# Social Network Analysis Algorithms, Techniques and Methods

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***Abstract*— Understanding how social structures with the use of a network have been an active field of study for academics in the past five years alone. The need to properly comprehends how Social Network Analysis (SNA) is being studied grows more and more in recent years. In this article, we propose a Systematic Literature Review (SLR) to the SNA to see how the algorithms, techniques, and methods are used also discuss their findings. We select thirty-one research studies on SNA. We found different algorithms and techniques that are being used. It is found that the selected research could be categorized into five different main topics which is academic, health, social media, communication, and technology. From all of the research paper discussed, it is also found that many algorithms and techniques are being used to enhanced the SNA, most of them are being machine learning algorithm such as Decision Tree, Random Forest, Support Vector Machine, Naïve Bayes, Logistic Regression, K Nearest Neighbor, and Whale Optimization Algorithm. While the common features of the datasets used in the research comes as different arrays of user information from social media platforms, Tweets and posts from multiple platforms, also a photographic input such as self-images, portraits, and context related pictures. This article will serve as a single reference for future researchers to the discovery of the latest SNA findings.**

***Keywords*— SNA, Social Network Analysis, SLR, Systematic Literature Review, Algorithm***

## I. INTRODUCTION

In this modern digital era, there is a lot of perspectives that someone can have on the world. Thinking on how the world works in terms of different networks that transmit and relationship, power, and information – we are able to see how analyzing things with social network analysis able lead to a new finding on culture, politics, history and lot more different topics. Therefore, we can see a surge of academics doing multiple kinds of research using SNA on different kinds of topics as well. In order to do an SNA, researchers applied different kinds of algorithms, techniques and methods as they see fit in their studies.

This study aims to examine and discuss the result on the uses of algorithms, techniques and methods in each of the studies presented. So that this study itself will serve as another contribution for the next researcher in understanding the findings on the latest studies on SNA. This article will also discuss the agendas of future researches that can be done, the contribution on the theories and also practical implications in this SLR.

### *A. Social Network Analysis*

Social Network Analysis (SNA) is a way of examining the structure of a certain social condition with the use of networks and graph theory [1]. The analysis is done by understanding the structure of the network build by the nodes as an individual or things and also how they interact with each other. These networks are usually portrayed by a sociogram in which nodes act as points tied with lines [2].

Social Network Analysis was first discussed by sociologists Georg Simmel and Émile Durkheim. These scientists in the social field have been using the terms "social networks" from the early 20th century to show the complexity of relationship sets between nodes. Moving on to 1930 is when Helen Jennings and Jacob Moreno introduced the basic methods of analyzing it [3].

In SNA representing a network with a visual is important to be able to understand the data and the result of the analysis itself [4]. There are a lot of analytic software that are being used in research and development nowadays that already have the modules to make a visualization of a network. The examination of the data is being done by showing nodes and ties with different layouts, colors, sizes, or other properties. With a visual representation, it is easier to convey complex information [5].

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Other than a visual representation, SNA can be implemented in another way as well. It can be implemented using a mathematical analysis. This concept calculates all of the numbers about nodes, networks, and links between them. Some examples of these numbers are the number of communities in a social network, the number of interactions between a community with the others, the number of actors inside a network, and the distance between each actor and their interaction [6].

### *B. Neural Networks And Data Mining Techniques*

It is vital to have an understanding how data mining works and its method on how they get their output, understanding each of their performance are important to mention one by one. Spiking Neural Networks are a network that could imitate the natural neural network [7]. It is a part of an artificial neural network. This artificial neural network itself is a computational system that works mimicking a biological neural on a typical brain. The way it works is the same way as any other computer system network where each connection point is called nodes. In the artificial neural networks, these nodes are known to be called as an artificial neuron. Artificial neural networks work similarly to the blueprint on how human brain could perform a task that some of the traditional computational algorithm having a problem with. The way that each node or neurons sending signals as an input and the patterns are analyzed and processed to gain the output as a weighted graph that is also directed [34].

In the machine learning itself there is a branch that will be used in the discussion which is deep learning. Deep learning works based on the artificial neural networks mentioned above. The process itself are divided into supervised, unsupervised, and semi-supervised deep learning [17]. While supervised works with labeled data, and unsupervised works the other way (non-labeled data). Semi-supervised meaning that it works with both labeled data and non-labeled data as well. It is proven that the combination of non-labeled data and an enough amount of labeled data as a reference can gain much more accurate result than one or the another [33].

## II. METHOD

This study uses a systematic literature review method which is preceded by making a systematic literature review protocol. This method was chosen based on the consideration of the needs of a systematic literature review on Social Network Analysis. This systematic literature review is expected to be a stimulus for further data science research that contributes to different kinds of field.

### *A. Systematic Literature Review*

Systematic literature review is a literature review method that aims to answer research questions by identifying, assessing, evaluating and interpreting all findings related to the research topic. Systematic literature review has proven to be an effective research method to provide an overview of trends in certain research topics, both results, methodology and coverage of previous research fields [29].

This method needs to be done by following certain steps. These steps are started by coming up with research questions to make a systematic literature review protocol. The protocol is needed to decide on the keywords used for searching articles in the database. By making these protocols we can also decide on the criteria of the research, inclusion and exclusion criteria. After all of the articles are found with the correct protocol, the next step is to identify the proper literature from the studies and examine the quality of the research results obtained. Lastly to analyze and combine the data, assessing the quality of the research and write a systematic literature review article based on the findings (see Figure 1).

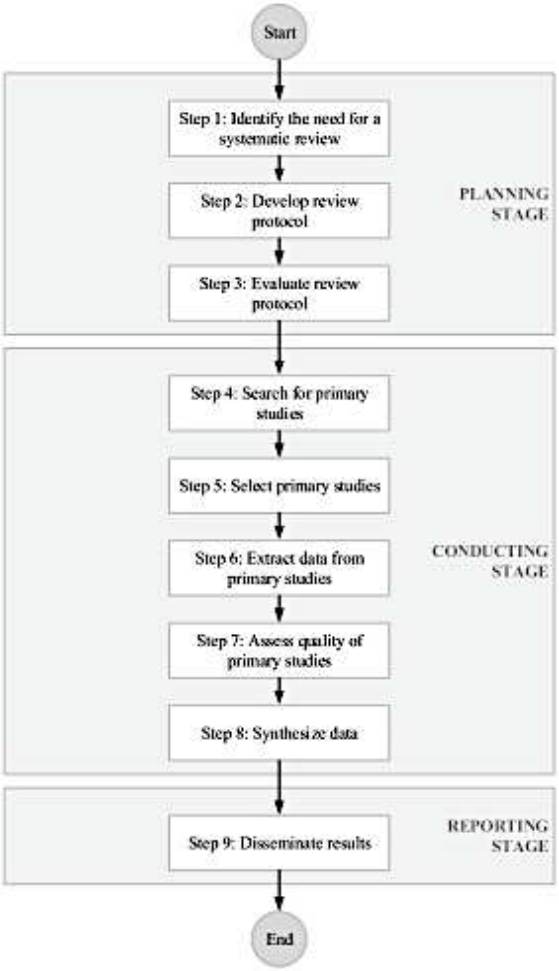


Fig. 1. Number of articles used based on the inclusion criteria

There are multiple tools that can be used to help researcher in doing SLR by following the steps accordingly, some of these tools are Rayyan, DistillerSR, Swift Active Screener, Covidence, and Syrev [28].

### *B. Research Question*

The main purpose of this systematic literature review is to examine the use of algorithms, techniques and methods in SNA research. To achieve this, the research questions (RQ) go as follows:

RQ 1: What are the main topics and purposes of recent SNA research?

RQ 2: What are the algorithms and techniques used to analyze or enhance SNA?

RQ 3: What are the methods of analysis of each research?

RQ 4: What are the characteristics of the dataset used in each research?

*C. Data Collection*

The study was conducted in July 2021. The standard rules in searching the database were carried out according to the exclusion and inclusion criteria, as well as the search results. The data collected is sourced from the IEEE Access and Science Direct databases. While the keywords used in the search are "social network analysis OR machine learning" AND "graph AND tool" AND "algorithms OR algorithm" OR "framework OR frameworks" which is filled in the advanced search column. After the selection was made based on scientific journal articles only, by exclusion of publication of articles in books, magazines and proceedings and selecting only articles in journals directly related to SNA and selecting articles with open access to full text.

The search is then selected based on the year of publication, the type of article and the abstract. The articles used as references are research articles published in the 2017-2021 range and written in English. The exclusion criteria are publications that are not available in full text, not in English and research that does not discuss Social Network Analysis.

*D. Data Analysis*

To analyze the data, each research article selected as a sample in a systematic literature review is grouped based on category to be used to answer the research questions.

## III. RESULTS

*A. Selected Articles*

This research was conducted in July 2021. In a search using the keywords "social network analysis OR machine learning" AND "graph AND tool" AND "algorithms OR algorithm" OR "framework OR frameworks" from the year 2017-2021, found 29,934 articles in the database IEEE Access. After the selection was made based on scientific journal articles only, by exclusion of publication of articles in books, magazines and proceedings and selecting only articles in journals directly related to SNA, 50 scientific journals was found

*B. Selection Of Articles With Inclusion Criteria*

The selection process started from 29,934 research articles. The title and abstract are read carefully to determine which articles are appropriate and which do not meet the inclusion criteria. After reading the title and abstract, there were 50 research articles that met the criteria.

After that, the entire text of the article was also read to ensure its suitability. At that stage, there were 31 scientific articles that met the inclusion criteria; while the rest are not used because they do not meet the inclusion criteria, such as not discussing about SNA or not using machine learning algorithms shown in Figure 2. This sample of 31 articles discusses the use of SNA with machine learning algorithms in different kinds of topics, while the rest fall into the exclusion criteria.

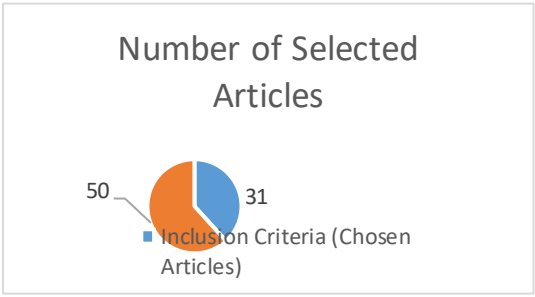


Fig. 2. Number of articles used based on the inclusion criteria

These 31 scientific articles are used as references in the preparation of a systematic literature review. After conducting a systematic literature review of 31 research articles, then the answers to the research questions that have been previously proposed are compiled.

*C. Research Articles Used*

A systematic literature review of 31 samples of research articles were all from IEEE Access journal. We make a category for all of the research article; this category is based on the field and the scope of the research itself. These categories are academic, health, social media, communication and technology shown in Table 1.

TABLE 1. NUMBER OF ARTICLES USED BASED ON THE TOPICS

| No. | Topic / Field | Number of Articles |
|---|---|---|
| 1. | Academic | 7 |
| 2. | Health | 4 |
| 3. | Social Media | 11 |
| 4. | Technology | 4 |
| 5. | Communication | 5 |

All of the selected journals are international scientific journals and all of them are in the Q1 category (in the Scimago Journal Rank ranking) [15].

*D. Discussion of The Findings*

From the 31 scientific articles are divided into 5 different categories. In this SLR we are going to use this topic to explain each of the findings to answer all of the research questions.

The purpose of the research that falls into academic category are to be able to predict arbitrary relations in heterogeneous academic networks, exploring the diverse feature sets and classifiers to assess the effectiveness, predicting pairwise trust based on machine learning in online social networks, to propose a smart access control method for online social networks, to show a method of detecting the gender of an author, investigating how we can predict personality traits of Facebook users based on the Big 5 model of personality, and to provide a mechanistic model that interprets these findings and help in assessing the likely efficacy on the strategies of intervention. We can see that

from the category of academic there are multiple sub-categories of research that are being done [34][15][16].

While in the health category there are 4 research articles with each different purpose of it. These are the purpose of the research articles from the health category. To assess the application of machine learning method on detecting mental health. Able to introduce an approach with a deep learning to detect and classify antisocial behavior, online. To propose a medical social media text classification (MSMTC) algorithm that integrates the terminology of the consumer health. Adopting deep learning as an approach for automatic identification of disaster victims in critical need. Also, from the health category we could conclude that there are sub-topics that can be seen on the research [17][18][30].

In the social media category, we can see that this category is dominating the others, the amount of research articles discussing SNA and its uses on social media are more than the other topic presented here. The purposes of this category are, to present a new text emotion classification model to be used in social network big data environment. Proposing and testing a mix of different machine learning algorithm to reveal the disaster events from different locations through posts on social media during disasters. Evaluating the techniques used in detecting offensive and hate speech in South African tweets [28]. To provides insights on the overall process for cyberbullying detection and overviews the methodology. Detecting social bots on Twitter using improved conditional generative adversarial networks. examining Reddit users' posts to detect depression attitudes [25]. Classifying mental illness using social media posts. To predict popularity of social media videos before they are published and to understand of how individual parts influence the final popularity score. recognizing emotion by textual tweets classification using voting classifier (LR-SGD). Describing how to extract data from Twitter, and the sentiment of the tweets on a particular topic is calculated. Focusses on halal tourism and halal cosmetics [22]. To have an argument that behaviors of troll accounts on social media that are sponsored are different from ordinary accounts because of their motivation, and that they cannot hide their behaviors that is suspicious, therefore these accounts can be identified using approaches from machine learning based on their behaviors on the social media platforms [32]. From all of this purposes in the social media category, we can conclude that there are more sub-topics inside the category of social media. These sub-topics ranging from how to conduct oneself in a social media platform to advancement of understanding social media post as a reference of a decision-maker system.

Last from the two categories, communication and technology. These are the purpose of the research. To propose deep learning techniques for community detection in social networks. Proposing a new task that aims to understand and analyze how sexism expressed in online conversation. Detecting social network spam based on improved extreme learning machine [30]. To be able to classify age groups in social network using deep learning. Proposing a method to detect Sybil attack in online social networks via deep learning [25]. To propose an updated deep neural network for identification of false news. To investigate how natural language is processed on Arabic text to predict depression, evaluate and compare the performance. Showing the possibility of user identification with a lower cost of data acquisition. To introduce a multi-head attention-based bidirectional long-short memory (MHA BiLSTM) network to detect sarcastic comments in a given corpus [35][31].

Answering research question number 2. We generate a list of all the algorithm used in the research article. Some of this algorithm that is being used are J48, JRIP, REPTree, Nnge, random tree, nave bayes, SMP, KNN, regression tree, random forest, decision tree, logistic regression, multilayer perceptron (MPL) neural network, support vector machine (SVM) and Artificial Neural Network as shown in Table 2.

TABLE 2. ALGORITHMS AND TECHNIQUES USED

| **Algorithm and Techniques** | **Reference** |
|---|---|
| *Convolutional Neural Network (CNN)* | [25], [22], [35] |
| *Recurent Neural Network (RNN)* | [22], [35] |
| *Artificial Neural Network (ANN)* | [28], [30] |
| *Whale Optimization* | [30] |
| *Linear Regression* | [28] |
| *Softmax Classification* | [33], [34] |
| *Novel DL Model* | [18] |
| *Matrix Reconstruction* | [16] |
| *Naive Bayes (NB)* | [28], [32], [31] |
| *UniLPF Framework* | [34] |
| *Name Entity Recognition (NER)* | [29] |
| *BERT Model* | [29] |
| *Graph-based Modeling* | [29] |
| *Decision Tree (DT)* | [28], [28], [32], [28], [35], [32] |
| *Random Forest (RF)* | [31], [32] |
| *Ensemble-based* | [15] |
| *Support Vector Machine (SVM)* | [28], [28], [32], [16], [28], [31] |
| *Gradient Boost* | [32] |
| Logistic Regression (LR) | [28], [28], [32], [35] |
| *K Nearest Neighbor (KNN)* | [28], [28], [32], |

Various algorithms used to implement and enhance SNA research were tested for accuracy according to the data analysis stages required in and it was found that the most widely used were Convolutional Neural Network (CNN) algorithms, Support Vector Machine (SVM), Logistic Regression, Decision Tree, and K Nearest Neighbor as shown in Figure 3.

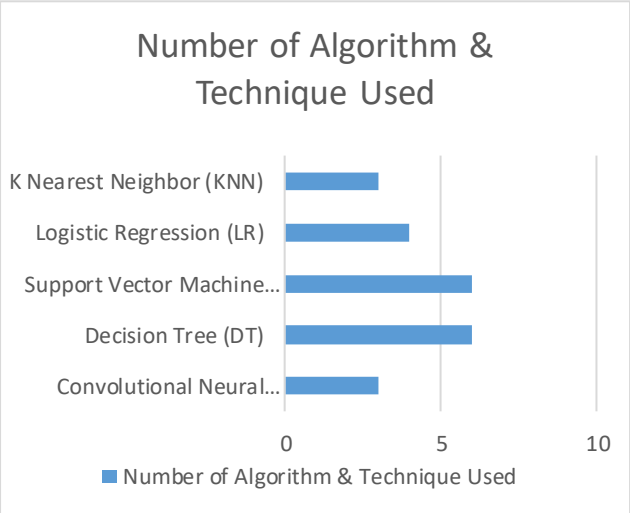


Fig. 3. Number of algorithm and technique used

While the results and conclusions obtained from the selected articles indicate that the implementation of algorithm and techniques that will also answer the research question number 3. can be explained as follows. For the research in the category of health, the methods that are being used are data analysis and screening method, using a dataset that serve as a benchmark generated with annotation that is multi-class under the supervision of a domain expert. After that, experiments were conducted with different deep learning algorithms and the results that is better were validated against the results from the machine learning algorithms that is more dated than the first [28]. In this research which falls under the category of health, the common feature of their datasets are articles with data sources, keywords, geographical location, text that is taken from social media posts about medical matters, terminology vocabulary that was downloaded from Sogou to start the dictionary of medical term [29].

As for the category of Academic, we can see that the most common feature of the datasets is user's data and information from multiple online social networks, public email dataset that is character-based, word-based, syntax-based, structured-based, and function. With these datasets, the methods that are being used on the research are construction the dataset, using a meta path searching method to define the arbitrary prediction, two meta-paths based on the similarity will combine information and content relevant, build a pervasive prediction model. Smart access control method based on SVM. Using an artificial neural network (ANN) is used to classify the gender of an email author and the whale optimization algorithm (WOA) is employed to find the optimal weights and biases for improving the ANN classification accuracy [30]. These serves as the answer for the research question number 4.

Social Media category have the most research article in it with 11 papers. The most common methods used in these papers are an integrated supervised and unsupervised learning approaches where original tweets can be processed into geographical mapping and how the events unfold. Data collection and annotation, continued with pre-processing such as cleaning, lemmatization and lowercasing. Then feature extraction, and the last one is classification. Also using a hybrid method such as feature extraction and data normalization at the same time as data pre-processing method. Continued with training and testing dataset to create proper classification model by the neural network classifier. And the most common feature of its datasets are social media information such as platforms, user data, interaction, for example Tweets with features such as: average number of topic tags and user mentions, number of links, retweets, and favorites, ratio of follower to followed, tweet source, and content similarity [31] [32].

While in the communication and technologies, the methods used are self-normalizing using CNN is used to get features from input data that is multi-dimensional. Then bi-SN-LSTM is adopted to get the higher features from the compressed feature map sequence. Lastly, classification of the dense layer and using SoftMax classifier [33] [34]. Feature extraction to concatenation and classification to achieve the output. Both machine learning and deep learning approach is used as a method of the research [35]. Common datasets feature that can be found in the research papers are open datasets of practical social networks were selected to evaluate the proposed method, and the experimental results show that the proposed deep community detection method obtained higher modularity than other deep learning methods. A more focused on platform datasets such as dataset containing more than a million sarcastic and non-sarcastic comments written on social media site Reddit, which is a topic-specific forum [36].

## IV. CONCLUSION

### *A. Summary*

In this modern digital era, there is a lot of perspectives that someone can have on the world. Thinking on how the world works in terms of different networks that transmit and relationship, power, and information – we are able to see how analyzing things with social network analysis able lead to a new finding on culture, politics, history and lot more different topics. Therefore, we can see a surge of academics doing multiple kinds of research using SNA on different kinds of topics as well. In order to do an SNA, researchers applied different kinds of algorithms, techniques and methods as they see fit in their studies.

This study aims to examine and discuss the result on the uses of algorithms, techniques and methods in each of the studies presented. So that this study itself will serve as another contribution for the next researcher in understanding the findings on the latest studies on SNA. This article will also discuss the agendas of future researches that can be done, the contribution on the theories and also practical implications in this SLR.

With the total of 31 research articles discussed, we can see that Some of this algorithm that is being used are Random tree, Naïve bayes, KNN, regression tree, random forest, decision tree, logistic regression, support vector machine (SVM) and Artificial Neural Network. Various algorithms used to implement SNA research were tested for accuracy according to the data analysis stages required in

and it was found that the most widely used were Artificial Neural Network (ANN) algorithms, Support Vector Machine (SVM), Logistic Regression, and Decision Tree.

From all of the research articles, we categorize them into five different topics. By understanding these different topics, we can see that there are some features of the datasets that are commonly used between these articles. Some of the methods and algorithm used also have a pattern on it. From all of the research paper discussed, it is also found that many algorithms and techniques are being used to enhanced the SNA, most of them are being machine learning algorithm such as Decision Tree, Random Forest, Support Vector Machine, Naïve Bayes, Logistic Regression, K Nearest Neighbor, and Whale Optimization Algorithm. While the common features of the datasets used in the research comes as different arrays of user information from social media platforms, Tweets and posts from multiple platforms, also a photographic input such as self-images, portraits, and context related pictures. Understanding the result of this SLR could have a beneficial result as well on the future research.

*B. Future Research Agenda*

With this Systematic Literature Review on Social Network Analysis comes in mind on how the future research is going to be. This paper aims to be a future reference on how the studies of SNA in the recent years happening. By understanding the research that has been done, as an academics we always tend to push forward for more proper research in the future. Therefore, we propose a future research agenda on SNA is that there will be the needs of another SLR on SNA in the near future. As the research will never stop, another SLR is needed to help others to understand on the state of the art of an SNA. A combination of studies from different topics using the most successful algorithms (see Figure 3) can bring the expected result that we want. On the other hand, looking at the least topic discussed in the recent years, and the least algorithm used in this research can also be a future research agenda. Based on our inclusion criteria, health and technology as a topic of research are still lacking in numbers of research done (see Table 1). As for the algorithm and technique, the use of Linear Regression, Graph-based Modelling and BERT Modeling can be optimized.

## REFERENCES


[1] Otte, Evelien; Rousseau, Ronald (2002). "Social network analysis: a powerful strategy, also for the information sciences". Journal of Information Science. 28 (6): 441–453.doi:10.1177/016555150202800601. S2CID 17454166.

[2] Grunspan, Daniel (January 23, 2014). "Understanding Classrooms through Social Network Analysis: A Primer for Social Network Analysis in Education Research". CBE: Life Sciences Education. 13 (2): 167–178.doi:10.1187/cbe.13-08-0162.PMC 4041496. PMID 26086650.

[3] Freeman, L. C. (2004). The development of social network analysis: a study in the sociology of science. Vancouver, B. C.: Empirical Press.

[4] Linton C. Freeman. "Visualizing Social Networks". Journal of Social Structure. 1.

[5] McGrath; Blythe & Krackhardt (1997). "The effect of spatial arrangement on judgements and errors in interpreting graphs" (PDF). Social Networks. 19 (3): 223-242. CiteSeer X10 .1 .1 .121 .5856. doi:10.1016/S0378-8733(96)00299-7.

[6] Borgatti SP, Mehra A, Brass DJ, Labianca G. Network analysis in the social sciences. science. 2009;323(5916):892–5

[7] Maass, Wolfgang (1997). "Networks of spiking neurons: The third generation of neural network models". Neural Networks. 10 (9): 1659–1671. doi:10.1016/S0893-6080(97)00011-7. ISSN 0893-6080.

[8] Zell, Andreas (2003). "chapter 5.2". Simulation neuronaler Netze [Simulation of Neural Networks] (in German) (1st ed.). Addison-Wesley. ISBN 978-3-89319-554-1. OCLC 249017987.

[9] Bengio, Y.; Courville, A.; Vincent, P. (2013). "Representation Learning: A Review and New Perspectives". IEEE Transactions on Pattern Analysis and Machine Intelligence. 35 (8): 1798–1828. arXiv:1206.5538. doi:10.1109/tpami.2013.50. PMID 23787338. S2CID 393948.

[10] Cabannes, Vivien; Rudi, Alessandro; Bach, Francis (2021). "Disambiguation of weak supervision with exponential convergence rates". ICML. arXiv:2102.02789.

[11] R. S. Wahono, “A Systematic Literature Review of Software Defect Prediction : Research Trends , Datasets , Methods and Frameworks,” vol. 1, no. 1, 2015.

[12] Van der Mierden S, Tsaioun K, Bleich A, Leenaars CH (2019). "Software tools for literature screening in systematic reviews in biomedical research". Altex. 36 (3): 508–517. doi:10.14573/altex.1902131. PMID 31113000.

[13] Scimago, “Scimago Journal and Country Rank,” 2019. https://www.scimagojr.com/journalrank.php.

[14] Lu, M., Wei, X., Ye, D., Dai, Y. (2019). A Unified Link Prediction Framework for Predicting Arbitary Relations in Heterogeneous Academic Networks. IEEE Access. 7. 124967-124987. DOI 10.1109/ACCESS.2019.2939172

[15] Ayyub, K., Iqbal, S., Munir, E.U., Nisar, M.W., Abbasi, M. (2020). Exploring Diverse Features for Sentiment Quantification Using Machine Learning Algorithms. IEEE Access. 8. 142819-142831. DOI 10.1109/ACCESS.2020.3011202

[16] Shan, F., Liu, J., Wang, X., Liu, W., & Zhou, B. (2020). A Smart Access Control Method for Online Social Networks Based on Support Vector Machine. IEEE Access, 8, 11096–11103. https://doi.org/10.1109/ACCESS.2020.2963932

[17] Rahman, R.A., Omar, K., Noah, S.A.M., Danuri, M.S.N.M., Al-Garadi, M.A. Application of Machine Learning Methods in Mental Health Detection - A Systematic Review (2020). IEEE Access. 8. 183952-183964. DOI

10.1109/ACCESS.2020.3029154
[18] Liu, K., & Chen, L. (2019). Medical Social Media Text Classification Integrating Consumer Health Terminology. IEEE Access, 7, 78185–78193. https://doi.org/10.1109/ACCESS.2019.2921938
[19] Sear, R. F., Velasquez, N., Leahy, R., Restrepo, N. J., Oud, S. El, Gabriel, N., Lupu, Y., & Johnson, N. F. (2020). Quantifying COVID-19 Content in the Online Health Opinion War Using Machine Learning. IEEE Access, 8, 91886–91893. https://doi.org/10.1109/ACCESS.2020.2993967
[20] Oriola, O., Kotze, E. (2020). Evaluating Machine Learning Techniques for Detecting Offensive and Hate Speech in South African Tweets. IEEE Access. 8. 21496-21509. DOI 10.1109/ACCESS.2020.2968173
[21] Tadesse, M. M., Lin, H., Xu, B., & Yang, L. (2019). Detection of depression-related posts in reddit social media forum. IEEE Access, 7, 44883–44893. https://doi.org/10.1109/ACCESS.2019.2909180
[22] Feizollah, A., Ainin, S., Anuar, N. B., Abdullah, N. A. B., & Hazim, M. (2019). Halal Products on Twitter: Data Extraction and Sentiment Analysis Using Stack of Deep Learning Algorithms. IEEE Access, 7, 83354–83362. https://doi.org/10.1109/ACCESS.2019.2923275
[23] Alhazbi, S. (2020). Behavior-based machine learning approaches to identify state-sponsored trolls on twitter. IEEE Access, 8, 195132–195141. https://doi.org/10.1109/ACCESS.2020.303366
[24] Zhang, Z., Hou, R., & Yang, J. (2020). Detection of Social Network Spam Based on Improved Extreme Learning Machine. IEEE Access, 8, 112003–112014. https://doi.org/10.1109/ACCESS.2020.3002940
[25] Gao, T., Yang, J., Peng, W., Jiang, L., Sun, Y., & Li, F. (2020). A Content-Based Method for Sybil Detection in Online Social Networks via Deep Learning. IEEE Access, 8, 38753–38766. https://doi.org/10.1109/ACCESS.2020.2975877
[26] Yousaf, A., Umer, M., Sadiq, S., Ullah, S., Mirjalili, S., Rupapara, V., & Nappi, M. (2021). Emotion Recognition by Textual Tweets Classification Using Voting Classifier (LR-SGD). IEEE Access, 9, 6286–6295. https://doi.org/10.1109/ACCESS.2020.3047831
[27] Kumar, A., Narapareddy, V. T., Srikanth, V. A., Malapati, A., & Neti, L. B. M. (2020). Sarcasm Detection Using Multi-Head Attention Based Bidirectional LSTM. IEEE Access, 8, 6388–6397. https://doi.org/10.1109/ACCESS.2019.2963630
[28] Guimarães, R. G., Rosa, R. L., De Gaetano, D., Rodríguez, D. Z., & Bressan, G. (2017). Age Groups Classification in Social Network Using Deep Learning. IEEE Access, 5, 10805–10816. https://doi.org/10.1109/ACCESS.2017.2706674
[29] Fan, C., Wu, F., Mostafavi, A. (2020). A Hybrid Machine Learning Pipeline for Automated Mapping of Events and Locations from social Media in Disasters. IEEE Access. 8. 10478-10490. DOI 10.1109/ACCESS.2020.2965550
[30] Safara, F., Mohammed, A. S., Yousif Potrus, M., Ali, S., Tho, Q. T., Souri, A., Janenia, F., & Hosseinzadeh, M. (2020). An Author Gender Detection Method Using Whale Optimization Algorithm and Artificial Neural Network. IEEE Access, 8, 48428–48437. https://doi.org/10.1109/ACCESS.2020.2973509
[31] Tariq, S., Akhtar, N., Afzal, H., Khalid, S., Mufti, M. R., Hussain, S., Habib, A., & Ahmad, G. (2019). A Novel Co-Training-Based Approach for the Classification of Mental Illnesses Using Social Media Posts. IEEE Access, 7, 166165–166172. https://doi.org/10.1109/ACCESS.2019.2953087
[32] Singh, R., Subramani, S., Du, J., Zhang, Y., Wang, H., Ahmed, K., & Chen, Z. (2020). Deep learning for multi-class antisocial behavior identification from Twitter. IEEE Access, 8, 194027–194044. https://doi.org/10.1109/ACCESS.2020.3030621
[33] Zhang, C., Xie, L., Aizezi, Y., Gu, X. (2019). User Multi-Modal Emotional Intelligence Analysis Method Based on Deep Learning on Social Network Big Data Environment. IEEE Access. 7. 181758-181766. DOI 10.1109/ACCESS.2019.2959831
[34] Liu, S., Zhang, L., Yan, Z. (2018). Predict Pairwise Trust Based on Machine Learning in Online Social Networks - A Survey. IEEE Access. 6. 51297-51318. DOI 10.1109/ACCESS.2018.2869699
[35] Al-Garadi, M. A., Hussain, M. R., Khan, N., Murtaza, G., Nweke, H. F., Ali, I., Mujtaba, G., Chiroma, H., Khattak, H. A., & Gani, A. (2019). Predicting Cyberbullying on Social Media in the Big Data Era Using Machine Learning Algorithms: Review of Literature and Open Challenges. IEEE Access, 7, 70701–70718.
[36] Tadesse, M. M., Lin, H., Xu, B., & Yang, L. (2018). Personality Predictions Based on User Behavior on the Facebook Social Media Platform. IEEE Access, 6, 61959–61969.
[37] https://doi.org/10.1109/ACCESS.2019.2918354
[38] Wu, L., Zhang, Q., Chen, C. H., Guo, K., & Wang, D. (2020). Deep learning techniques for community detection in social networks. IEEE Access, 8, 96016–96026. https://doi.org/10.1109/ACCESS.2020.2996001
[39] Rodriguez-Sanchez, F., Carrillo-de-Albornoz, J., & Plaza, L. (2020). Automatic classification of sexism in social networks: an empirical study on Twitter data. IEEE Access, 219563–219576. https://doi.org/10.1109/ACCESS.2020.3042604
[40] Wu, B., Liu, L., Yang, Y., Zheng, K., & Wang, X. (2020). Using improved conditional generative adversarial networks to detect social bots on Twitter. IEEE Access, 8, 36664–36680. https://doi.org/10.1109/ACCESS.2020.2975630
[41] https://doi.org/10.1109/ACCESS.2018.2876502
[42] Abdelminaam, D. S., Ismail, F. H., Taha, M., Taha, A., Houssein, E. H., & Nabil, A. (2021). CoAID-DEEP: An Optimized Intelligent Framework for Automated Detecting COVID-19 Misleading Information on Twitter. IEEE Access, 9(December 2019), 27840–27867.

https://doi.org/10.1109/ACCESS.2021.3058066
[43] Alghamdi, N. S., Hosni Mahmoud, H. A., Abraham, A., Alanazi, S. A., & García-Hernández, L. (2020). Predicting depression symptoms in an Arabic psychological forum. IEEE Access, 8, 57317–57334. https://doi.org/10.1109/ACCESS.2020.2981834
[44] Bielski, A., & Trzcinski, T. (2018). Under2standing Multimodal Popularity Prediction of Social Media Videos With Self-Attention. IEEE Access, 6, 74277–74287. https://doi.org/10.1109/ACCESS.2018.2884831
[45] Li, Y., Peng, Y., Ji, W., Zhang, Z., & Xu, Q. (2017). User Identification Based on Display Names Across Online Social Networks. IEEE Access, 5, 17342–17353. https://doi.org/10.1109/ACCESS.2017.2744646
[46] Subramani, S., Wang, H., Vu, H. Q., & Li, G. (2018). Domestic violence crisis identification from facebook posts based on deep learning. IEEE Access, 6, 54075–54085. https://doi.org/10.1109/ACCESS.2018.2871446