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Towards Data Analytics Approach for Monitoring of Disaster Management using Machine Learning Techniques: A Systematic Literature Review (SLR)

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ABSTRACT

Opinion mining is not just applicable to businesses, but also to other areas such as politics and governance. As of April 2020, there are 4.57 billion active internet users and 3.81 billion active social media users depositing huge amount of data on several social media platform such as Facebook, Twitter, Instagram, WhatsApp and others. During the period of disaster response, a large number of users post several information on Twitter like disaster damage reports and disaster preparedness situations, making Twitter an essential social media for updating and accessing data. Globally, governments spend huge amounts to provide aid packages to their citizens. The primary objective of government palliatives, relief and aid packages is to cushion economic and psychological effects on the citizens affected by disaster. This study aims to conduct a systematic literature review (SLR) to identify the current researches concerning the public opinion and sentiment on Twitter with regard to COVID-19 palliative and relief aid packages distributed to vulnerable citizens during disaster. Also, to find the most effective machine learning algorithms in classifying public opinion and sentiment on Twitter social media by extracting data from two digital libraries (databases) Scopus and ProQuest. Conclusively, Findings from the SLR study shows that Naïve Bayes and Support Vector Machine (SVM) classifiers are the most popular and effective techniques used on Twitter opinion and sentiment analysis.

Keywords: Opinion Mining, Sentiment Analysis, Twitter, COVID-19 Palliatives, Disaster Management, Machine Learning

Introduction

There are several approaches to governance, some of which involves the participation of the public as customers, partners, or citizens [1]. Good governance requires improvement overtime to address key issues concerning existing and emerging challenges to those that are governed. Part of such challenges is to improve government ability to manage rapidly growing information demands on accountability and transparency of public funds which requires the use of analytics to proactively address governance challenges [2]. Recognizing the relevance of technological advancements, governments establish technological centers and some try to involve technology as a process in their governance process. This brought about processes like e-governance, smart cities, and smart government.

With tremendous advancements in information and communication technology, business intelligence has become an influential and successful instrument in shaping business objectives to target customer's needs [3]. Opinion mining is not just applicable to businesses, but also to other areas such as politics and governance. Opinion mining becomes highly popular and interesting by researchers recently because of its application to several field [4]. According to Statista Info graphic (2020) there are 3.81 billion active social media users depositing huge amount of data on several social media platform such as Facebook, Twitter, Instagram, WhatsApp and others. This study choses Twitter as the primary sentiment analysis object as it is a popular microblog that has 140 million active users posting more than 400 million tweets every day. During the period of disaster response, a large number of users post information like disaster damage reports and disaster preparedness situations, making Twitter an essential social media for updating and accessing data. Mining sentimental data efficiently will help

in better understanding the disaster response timely and easily [5].

A. Background

As defined by United Nation, disaster is a serious disruption of community and society. There are four types of disaster namely; (i) natural disaster such as floods, earthquake, volcano etc., (ii) environmental disaster such as forest fire outbreak, industrial accidents of hazardous materials etc., (iii) complex disaster such as communal clash, war etc., and (iv) pandemic disaster such as deadly and dangerous diseases like COVID-19, HIV/AIDS Cholera etc. In this regard, COVID-19 is also part of the four types of disaster which fall under the pandemic emergency disaster [6].

COVID-19 is a disastrous disease that started spreading amongst people on December, 2019 at Wuhan, China [7]. The virus started increasing and spreading on 31st December, 2019 which begin to draw the attention of public. With the rising number of new cases and death toll every day, World Health Organization announced COVID-19 as pandemic [8].

There are several related works on social network data analytics in relation to disaster mitigation, monitoring, and management. A study by [9] on disaster monitoring and mitigation proposed ways to improve search algorithms, and concepts built controlled vocabularies and conducted search experiments for determining improvements for the algorithms for the search of Social Networks (SNs). The study also showed how to use several parameters derived from the search results to interpret collected data. It also proved that some of the characteristics of interest of the emergency events, as the amplitude of the population involved and the gravity of the event are well represented by the temporal density of the

number of related messages on the SNs. Findings from the study reveals a good correlation between the increment of the number of messages and the speed of the unfolding of the event. The time lag between the emergency onset and the peak of the number of messages was large. However, the delay between the event onset and the moment when the maximal gradient of the number of messages occurs is much lower. They concluded that effective emergency monitoring can be improved by renewed scanning per minute, taking into account that for life-threatening conditions the intervention must be in a few minutes to a few hours.

Social media is a way of life to so many people because it is the only platform that allow them to express their feeling and share news that can help others as quickly as possible. The recent COVID-19 pandemic has been trending on social media since the beginning of the virus outbreak in December, 2019. [10] Express concern about the daily spreading of COVID-19 information and news that could perhaps be a good or fake news which might jeopardize others to an unfortunate incidence that may happen when hearing the negative news about the pandemic. Also [11] describe the hate speech and misinformation disseminating on social media as a serious problem that affect the society especially for the recent allegation by some people linking 5G to COVID-19 pandemic. Several researchers conducted their research on the role of social media and data analytics in disaster management [12], [13] by employing several machine learning techniques in classifying the sentiment and opinion of public from social media specifically Twitter.

The novel coronavirus is a serious disaster that ceased almost every social and economic activities across the world, people were forced to stay at home, regularly wash their hand and maintain social distancing to reduce the spread of the virus

which could be the only way out to curtail and contain the deadly infectious disease [14]. Government agencies and media organization provide information about the daily cases to the public. However, individuals share their opinion and sentiment on social media regarding coronavirus pandemic every day. Recent study by [15] showed how Twitter data through the analysis of public opinion and sentiment could help governmental organization and humanitarian agencies to predict disaster management, election votes and many more. There are several machine learning algorithms available. Some are known to be efficient on huge amount of data, fast and reasonably accurate such as the Naïve Bayes algorithm, while others such as the Decision tree are known to be efficient on medium to small scaled data [26], [27] conducted their researches by identifying the most effective and best performing machine learning models in the field of opinion mining and sentiment analysis from different platforms.

In this study, a systematics literature review is conducted to identify the current researches and to find the most effective machine learning classifiers in the context disaster management, focusing on COVID-19 Palliatives and relief aid packages from two digital libraries (databases).

I. RESEARCH METHOD

Systematics literature review (SLR) is the procedure for finding all available research evidences to evaluate and interpret them in order to provide answers to specific research questions [16] it is a method that seeks to create an objective overview of the facts in a given field, in contrast to the ordinary narrative analysis. SLR use to identify and examine different kind of researched conducted within the periods selected with the corresponding research scope [17]. This research is aimed to collect information from reputable

research databases on opinion mining and sentiment analysis related to disaster management and relief packages specifically on the recent COVID-19 pandemic. The study adopted the

(PRISMA) Framework.

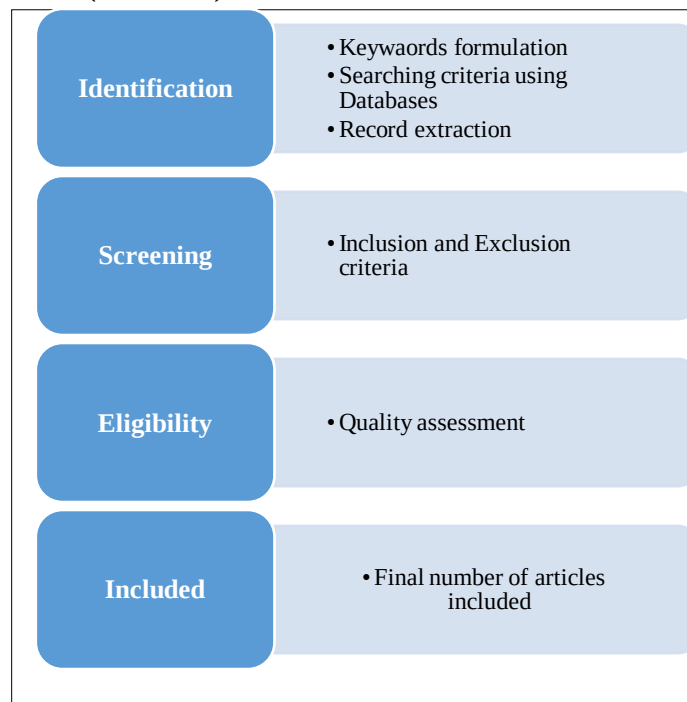


Figure 1: PRISMA Framework

Figure 1 above shows the stages of the popular systematic literature review framework called PRISMA with the task that need to be conducted at each stage, see figure 2 for more details regarding the final data extraction and analysis of this study. Moreover, the methodology section covers the systematics literature review research questions and methodology reporting techniques which describe more about the extracted articles.

A. Research Question

The following research questions (RQ) were formulated to conduct the systematic literature review (SLR) for the study:

B. Methodology Reporting

RQ 1.	What are the relevant papers for disaster management responses on COVID-19 palliatives and relief aid packages?
RQ 2.	Which machine learning techniques are frequently used on Twitter data?
RQ 3.	What are the most popular machine learning classifiers used for opinion mining and sentiment analysis?
RQ. 4	What are the limitations of current research?

To explain more on the methods used in collecting the data, this section follows four most important steps or reporting criteria. These are: searching strategy, selection criteria, quality assessment and data extraction.

1) Searching Strategy

The searching strategy applied in this systematic research is to find out the most related and relevant articles within the scope of this research. Also, two popular databases were chosen; Scopus and ProQuest. The terms or keyword used for the searching strategy were extracted from the research questions and the query used from the keyword are: ((“Sentiment” OR “Opinion”) AND (“Disaster management” OR “COVID-19” OR “Palliatives” OR “Coronavirus relief packages” OR “Disaster relief aid”) AND (“Opinion mining” “Sentiment analysis” OR “Twitter” OR “Machine learning” OR “Classifiers”)). All searches from the two databases were spanned from 2012 to 2020 which is eight years, and the search relevant literature included only journal articles, conference proceedings, review papers, within the subject areas in computer science, engineering, environmental science and all the articles includes open and others access types, they were narrowed only to English publications.

2) Selecting Criteria

For this study, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is adopted as a standard systematics literature review framework to inform the article selection protocol [18]. The selection criteria focuses on the mapping of current literatures that are relevant to the research scope which is disaster management response on COVID-19 relief aid and packages distribution to vulnerable citizens using machine learning techniques on Twitter social media. All articles, journals and conference proceedings selected were open to all countries but only published in English language. Also any article

from 2011 downward were excluded from the search. A total number of the initial search from the two databases is 6,572. The selection criteria was further limited which was eventually narrowed down to 396 for Scopus database and 218 for ProQuest totaling 614. Therefore, at this stage, a total number of 5,958 were excluded after all the inclusion and excluding selection criteria applied.

3) Quality Assessment

The research study is targeted to extract only original articles, journal, review paper and conference proceedings. In this regards all duplicated articles need to be removed in order to maintain the quality of the review. Analysis and purification of each article’s abstract was carefully evaluated and carried out to ensure that the systematic review is based on the relevant academic literature of this study. The selected 614 articles was also assessed by removing all the duplicated articles. Moreover, 195 more articles were removed after the final filtration of the duplicated articles. Therefore, 419 articles were selected after the assessment and selection criteria for the inclusion and exclusion criteria. See figure 1 shows every stage based on PRISMA framework.

4) Data Extraction

In this stage, the data extracted and finally selected for inclusion and exclusion criteria are 419. Out of the number of selected articles, 187 selected based on their title and relevance to the study while 218 were removed. Furthermore, 43 articles were selected based on the abstract that are relevant to the study and 144 were excluded. Finally, after all the assessment from the aforementioned inclusion and exclusion criteria, 11 articles were selected for the inclusion while 32 were excluded based on their irrelevancy to the study. See figure 1 for the PRISMA statement on inclusion and exclusion criteria at each stage.

The 11 articles or data extracted at this stage strictly follows the following criterion and characteristics:

1. All the articles were original, journal articles, conference proceeding, reviewed papers, and published papers. Papers with case studies, books were excluded.
2. The articles are all published in only English language from the computer science, engineering and environmental sciences subject areas.
3. Published articles extracted and selected are only from 2012 to 2020. All papers from 2011 downward were excluded.
4. The papers extracted were from every country who published papers that are relevant and related to the research scope.

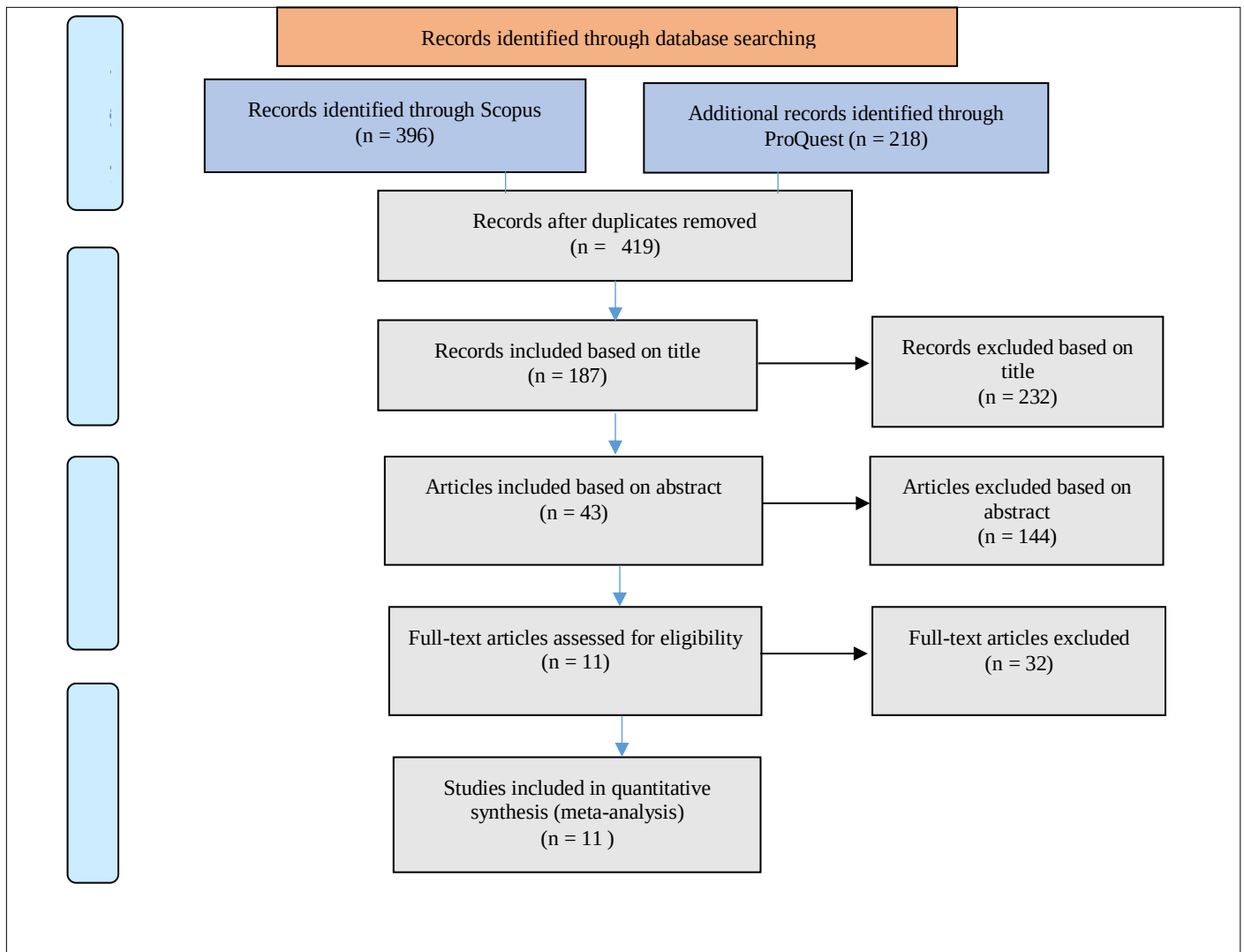


Figure 2: PRISMA framework statement on the papers inclusion and exclusion criteria in each stage
 After careful data extraction and analysis, 11 papers were finally selected based on the qualitative approach, Table 1 reviewed the final set of studies on the role of twitter sentiment in disaster management and responses while Table 2 reviewed the machine learning techniques based on their performance and popularity. The selected papers included the details about the objective of the research, source of data collection, evaluation criteria, year of publications, classifiers or machine learning techniques and the findings of the studies.

TABLE I**Role of Social Media and Data Analytics in Disaster Management**

Description	Objective	Model used	Source of data collection	Year
Detection	Detect and sense possible occurrence of earthquakes so quickly than seismological observatories [19]	Text Mining	Twitter	2012
Disaster Management	Develop model for relief aid agencies to discover disaster based on twitter social media and to store data, stream reader and visualization [20]	Support Vector Machine (SVM), Latent Dirichlet allocation (LDA) and Topic clustering	Twitter	2012
Disaster Management	Using Twitter in floods disaster to discover key players by Involving local authorities to help in combating disaster menace [21]	Text mining methods	Twitter	2011
Prediction	Developed a model classification to predict disaster (land slide) based on the rainfall, slope etc. [22]	Support Vector Machine (SVM) and Nai've Bayes	Twitter	2013
Disaster management	Utilizing Twitter by governmental organization to notify citizens about the occurrences on natural disaster and comparison of traditional method of dissemination information to citizens [23]	Text processing techniques	Twitter	2012
Disaster management	Design a model to collect vital information on Twitter for humanitarian agencies [24]	Text processing techniques	Twitter	2014
Behavioral and social analysis	Post natural disaster e.g. earthquake to understand the reaction of peoples on returning back to normal life [25]	Time series, text processing	Twitter	2012

TABLE II

Summary and Evaluation of Machine Learning Classifiers and their Performances

Evaluation Criteria	Objective	Classifiers	Source of data collection	Findings	Year
Performance Evaluation	To discover the best classifier and its effectiveness in mining text on Twitter sentiments using Stanford Testing Sentiment (STS) dataset [26]	Multinomial Naive Bayes and Bernoulli Naive Bayes Support Vector Machine (SVM)	Twitter	Findings from the study reveals that Multinomial Naive Bayes is the best classifier among the selected classifiers in Twitter sentiment analysis.	2016
Comparative Analysis and Evaluation Metrics	To conduct a survey and comparison of machine learning algorithms and lexicon-based approaches in opinion mining and Twitter sentiment analysis [27]	Naive Bayes, Max Entropy, and Support Vector Machine (SVM)	Twitter	The findings show that Naïve Bayes and SVM machine learning models are more effective and accurate than the lexicon-based approaches.	2016
Optimizations of sentiment analysis	To identify the machine learning classifiers with the fastest in learning and accurate in precision, F1 measures and instances classification using manual compiled dataset from amazon and IMDV movie review [28]	Naïve Bayes, J48, BFTree and OneR	Amazon and IMDV movie review	Their results of the experiment Naïve Bayes is the fastest classifier in terms of learning while One R classifier is the more accurate in generating precision, f-measure and classifiers instances with more than 90% respectively.	2017
Comparison of sentiment on COVID-19	To leverage the public opinion and sentiment on COVID-19 pandemic and make comparison of	Naïve Bayes and logistic regression	Twitter	The results shows that Naïve Bayes classifier produced 91% classification	2020

	machine learning classifiers to discover their performances regarding the different length of Tweets on coronavirus [29]			accuracy for short Tweet while logistics regression produced 74% and both of them are weak in performance on longer Tweets.	
COVID-19 Public reaction	To find out the daily reaction of people regarding COVID-19 pandemic on Twitter [30]	TextBlob python library	Twitter	The results shows that the populace reactions and the feelings posted on social media especially on Twitter regarding COVID-19 outbreak varies daily.	2020

RESULTS AND DISCUSSION

Finally, 11 research papers were selected in this systematic research using PRISMA framework as discussed in research methodology and analysis section. Moreover, this section explained the collected results as well as answered the research questions formulated in section II.

Research Question 1: What are the relevant papers for disaster management responses on COVID-19 palliatives and relief aid?

To answer research question 1, the final selected papers after the inclusion and exclusion criteria shows that 6 out of the 11 final extracted papers discusses about the disaster management in various aspect. The evaluation and description criteria as well as the machine learning and social media used for data collections were depicted in all of the 6

papers which are journal articles as shown in Table 1 section II. However, none of them was related or relevant to COVID-19 relief aid and palliatives but, the 6 papers were selected because the coronavirus pandemic is one of the types of disaster management.

Research Question 2: Which machine learning techniques frequently used on Twitter data?

Table 2 from section II reviewed and explained the objectives of the machine learning classifiers. Likewise, their performance and findings shows that the most popular and frequent machine learning classifiers used in the domain of sentiment analysis using Twitter data as well as the most performing techniques with regard to the selected journal articles are Naïve Bayes [19] [20] [21] [22] and Support vector machine [23] [24].

Research Question 3: What are the most popular machine learning techniques used for opinion mining and sentiment analysis?

To answer research question three, the most popular machine learning techniques used in all the 11 selected papers are Naïve Bayes and Support vector machine. Likewise, research question 2 and 3 are mapped together.

Research Question 4: What are the limitations of the current research?

Despite the fact that all the published literatures were obtained through a rigorous and thorough research process that depicts the completeness of this study, however there may be still possibilities of missing some important relevant work. Furthermore, the research was intended to be scoped only on the COVID-19 relief aid and packages but, all the two databases could not identify any research article either journal or conference paper that are related and relevance to this study, that is why the research questions from the systematic literature review was formulated to search for disaster management and responses because COVID-19 is also one of the types of disaster under Pandemic emergency disaster.

II. CONCLUSION AND FUTURE WORK

This study has provided a solid and comprehensive review of literature researches from 2012 to 2020 extracted from two reputable digital libraries (databases) Scopus and ProQuest. Meanwhile, the study followed a popular and standard systematic literature review protocol called PRISMA framework which had applied, reviewed, analysed and evaluated the extracted data obtained from the literature databases that helps in answering the SLR research questions.

Finally, for the future work, the study suggested to perform a comparative analysis of the popular machine learning techniques in the field of humanitarian relief aid and packages in terms of disaster management because this study was scoped on public opinion and sentiment analysis on COVID-19 palliatives and relief aid packages using machine learning techniques on Twitter social media but unfortunately there were no available related researches as there is no single research currently in that area

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