

Sentiment Analysis of Social Media: Techniques, Applications, and Reliability

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ABSTRACT

Big data analytics can be used by smart cities to improve their citizens' liveability, health, and wellbeing. Social surveys and also social media can be employed to engage with their communities, and these require sophisticated analysis techniques. Twitter and Reddit are ideal social media tools for natural language processing since they have predominantly text-based content. Data from these social media systems can be analysed to provide sentiment on issues of importance in near real-time for decision makers. Techniques such as word clouds can provide initial qualitative analysis while quantitative analysis can produce bar charts and time series of sentiment values. Access to the Twitter and Reddit APIs are described together with analysis techniques using Python libraries. The advantages and disadvantages of this type of analysis are discussed. Social media users tend to be concentrated in the more youthful and socially progressive social cohorts, which may cause bias.

KEYWORDS

CCS CONCEPTS •Computing Methodologies, Artificial Intelligence, Natural Language Processing, Information Systems, Information Systems Applications, Data Mining
Additional Keywords and Phrases: Twitter, Reddit, Quora, APIs, Python libraries

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Social media describes internet-hosted systems that enable interaction among people to create, share and exchange ideas and information. The extent of social media use worldwide is staggering. It is estimated that there may be over 3 billion active social media users by 2023, a third of the world population with over 800 million from China and 450 million from India alone [1]. Billions of posts, photos, videos, audio files, messages, documents, and other media are uploaded to the internet and shared across a wide range of platforms such as Facebook, Instagram, and TikTok every day.

Social media platforms provide a ready source of big data that can be mined and analysed using a variety of techniques [2]. Indeed, social media analytics (SMA) is a growing area of research in its own

right [3]. Sentiment analysis refers to determining opinions about specific issues from social media data. For example, companies can use sentiment analysis as another method of assessing market success. It can also be used to predict election results by monitoring relevant messages about political parties and politicians.

Opinion mining from social media is employed by the media giants for research and marketing purposes using their own tools [4].

In this paper, the research objectives are to develop and demonstrate applications to assess sentiment by mining and analysing data from several common social media platforms, comparing results for the same search criteria, and exploring further research pathways.

1 REVIEW OF PREVIOUS WORK

Data from social media can be used to determine immediate, although less formal, responses than social surveys [5]. For example, Yigitcanlar et al. used geolocated Twitter analysis to study perceptions about smart city concepts and technologies in Australia [6]. Attitudes towards the Covid-19 pandemic have also been studied using Twitter [7, 8]. These authors used word clouds to present key words and phrases indicative of public sentiment on the emerging pandemic. A similar approach was adopted by Kankanamge et al. to assess disaster severity from flooding using Twitter feeds [9]. These authors found that the analysis could track disaster severity fluctuations over time and demarcate highly impacted disaster zones through message geolocation.

Reddit has also been used for sentiment analysis. Melton et al investigated COVID-19 vaccine-related discussions from 13 Reddit communities across 2020-2021 [10]. They found that sentiment was generally more positive than negative over this period although misinformation needs to be combated. Thapa analysed sentiment for cybersecurity on both Twitter and Reddit platforms and found that mostly positive or neutral sentiment was recorded [11].

Quora is a further text-based social media platform amenable to sentiment analysis. Lexicon-based analysis has been studied for Quora and compared with Twitter using Indian election data. The results infer that Quora can be used to obtain the behavior of different political parties [12].

There are various techniques for analysing sentiment. Natural Language Processing (NLP) is the most straightforward using text analysis. More sophisticated approaches such as Machine Learning (ML) and Deep Learning (DL) can be applied usually after pre-processing using NLP [13]. However, these techniques require a saved dataset that can be split into training and testing components.

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Table 1: Comparison of Twitter and Reddit

Feature	Twitter	Reddit
General Description	Social networking service founded in 2006, California, US	News and content aggregation with discussion service founded 2005, Massachusetts, US
Privacy	Username and biography required	Username only required
Message Ranking	Trending tweets decided by public	Posts voted on by users
Message Size	280-character limitation for text	25 MB
Geolocation Services	Provided but default is to leave out	Not provided
Language identification	Yes	Not provided
Users	62% male; 38% female	64% male; 36% female
Demographics	25-34 age group about 40%; Over 50 about 17%	18-19 age group 36%; Over 50 about 13%

2 SOCIAL MEDIA ANALYSIS

2.1 Social Media Descriptions and Application Programming Interfaces

Social media companies generally provide Application Programming Interfaces (APIs) for developers to access and analyse data. Most have a free plan for APIs that provide limited but useful functionality. A recent review rates Tik Tok and Instagram as having the easiest to use APIs [14].

However, these authors have found that the Twitter and Reddit APIs are relatively easy to use once appropriate permissions have been obtained. Twitter is a rapidly expanding social media microblogging service, provides a free API for practitioners, and can be considered as open data compared to other social media that are more restrictive such as Facebook [6].

Similarly, Reddit is primarily a text-based social media platform. Registered users submit content as text posts, images, or videos to areas organised into communities of interest known as ‘subreddits’. However, Reddit content is administered by moderators. As of September 2022, there were more than 3 million subreddits. Reddit statistics are available at: <https://foundationinc.co/lab/reddit-statistics/>. Unlike Twitter, Reddit does not have location services for subscribers.

Other social media services such as Facebook and Instagram use a mix of media formats including text, audio, imagery, and video, whereas Twitter and Reddit are primarily text-based, enabling NLP techniques such as sentiment analysis to be applied. Furthermore, it is also easier to extract keywords from tweets than Facebook comments, most likely because of the use of hashtags, mentions, and emoticons in Twitter and subreddits for Reddit [4].

Twitter has far more subscribers than Reddit. However, Reddit has greater privacy since only the user’s username is displayed in posts. Reddit aggregates items into subreddits that only display verified items while Twitter is a social networking service, an internet platform that enables creation of relationships with other people. For each system, one needs to be a registered user to post items. Reddit is a more ‘serious’ social media system than Twitter with no constraint on size of posts compared to the Twitter 280-character limit.

The principal differences between Twitter and Reddit are summarised in Table 1.

2.2 Twitter API and Analysis

Access to Twitter data is provided by applying for a developer licence that is readily granted. There are several levels of access: Essential, Elevated, and Academic Research. Twitter currently has two versions of its API: v2 and premium v1.1. When access is granted a set of tokens (*API_key*, *API_Key_secret*, *Bearer_token*, *access_token*, *access_token_secret*) is provided for each app. These tokens are used programmatically to access Twitter data with Python 3.86 code running in the command line interface of the provided Integrated Development Environment (IDE) on a Windows 11 PC. Plots were done using the *matplotlib* library.

Twitter data is generally dirty and must be cleaned before analysis. Here, retweets and tweets in non-English languages are filtered out. Retweets must be removed or the results will be biased towards the sentiment expressed in these tweets. The tweets were also converted to lower case for ease of analysis. The data were further cleaned to remove mentions, hashtags, and hyperlinks using the Python library *re* that provides regular expression operations for analysis [15].

Libraries such as *TextBlob* can be used for sentiment analysis. *TextBlob* provides both subjectivity and polarity in the range [-1.0, +1.0] for a given string of text (a tweet) by using lexicon-based analysis [16]. Words in the text string are compared with a pre-defined dictionary, scores assigned to each word, and an overall sentiment (polarity) determined by averaging or a similar operation. Subjectivity is determined by assessing the intensity expressed in the text string. These are computed from *TextBlob* by:

```
polarity=TextBlob(tweet.text).sentiment.polarity
subjectivity=TextBlob(tweet.text).sentiment.subjectivity
```

For a set of tweets, statistics can be built up by determining the polarity of each tweet, and assigning that polarity to a sentiment in the range Very Negative to Very Positive. Tweets are determined to be very negative if polarity is less than -0.5; negative if in range [-0.5, to 0.15], neutral if in range [-0.15 to 0.15], positive if in range [0.15 to 0.5] and very positive if greater than 0.5.

An example is shown for the query ‘Russia Ukraine War’ in Figure 1 for a sample of 2500 tweets. Here there were 1881 retweets and 180 non-English tweets that were eliminated leaving a sample of 529 original, English language tweets. This shows a generally positive sentiment among users. The tweets were judged to be mainly subjective with an average positive subjectivity of 0.38. This

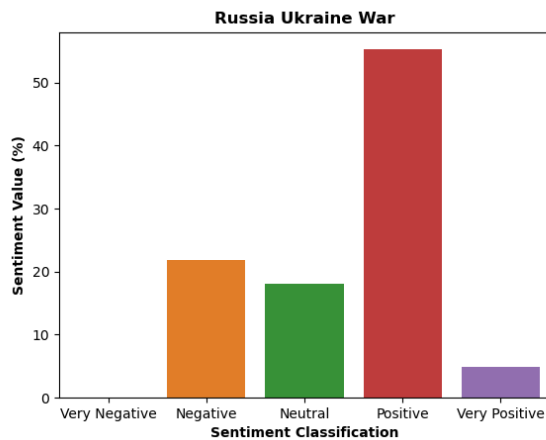


Figure 1: Sentiment values for query “Russia Ukraine War” (on 27 October 2022)



Figure 2: Word cloud of tweets from query “Russia Ukraine War” (on 27 October 2022)

shows a generally positive impression of the Russia-Ukraine War with over 55% positive responses.

The *wordcloud* library can provide word cloud output of a set of tweets to provide a qualitative sentiment analysis. A word cloud analysis of 2500 tweets filtered with the query ‘Russia Ukraine War’ is shown as Figure 2. Again, 1990 retweets and non-English tweets were excluded from the analysis. This shows that the most common words are ‘Russia’, ‘Ukraine’, ‘Putin’, and ‘war’.

Geospatial analysis of Twitter data can provide further insights. However, the default is to disable locations so there are generally low statistics on geolocated tweets. For example, only 4 of the 2500 tweets in Figure 2 include geolocation information.



Figure 3: Word cloud of reddit posts to subreddit ‘JonBenetRamsey’ (on 23 September 2022)

2.3 REDDIT API and Analysis

Reddit has several Python API libraries – among these *py-reddit* and *praw* are the most widely used. To get access, one obtains a *client_id* and *client_secret* by creating an app on one’s Reddit account¹. Using the *praw* library, for example, this code provides access to Reddit content:

```
r = praw.Reddit(client_id=id, client_secret=secret, user_agent=name)
```

where ‘name’ is the name given to the app.

Similar analysis techniques can be applied for Reddit posts as described for Twitter. An application in Python was developed to read and analyse Reddit posts relevant for a specific topic. As for the Twitter app, the script is written in Python 3.86 and runs in the command line interface of the provided IDE on a PC running Windows 11. Reddit threads can be sorted by multiple criteria (top, hot, new, relevant, most comments) and by time (past hour/day/week/month/year or all time). The data were cleaned as described earlier. For example, one of the authors (PJR) is interested in the 1996 JonBenet Ramsey murder in the US [17]. A word cloud for the top 500 posts selected in the subreddit ‘JonBenetRamsey’ is shown as Figure 3.

The word cloud shows that the most common words are “Patsy” and “John” the parents of the six-year old victim JonBenet Ramsey, and “case”. Indeed, big data analytics such as this can help solve crimes [18]. Note that this word cloud is determined only from the 500 most recent significant posts on this issue.

Reddit does not use location data so geospatial analysis of posts is not possible. Further, there is no facility to check which language the posts are written in. Reddit is primarily English (US)-based although there are many non-English subreddits such as *r/fr* and *r/de* that contain French and German language posts respectively [19, 20]. These features restrict more detailed analysis of users than

¹c# - How to get access token? (Reddit API) - Stack Overflow

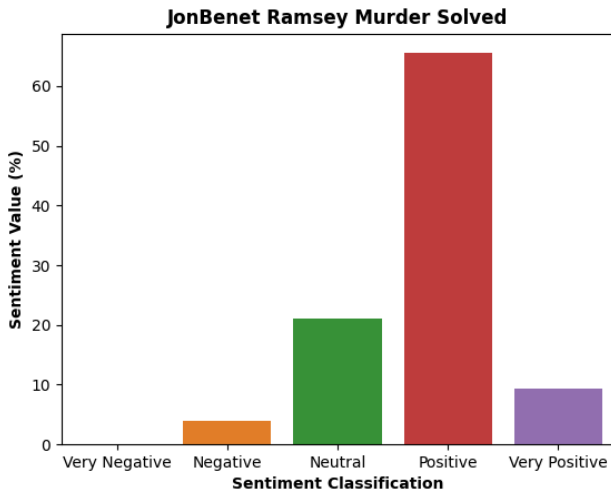


Figure 4: Sentiment values for query “JonBenet Ramsey Murder Solved” (on 23 September 2022)

Figure 5: Sentiment from string ‘Energy Costs’ from Twitter (left) and Reddit (right)

can be done for Twitter. On the other hand, Reddit does not have a rigid length for posts like Twitter. In the analysis here the largest post is 39979 characters in length, 625 lines of text.

The *praw* library allows the user to search the whole of Reddit. Using the phrase “JonBenet Ramsey Murder Solved” gives the result shown as Figure 4. This indicates that the general sentiment expressed by Reddit users is that this case will eventually be solved.

It is noteworthy that these Reddit posts range from 2015 to 2022 whereas the Twitter API is restricted to the past 30 days.

2.4 Comparison of Twitter and Reddit

How do these social media systems compare? Figure 5 shows sentiment from Twitter and Reddit for the search string ‘Energy Costs’.

These show reasonable agreement even though they cover different time periods with positive sentiment dominant in both cases. Interestingly Twitter has non-zero Very Negative and Very Positive values whereas Reddit does not. This may be an artefact of the different time spans covered or the different post sizes. Reddit posts can be far larger than Twitter and are likely to contain more reasoned and less emotive opinions.

3 DISCUSSION

3.1 Applications

Sentiment Analysis has many applications. In their review of sentiment analysis methodologies, practices and applications Mehta and Pandya identified decision support, business applications such as marketing, and prediction/trend analysis as the key applications [21]. Sentiment analysis can also be used in place of, or to complement, traditional polls and surveys. Lepelaar et al. [22] compared a standard survey for a local government area (LGA) in Australia with sentiment analysis from Twitter and found qualitative agreement for key issues. Sentiment analysis can be used by LGAs to quickly assess community opinion on critical or controversial issues.

Sentiment analysis has been used for predicting the 2020 US Presidential election [23, 24]. Ali et al. analysed over 7 million tweets around the 2020 US election pertaining to the two candidates and found that sentiment changed over the 10 key days to favour the eventual winner, Joe Biden. Chaudry et al. also found agreement between sentiment from Twitter and the election result using the Term Frequency-Inverse Document Frequency approach [25].

3.2 Reliability

Social media demographics are provided at [26]. This shows that the largest age group for Twitter is 18 – 29 with 38.4% female and 61.6% male users. However, its market penetration is slowing as newer social media platforms emerge. A further caveat on the use of Twitter is that only a fraction of the population use it (less than 25% in Australia [27]), and most of those lean strongly to the progressive, left-wing side of politics [28]. This would help explain the low numbers of relevant tweets for specific topics and also skew the results of any Twitter analysis.

Reddit’s users are mostly in their 20s and 30s but still with 10% over 50 (Table 1). Quora is also biased towards a young age group with students providing most subscribers. While it is only one sample, the agreement between Twitter and Reddit noted in section 3.4 is encouraging. Future work may involve a systematic comparison across a range of issues among several social media platforms.

3.3 Other Social Media Platforms

Twitter and Reddit are the principal subject of the present study. However, there are many other systems such as Quora and LinkedIn that have less developed APIs. Quora is a question and answer platform whereas LinkedIn is primarily a social networking platform for professionals. Quora discourages users from developing APIs to access its data. Nevertheless, lexicon-based analysis has also been studied [29].

LinkedIn is primarily used for professional networking rather than general social discourse and has also been used for opinion mining and sentiment analysis [30]. Increasingly people are adding comments and opinions to LinkedIn posts leading to sentiment analysis of topical issues such as remote versus office working arrangements.

Future research could examine how data from different social media platforms can be analysed to provide sentiment and opinions on current issues.

3.4 Implications for Social Theory

Sentiment analysis is more than just extracting sentiments from social media streams. There are also research implications for social theory as discussed in [31]. Social media enables social scientists to observe and study the behaviour of a vast number of users whereas existing social theories of human interaction have been determined from small-scale experiments with limited numbers of subjects. The vast quantity of data from social media can enable testing of existing theories and may also lead to new social theories of human interaction particularly as they pertain to the virtual online world.

3.5 Sentiment Analysis using Machine Learning Prediction

The analysis described here does not make use of ML or DL to predict the sentiment contained in words or sentences by comparison with their context. By determining the relative count of each word in a document reweighted by its prevalence over all documents in a set, the overall sentiment can be predicted using a logistic regression classifier on labelled examples [32]. Many datasets are available for training these models. More advanced models to predict sentiment using DL have also been used. This approach was not possible in the present work since the live social media streams were being analysed for rapid assessment of sentiment.

4 CONCLUSIONS

Social media provide a vast quantity of big data pertaining to current issues. Analysing these data to determine sentiment is in its early stages but shows promise as a means of quickly assessing community opinion on critical or controversial issues. This can help organisations and governments understand their constituents' needs and concerns. Several applications were developed using Python libraries to perform sentiment analysis and some sample sentiment analysis was demonstrated for the Twitter and Reddit platforms showing both qualitative (word cloud) and quantitative results (bar charts of sentiment).

The social media user base is constantly increasing worldwide and becoming an acceptable way of communicating opinions and news in near real-time. Sentiment analysis of social media is an emerging field that shows great promise for smart city applications such as monitoring community opinion on critical issues. Future work could include refinement of the social media analysis techniques and comparing predictions with different social media platforms. Further areas of work involving machine learning prediction techniques, and the implications for social theory are noted.

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