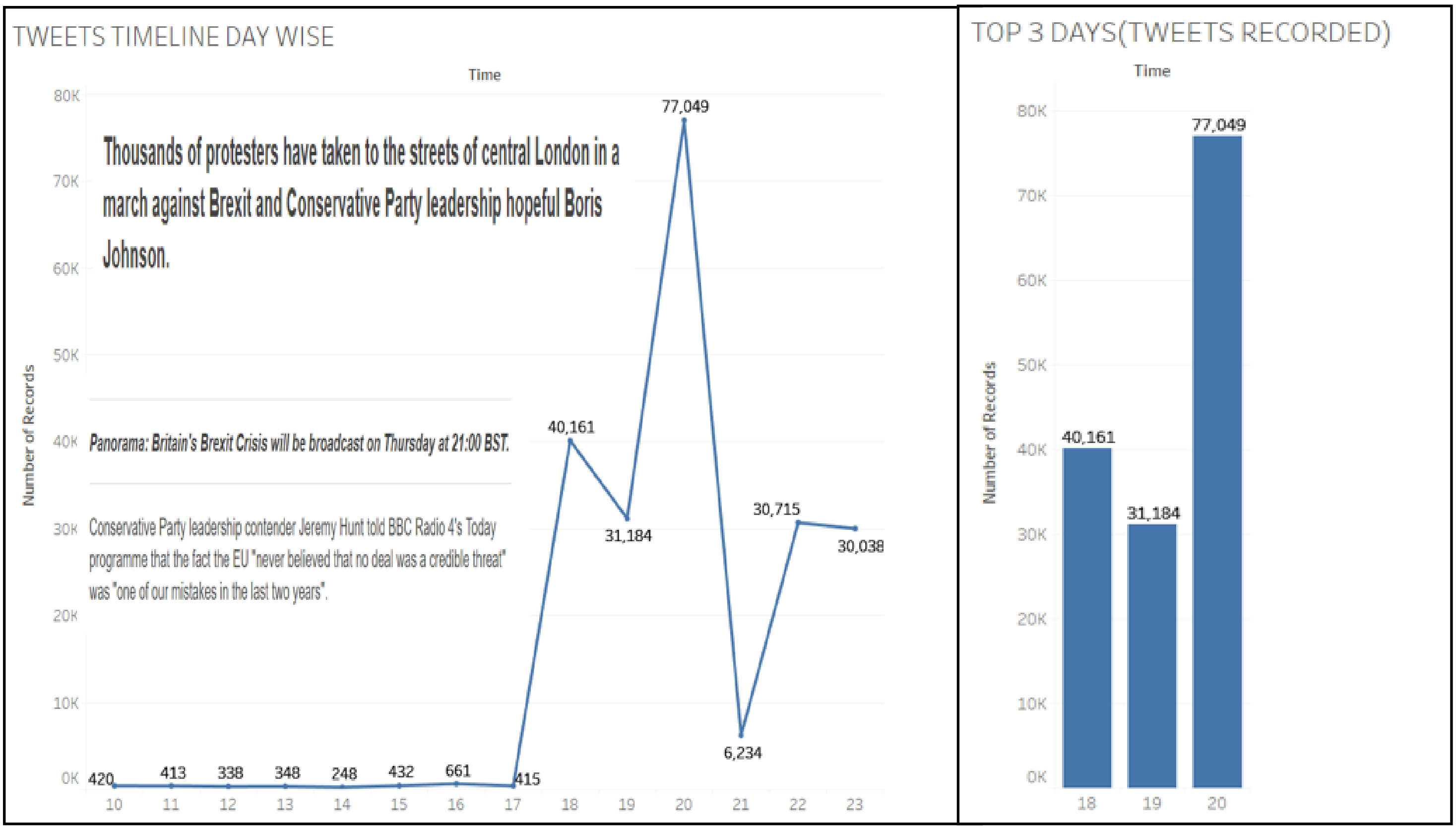
```python
def analyze_sentiment(self, tweet):
    analysis = TextBlob(self.clean_tweet(tweet))

    if analysis.sentiment.polarity > 0:
        return 1
    elif analysis.sentiment.polarity == 0:
        return 0
    else:
        return -1
```

Fig 8: TextBlob Approach

This approach classifies polarity of textual data in positive, neutral and negative categories with ‘1’,’0’ and ‘-1’. The sentiment scores for collected tweets is calculated as shown in fig7.

5.4 Visualizations

Once sentiment scores of the tweets were calculated, Tableau is used as the business intelligence tool in order to build graphs and interactive dashboards showcasing trends and patterns. Insights obtained pertaining to the collected tweets data is as follows.



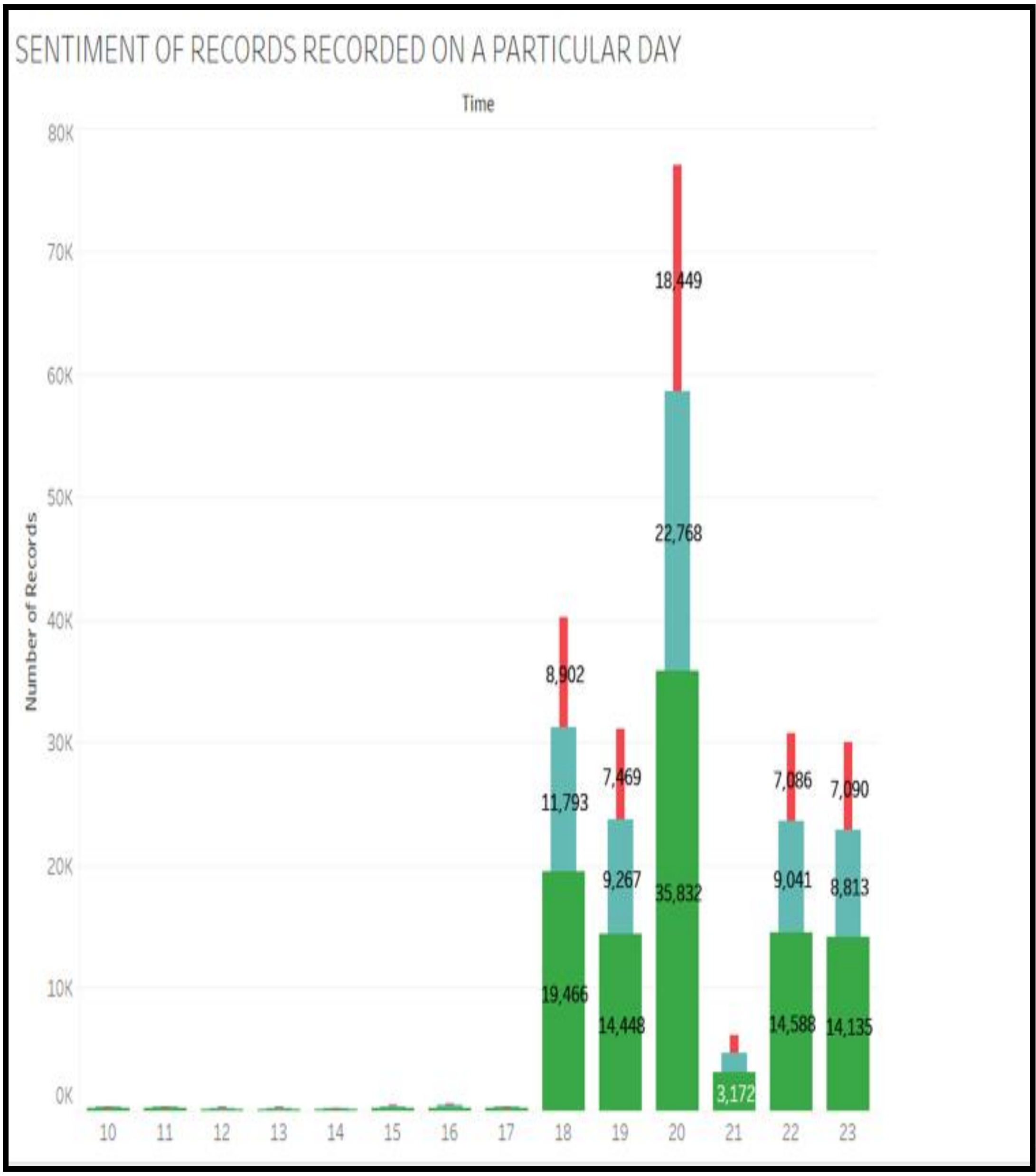
Thousands of protesters have taken to the streets of central London in a march against Brexit and Conservative Party leadership hopeful Boris Johnson.

Panorama: Britain's Brexit Crisis will be broadcast on Thursday at 21:00 BST.

Conservative Party leadership contender Jeremy Hunt told BBC Radio 4's Today programme that the fact the EU "never believed that no deal was a credible threat" was "one of our mistakes in the last two years".

Fig 9: Most number of recorded tweets

Figure 9 depicts visualizations built from collecting tweets between 10th July 2019 to 23rd July 2019. It is observed that there is a sudden surge in the number of tweets on 18th and 20th July 2019. As shown in figure, on 18th July 2019 the conservative party minister of parliament Mr. Jeremy Hunt held a show on BBC radio in order to clear general rumours about BREXIT among public and explained the positive side of it. BBC News (2019) However, on 20th July 2019, on London's street more than thousand people carried out a rally to show their protest against BREXIT in order to put forward their opinion before the newly appointed Prime Minister of England Mr. Boris Johnson. BBC News (2019) Therefore, it is interesting to find out what impact does these two events had on sentiment of people belonging to important countries for United Kingdom.



Fig

Fig10: Most number of recorded tweets

Figure 10 demonstrates the category wise sentiments of all the tweets received on the respective days. The tweets were categorized into Positive, Negative and Neutral classes.

Dashboard 1

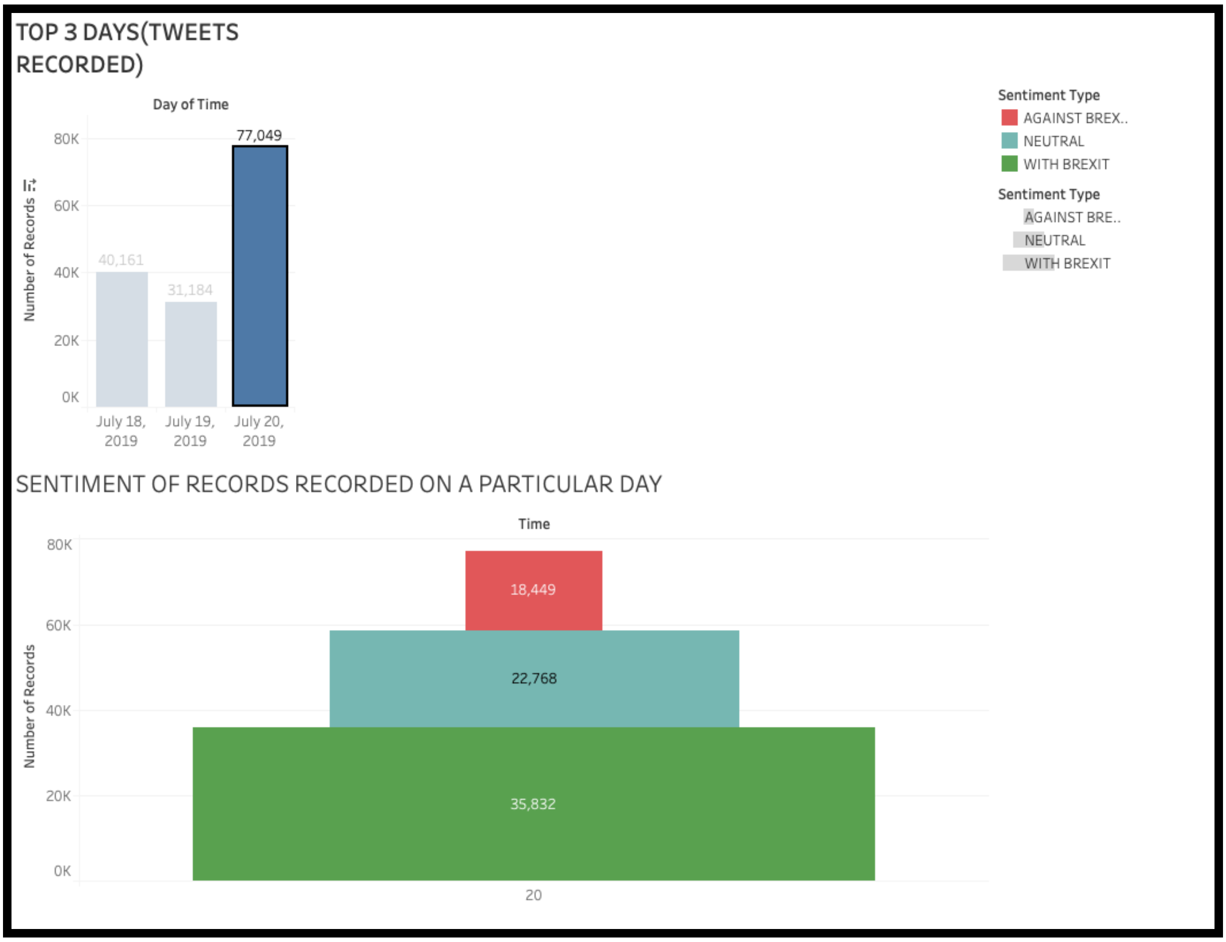


Fig 11: Dashboard for Cross Checking Data Accuracy

The figure 11 depicts a dashboard which was created to verify the accuracy of cleaned tweets dataset used for analysis. It consists of two linked graphs; the first graph depicts the top 3 days for which tweets have been gathered. Whereas, second graph has been built to showcase tweets count based on sentiment type on respective days for duration of 10th July to 23rd July 2019. When statistics for 20th July 2019 were selected then corresponding respective tweets count based on sentiment type (Positive = ‘With Brexit’, Neutral, Negative = ‘Against Brexit’) were reflected on the graph ‘sentiments of records recorded on a particular day.’ Therefore, for cross verifying the number of tweets gathered on 20th July and count of sentiment type of the tweets we can just add up the tweet count for sentiment type and then check whether the total number comes equal to count of the tweets obtained on 20th July 2019.

Total Count of Tweets in a day = Count of (With Brexit + Neutral + Against Brexit) Tweets

Therefore, Total Count of Tweets gathered on 20th July 2019 = 18,449 + 22,768 + 35,832.

Total Count of tweets gathered on 20th July 2019 = 77,049

As, above calculation matches with total number of tweets obtained on 20th July 2019. It is evident that the cleaned tweets dataset is free of redundancy.

Dashboard 2

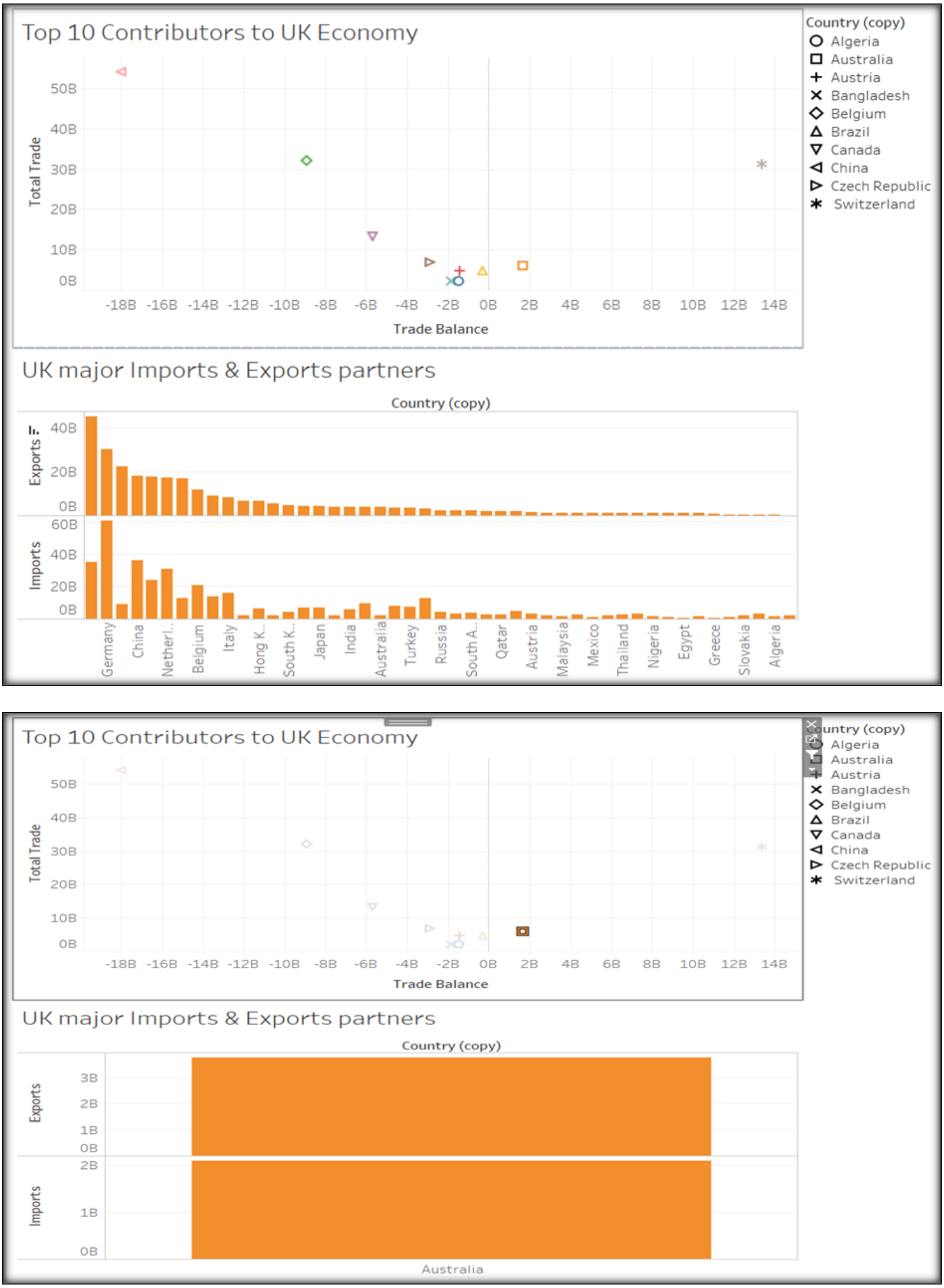


Fig 12: Major Contributors to United Kingdom's(UK's) Economy

The dashboard 2 built in figure 12 depicts United Kingdom's economy at a glance. The graphs used in dashboard have been built using the data obtained from Uktradeinfo.com. the first graph(Scatterplot) in the dashboard represents top 10 countries contributing in United Kingdom's (UK) economy in billion GBP. Whereas, the second graph (Bar plot) is showcasing Imports and Exports trade (in billion GBP) of UK with respective countries. A countries contribution in UK economy has been calculated based on difference in total Exports (in billion GBP) and Imports (in billion GBP) between UK and respective countries. Therefore, a countries positive contribution in UK economy is determined by finding the difference between its total export and import with UK. As, depicted in the dashboard 1, overall contribution of Australia in UK's economy is positive. When Australia is selected in the scatter plot depicting difference in total trade and trade balance corresponding exports and imports figures are illustrated in dashboard 2.

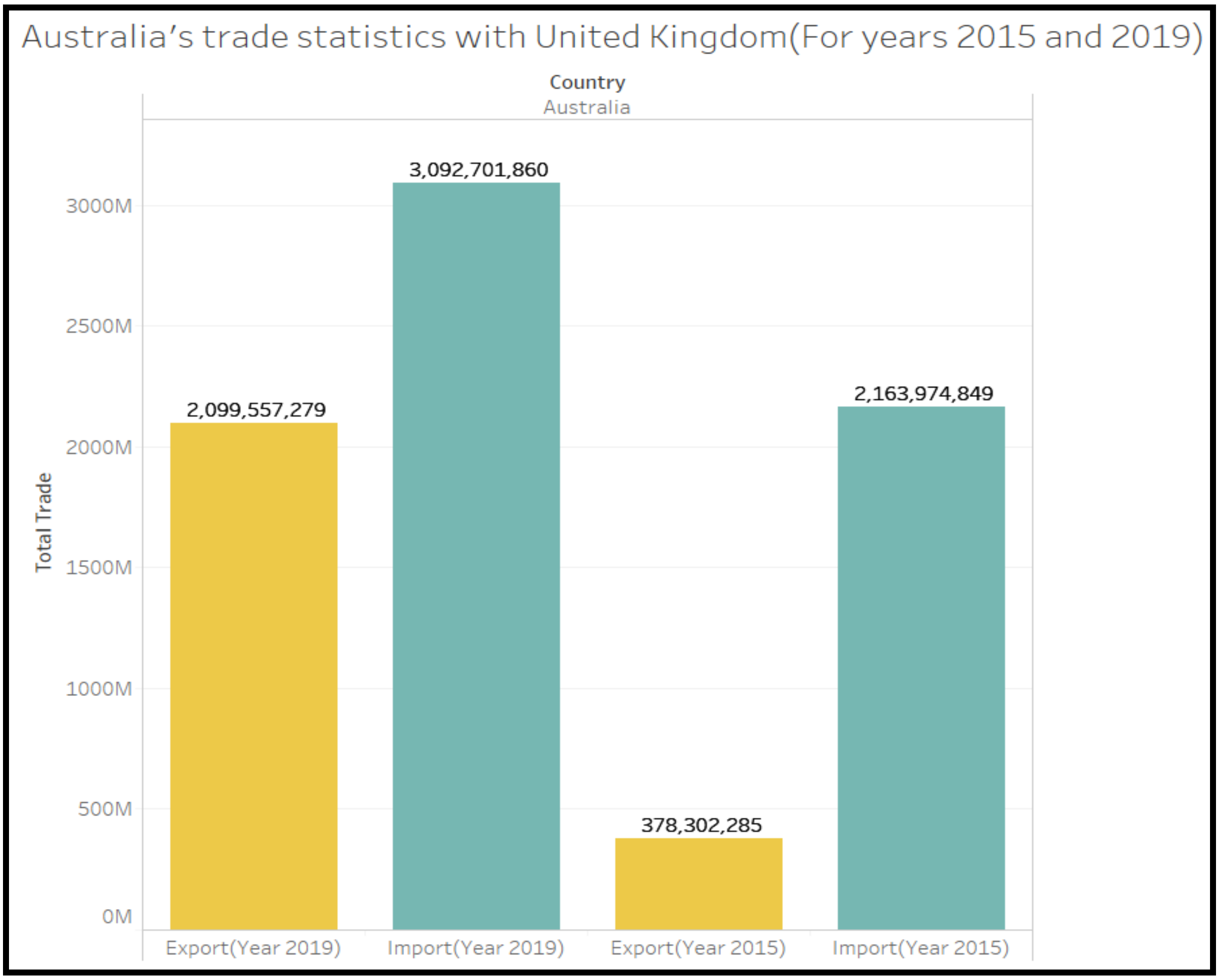


Fig 13: Australia's trade statistics with United Kingdom

Fig 13 illustrates Australia's trade statistics with United Kingdom before and after BREXIT referendum. This visualization has been prepared from the data retrieved from UKtradeinfo.com. It is observed that Australia's trade statistics with UK have been skyrocketed since year 2015. Therefore, it is now evident that Australia is one of the extremely important countries for UK and it is very important for UK government to know what the impact of the events was held on 18th July 2019 and 20th July 2019 on Australian public.

Dashboard 3

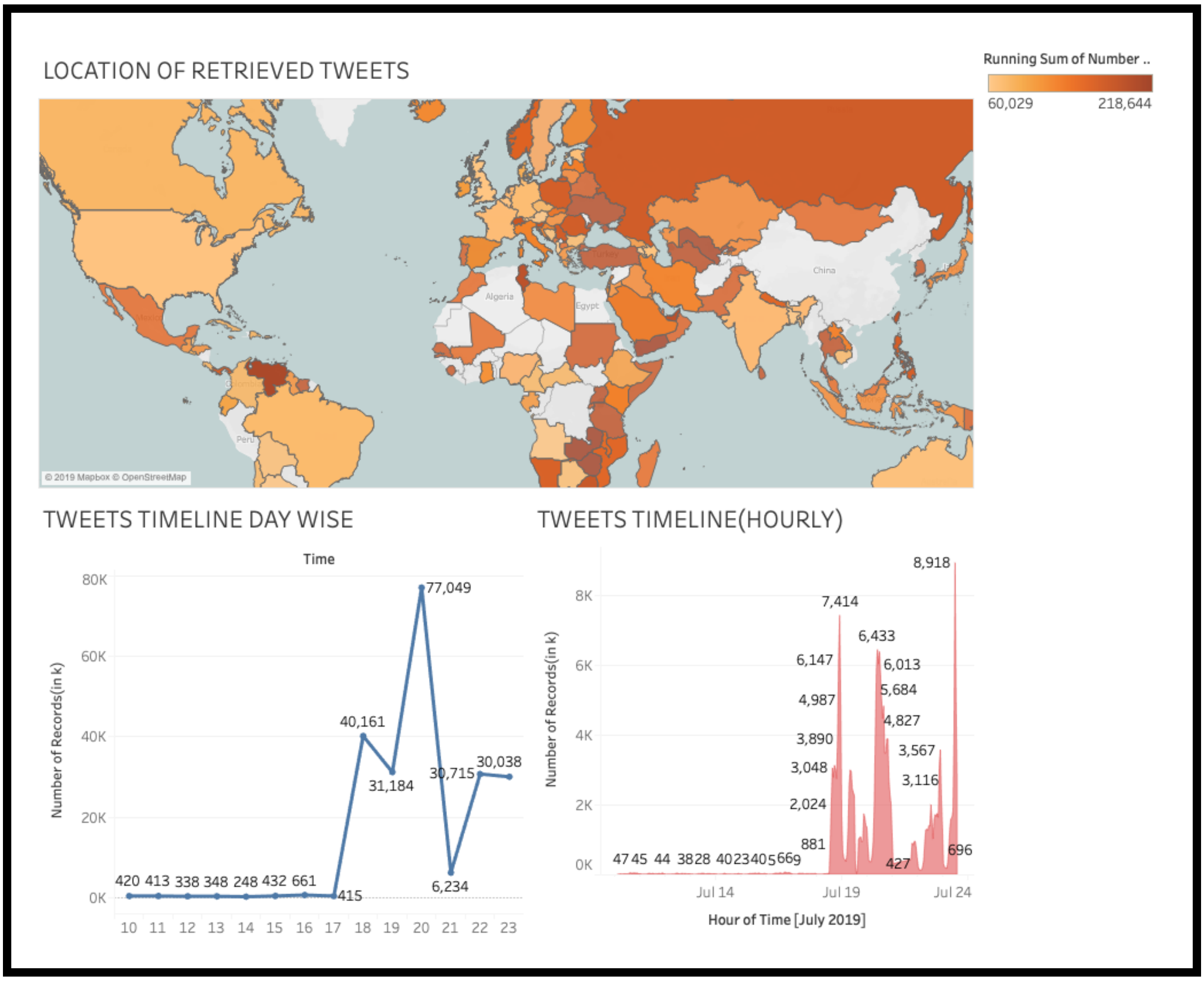


Fig 14: Location and Count of Tweets based on Day and Time.

The dashboard 3 shown in fig 14 was built using retrieved tweets. It was built for illustrating the different regions of the world from which tweets have been gathered for the duration between 10th July 2019 to 23rd July 2019. The geographical world map depicts the locations from which tweets have been fetched and the count of total number of tweets obtained is illustrated in line graph on day basis and on area graph on hourly basis for each day. It is interesting to see that, Australia is also among the locations from where tweets have been retrieved for 13days duration.

Dashboard 4

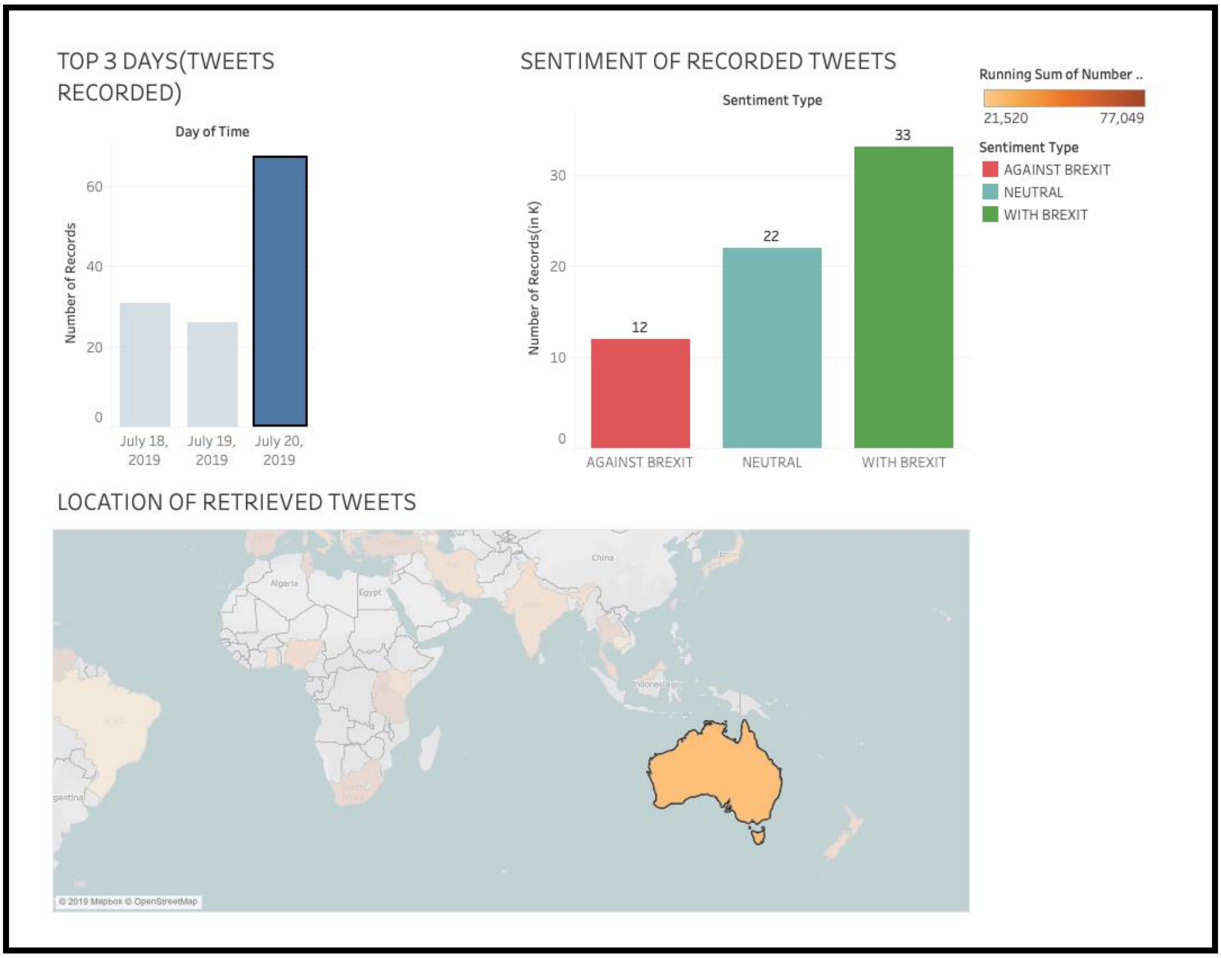


Fig 15: Top 3 days Dashboard with location and sentiment types

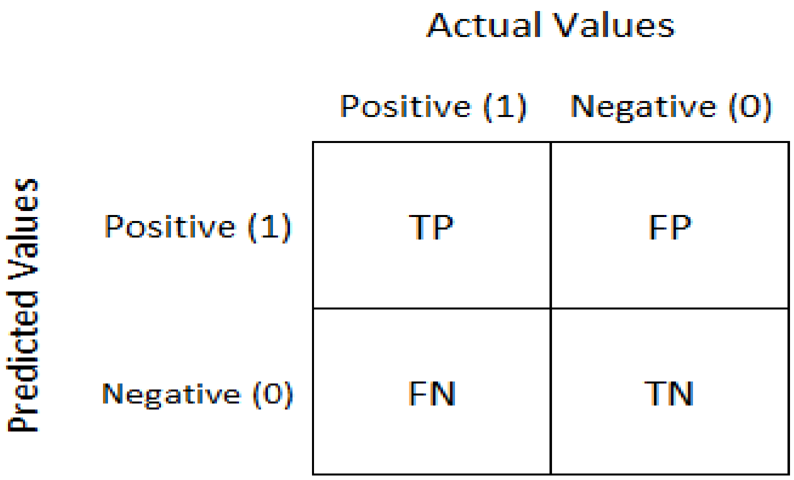
The dashboard 4 in fig15 depicts a drill down approach based on top 3 days on which tweets have been fetched. It consists of graphs belonging to count of tweets based on top 3 days, Overall count of sentiment type of the tweets and geographical world map. So, far it is observed that Australia was also among the locations from where tweets have been fetched regarding BREXIT for duration of 10th July 2019 to 23rd July 2019. Therefore, when 20th July is selected in dashboard, it drills down gained insights to next step by showing that tweets from top 3 days (in terms of tweet count) also consists of proportion of tweets fetched from Australia. In the next step when Australia is selected, it has provided statistics pertaining to number of tweets supporting BREXIT, Neutral in opinion and Against BREXIT through sentiment type graph. Therefore, by using filters in dashboard and selecting 20th July and Australia has helped in gaining important insights which can help the United Kingdom(UK) government to understand how reaction or sentiments of general public in Australia were when protest against BREXIT was carried out in central London on 20th July 2019. Similarly, insights for sentiment reaction of public in Australia or other important countries can be gained for 18th July 2019 when Conservative Party member Jeremy Hunt held a programmed on BBC radio for clearing doubts about BREXIT among general public. All such insights are helpful for UK government to formulate their strategy for making future policies.

6 Evaluation

In order to evaluate performance of both the approaches the results are compared. Accuracy of both the models have been considered as main comparison criteria.

6.1 Accuracy of Naïve Bayes Classifier Model

The accuracy of Naïve Bayes Classifier Model is calculated using Confusion Matrix. As stated by Simon (2010) a confusion matrix helps in understanding the parameters which assists in testing stability of a machine learning model. A typical example of a confusion matrix is as shown in fig 16.



		Actual Values	
		Positive (1)	Negative (0)
Predicted Values	Positive (1)	TP	FP
	Negative (0)	FN	TN

Fig 16: Confusion Matrix

As shown in above figure, there are four components used for calculating the parameters to evaluate a machine learning model's performance.

1. **True Positive Rate (TP):** When predicted values are predicted correctly then it is called as True Positive Rate.
   For example:- Predicting England will win the football match and it actually won it.

2. **False Positive Rate (FP):** When the prediction made turns out to be wrong then it is known as False Positive Rate.
   For example:- Predicting England will win the match but it lost it.

3. **False Negative Rate (FN):** When a negative prediction is made and it actually turns out to be negative then its called as False Negative Rate.
   For example:- Predicting England will not win the football match but it actually won it.

4. **True Negative Rate (TN):** When the prediction made is negative in respect to the actual values then it is termed as True Negative.
   For example: Predicting England will not win the football match and it actually lost.

   Based on these components of confusion matrix, following parameters are calculated to evaluate a machine learning model's performance.

1. **Accuracy:** Accuracy of a machine learning model is calculated as below.

$$accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

2. **Precision:** Precision is used for calculating accuracy of a positive class.
   It measures likelihood for prediction of classes which are positive. It is calculated as below.

$$Precision = \frac{TP}{TP + FP}$$

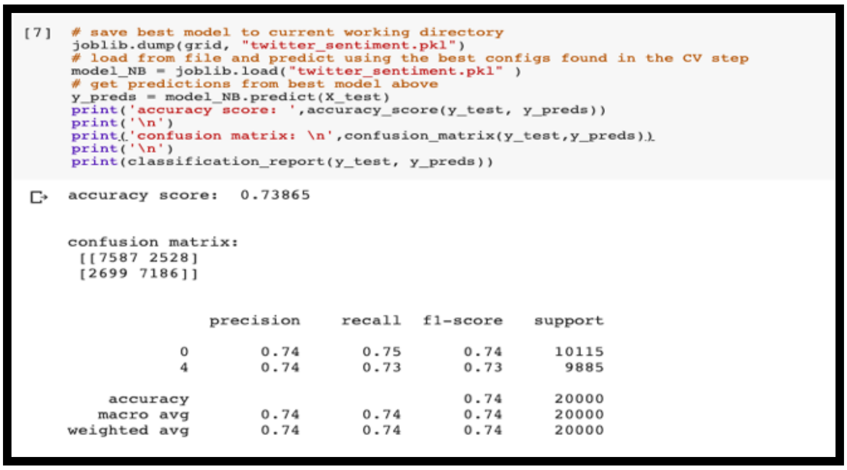
3. **Sensitivity (Recall):** Sensitivity or recall is defined as proportion of accurately classified positive classes. It also tells how a model behaves for a positive class. It is calculated as below.

$$Recall = \frac{TP}{TP + FN}$$

4. **F1 Score:** F1 score helps in keeping a balance among precision and recall. It is calculated as below.

$$\mathrm{F1} = 2\ \mathrm{x}\ \frac{Precision * Recall}{Precision + Recall}$$

The confusion matrix calculated is shown in fig 17**.**



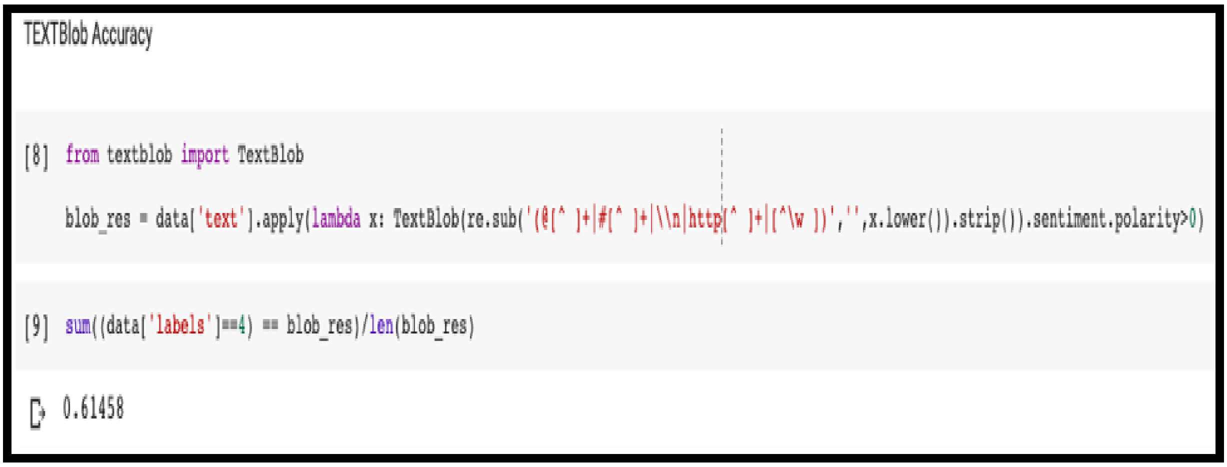
```
[7] # save best model to current working directory
    joblib.dump(grid, "twitter_sentiment.pkl")
    # load from file and predict using the best configs found in the CV step
    model_NB = joblib.load("twitter_sentiment.pkl" )
    # get predictions from best model above
    y_preds = model_NB.predict(X_test)
    print('accuracy score: ',accuracy_score(y_test, y_preds))
    print('\n')
    print('confusion matrix: \n',confusion_matrix(y_test,y_preds))
    print('\n')
    print(classification_report(y_test, y_preds))
```

```
accuracy score:  0.73865


confusion matrix:
 [[7587 2528]
 [2699 7186]]


              precision    recall  f1-score   support

           0       0.74      0.75      0.74     10115
           4       0.74      0.73      0.73      9885

    accuracy                           0.74     20000
   macro avg       0.74      0.74      0.74     20000
weighted avg       0.74      0.74      0.74     20000
```

Fig 17: Confusion Matrix for Naïve Bayes Classifier Model

From fig16, it is clear that Naïve Bayes Classifier Model achieved Accuracy of 74% accuracy with 74%, 75%,74% scores of precision, recall and F1 Score respectively.

6.2 Accuracy of TextBlob Approach



TEXTBlob Accuracy

```
[8] from textblob import TextBlob

    blob_res = data['text'].apply(lambda x: TextBlob(re.sub('(@[^ ]+|#[^ ]+|\\n|http[^ ]+|[^\w ])','',x.lower()).strip()).sentiment.polarity>0)
```

```
[9] sum((data['labels']==4) == blob_res)/len(blob_res)
```

```
0.61458
```

Fig 18: Accuracy Calculation for TextBlob Approach

The accuracy calculation for textblob approach is as shown in fig 18.
Though, textblob approach is part of natural language processing but it does not come under machine learning. Therefore, in the absence of confusion matrice, the accuracy for this approach is calculated using formulae.

Accuracy = Total number of Correct results/Total number of records.

6.3 Comparison Between Naïve Bayes Classifier Model and TextBlob Approach.

Model	Accuracy	Precision	Recall	F1 Score
Naive Bayes	74%	74%	75%	74%
TextBlob	61.45%			

Table 2: Accuracy Comaprison

As shown in above table it is observed that Multinomial Naïve Bayes Classifier Model(74%) achieved higher accuracy over TextBlob Approach(61%).

7 Conclusion and Future Work

The research question basically centres around deciding the affected regions of the world due to BREXIT by utilizing Naïve Bayes classifier algorithm, technology: Natural language handling (NLP), Python NLTK library, Python's TextBlob NLP library. Furthermore, the work focussed on the Twitter opinion mining which bifurcates the tweets based on three categories: positive, negative and neutral. This work can help organizations, associations or any governing body to centre about the opinion of the user about a rule or product. The sentiment score has been implemented using Naive Bayes Classification algorithm and compared using TextBlob library of python. it was inferred that the Naive Bayes algorithm provided a strikingly contrasting accuracy of 74% as compared to 61.45% of TextBlob.

The revelations of this investigation will support the British and Irish governments to refine their game plans in order to alleviate any repercussion of the BREXIT decision on their economies and lives of their inhabitants.As examined before, the significant restrictions of this examination are the load it will add about while recovering the huge amount of data from twitter and cleaning it all concurrently. To alleviate this issue, other Artificial Intelligence approach like N-gram approach can be utilized to improve the general proficiency of the model. Additionally, the model is not able to divide the polarity and identify the words correctly as positive or negative tweets because of the double meaning words, these issues can likewise be worked upon in future to improve the productivity of the model.One point to be added for future work is to understand the N-gram approach and apply it to other languages such as Arabic, Latin, Mandarin, among others, as the tweets are tweeted invarious languages, so in order to provide a detailed analysis on the type of language, i.e. making the model understand the language and then dividing it on the basis of positive and negative frontier, will be a commendable step towards future work.Besides this, the Google BERT is a new algorithm, can be used to provide higher accuracy for sentiment analysis.

Acknowledgement

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