Annals of Emerging Technologies in Computing (AETiC)
Vol. 6, No. 2, 2022

Review Article

Examining Mental Disorder/Psychological Chaos through Various ML and DL Techniques: A Critical Review

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Received: 8th January 2022; Accepted: 17th March 2022; Published: 1st April 2022

Abstract: Mental soundness is a condition of well-being wherein a person understands his/her potential, participates in his or her community and is able to deal effectively with the challenges and obstacles of everyday life. It circumscribes how an individual thinks, feels and responds to any circumstances. Mental strain is generally recognised as a social concern, potentially leading to a functional impairment at work. Chronic stress may also be linked with several physiological illnesses. The purpose of this research stands to examine existing research analysis of mental healthiness outcomes where diverse Deep Learning (DL) and Machine learning (ML) algorithms have been applied. Applying our exclusion and inclusion criteria, 52 articles were finally selected from the search results obtained from various research databases and repositories. This literatures on ML and mental health outcomes show an insight into the avant-garde techniques developed and employed in this domain. The review also compares and contrasts amongst various deep learning techniques for predicting a person's state of mind based on different types of data such as social media data, clinical data, etc. Finally, the open issues and future challenges of utilising Deep learning algorithms to better understand as well as diagnose mental state of any individual were discussed. From the literature survey, this is evident that the use of ML and DL in mental health has yielded significant attainment mostly in the areas of diagnosis, therapy, support, research and clinical governance.

Keywords: ***DL; Mental Disorders; ML; Social Media; Stress; Suicide***

1. Introduction

Stress, mental illness, social anxiety, depression, schizophrenia and psychological issues are all elements that contribute to mental health issues that lead to mental disease. Positive mental health improves one's efficiency and helps reach one's full potential. With approximately 300 million people worldwide experiencing depression, the prevalence of mental illness is on the rise. People who are happy with their lives have fewer mental health problems [1]. To achieve a sound mental health, it is crucial to be able to determine any mental illness or issues at the preliminary stage. There are many clinical approaches

Afra Binth Osman, Faria Tabassum, Muhammed J. A. Patwary, Ahmed Imteaj, Touhidul Alam, Mohammad Arif Sobhan Bhuiyan and Mahdi H. Miraz, "Examining Mental Disorder/Psychological Chaos through Various ML and DL Techniques: A Critical Review", *Annals of Emerging Technologies in Computing (AETiC)*, Print ISSN: 2516-0281, Online ISSN: 2516-029X, pp. 61-71, Vol. 6, No. 2, 1st April 2022, Published by International Association for Educators and Researchers (IAER), DOI: 10.33166/AETiC.2022.02.005, Available: http://aetic.theiaer.org/archive/v6/v6n2/p5.html.

to identify mental illness, mainly through brain chemistry abnormalities which are considered as solid evidences of mental illness [2]. Understanding and providing therapy for people with aberrant mental behaviour requires a thorough examination of mental well-being [3]. Stress has an impact on both mental and physical health by generating issues like arrhythmia (abnormal heart rhythm) and depression. The American Institute of Stress claims that 80% of the US workers are stressed at work and nearly half of them believe they require assistance in learning how to manage stress, while forty-two percent of workers think their colleagues also require assistance for stress management [4]. Various bio-signals can be used to detect stress levels (e.g. ECG, EMG, Respiration, GSR, etc.), since these signals show typical changes when stress is induced. Suicide has consistently been one of the significant causes of death worldwide. Psychiatric stressors act as a major catalyst for suicide. The early recognition of mental disturbances in a highly hazardous group will aid in the prevention of suicidal behaviour and suicide. Social media is a popular platform for individuals to express their emotions [5-6]. Social media's immense popularity and real-time information sharing flow have made it possible to intervene early in large population. However, few automated strategies for collecting psychiatric stressors from social media platforms like Facebook, Weibo, Twitter, Reddi and so forth have been developed [7]. People use social media to change how they identify themselves as having a condition and how they interact with those who have had similar problems, typically inquiring about the treatments of the unpropitious effects or providing coping methods, and therefore, experiencing less stigmatised [6]. Machine learning algorithms could assist Mental Health professionals to determine whether patients are at risk of acquiring a specific mental depressive illness by identifying important behavioural biomarkers. Furthermore, these techniques might help in measuring the effectiveness of a treatment strategy. Recently, DL algorithms are also used for mental health detection. Artificial intelligence is used in mental health research to make predictions based on patients' voices, choice of words and conversation duration. Nevertheless, little study has been conducted on situation prediction to prevent depression [7-8]. The World Health Organization (WHO) classified COVID-19, which is known coronavirus disease 2019, as an outbreak on the 11th March, 2020. There were more than 483 million confirmed cases of infection and 6132461 confirmed deaths in 216 countries as of May 31, Mar 2022[1]. This global pandemic has significant pessimistic effects on many individuals' mental healthiness. This COVID-19 pandemic has thus far claimed many lives worldwide and poses a severe threat to global health, food systems and workplace safety [9-10]. Approximately, 40.4 percent of the participants reported having psychological issues and 14.4 percent of the young groups had post-traumatic stress disorder (PTSD) symptoms. In addition, researchers used ML and DL techniques to analyse the effect of the corona virus epidemic on mental disease [12].

Technological refinements, such as online social media, mobile phones and sensors, have enabled psychiatric researchers and clinicians to collect a vast amount of facts and figures within a short span of time. Machine learning has been established as an effective method for investigating these data [42-44]. In fact, this is achieved through the application of cutting-edge statistical and probabilistic methods to develop systems that can learn from data on their own. This study offers an exhaustive summary of the studies on ML & DL applications in detecting mental illness based on various data sources. Jadhav *et al*. [13] utilised machine learning techniques for scrutinising bipolar disorder using the Mood Disorder Questionnaire. Another research [14] used supervised machine learning for detecting stress levels from bio-signals and was capable of attaining 98.6% accuracy. Subhani *et al.* [15] proposed a paradigm for assessing psychiatric distress at multiple considerable levels involving electroencephalogram signals. The above paradigm used several algorithms, such as Support Vector Machine (SVM), Logistic Regression (LR) and Naive Bayes (NB) classifiers), which achieved 0.94 percent overall accuracy in level-two stress identification and 0.83 percent maximum accuracy for numerous level stress detection. Srividya *et al.* [3] also employed these algorithms (i.e. SVM, NB, LR) to identify the mental state in a target group. They could achieve an accuracy of 0.89, 0.73 and 0.84 percent, respectively. They also used Decision trees, Ensemble (Bagging), KNN and Tree Ensemble algorithm with 0.81, 0.90, 0.89 and 0.90 percentage of accuracy, respectively. Besides machine learning, many researchers started employing DL techniques for predicting depression risk [45-46]. They used Context-DNN Model for predicting the probability risk of depression [8]. In recent years, people have begun to publicly disclose their sentiments on social media

[1] https://covid19.who.int/

platforms. Many researchers have emphasised on the contents generated by the users on the social networks, in order to observe peoples' mental state or psychiatric disorders, such as bipolar depression, anxiousness or schizophrenia. Gkotsis *et al.* [9] and Kharel *et al.* [16] analysed Reddit posts to characterise mental illness-related posts using a DNN and DL approach. Based on data from Reddit, the authors in [17] also present a methodology to diagnose individuals with chronic mental disorders, i.e. panic, bipolar disorder, depression and attention deficit hyperactivity disorder (ADHD). A fact-based review on the detection of psychological issues utilising online social network (OSN) is presented by the authors of [18]. Other researchers used data collected from Twitter, Facebook, Weibo social media for detecting different types of mental illness such as schizophrenia [7], bipolar disorder [8], major depressive disorder [19], distress [20], spectrum disorder [21], anxiety and sentiments [12].

2. An Overview of the Diverse ML and DL Classifiers for Mental disorders

Machine learning technology is a sort of AI technology and computer science that focuses on using data and models to imitate how humans understand and learn, then gradually trying to improve its exactness. This ML technology is supposed to become a highly useful technique for predicting mental state as well as providing significant benefits in a variety of fields, including natural language processing, human-computer interaction, voice recognition and so forth. The most prevalent machine learning methodologies are supervised learning as well as unsupervised learning. SVM, RF, NB, LR, DT, ANN, CNN, KNN, and LSTM are the most extensively used ML and DL approaches in many research, investigations and experiments, particularly in identifying health disorders in the medical area. In this review article, the study materials were segregated, primarily based on mental health issues including schizophrenic, bipolar disorder, chronic depression, posttraumatic distress disorder and other mental health problems of the workers, children and youths. It has been found that these disorders were examined differently in various ways with diverse predictive models.

Amongst the reviewed articles, there are five studies that utilised random forest predictors for different mental states such as chronic mental illness diseases [20], depression and PTSD [23], mental health [3], mental disorder [16] and stress [39]. It is mostly utilised for regression, classifications and other undertakings, i.e., machine learning problems that may be accomplished with the support of decision trees. Furthermore, eleven research publications employed SVM classifier for the prediction of suicide [7], mental disorder themes [6], sentiments [10], depression [22], chronic mental illness diseases [20], Stress [14-15, 39], relaxation detection [21], mental health [3], and mental disorder [16]. It is mostly used for classification; however, it can also be used for regression. Similarly, nine articles applied LR, four articles used Decision tree, seven articles deployed naïve bayes and two studies utilised K-nearest Neighbour that can be applied to labelled data. KNN classifies dependent variables based on similar examples of its individual variables from already known data. Others ML techniques like Bagging uses the ensemble meta-algorithm but involves model training using data from different types of datasets. It will not only help in enhancing the stability and increase models' accuracy; but also help to reduce the diversity of the model. Boosting is a very impactful and extensively used feed classification. The main purpose of boosting algorithm is to reduce the bias of the model.

Additionally, Deep learning have lately gained popularity amongst the machine learning methodologies owing to their capacity to address a wide range of issues such as image recognition, speech recognition and natural language processing. These theories are based on neural networks in the brain, allowing algorithms to learn from experimental data. In this review article, we explored some of the most prominent DL model architectures, such as recurrent neural network (RNN), convolutional neural network (CNN) and long-short term memory (LSTM). A convoluted neural net can process any input, emphasise different aspects of the image/objects and be able to distinguish them from each other. In addition, long-short term memory is an artificial repeating neural network (RNN) architecture used in deep learning. LSTM networks are well suited for classifying, processing and predicting time series data. Since recent past, these deep neural models are being applied in the psychological health sector. According to our study of the selected articles it has been found that CNN has been used in ten articles while RNN and LSTM were both applied in four studies each, for detecting various mental state. Figure-1

demonstrates the overall percentage of use of ML & DL models amongst the reviewed articles in this study. It has been found that the SVM is mostly used algorithm.

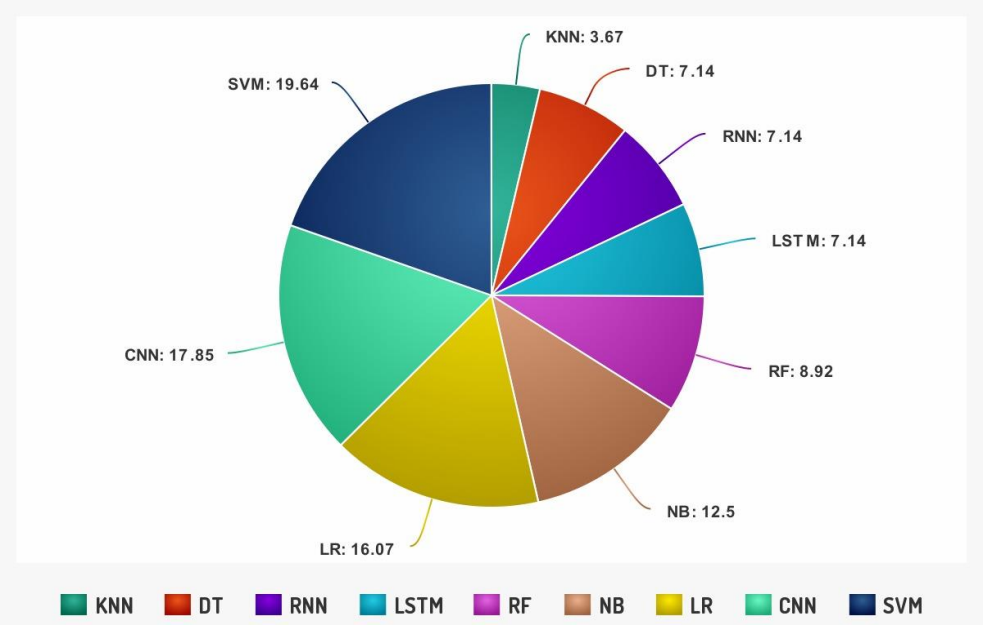

Figure 1. Percentages of Algorithms from Reviewed Articles

3. Method

The foremost objective of this study is to to investigate the suitability, limitations and challenges of detecting mental health problems using ML and Data mining algorithms based on social media data and a variety of other data sources. We also looked into the suitability of this pre-mental illness detection system by examining the methods of data analysis, data extractions, outcomes and limitations. The sources of data, feature extraction methods and the performance of the classifiers in ML and DL approaches were explored in this study. The search for literature was conducted mainly using major research databases, such as Scopus, Pub-med and WoS (Web of Science). Articles published from 2017 till 2021 were included in the review of this literature. We also checked the medical subject headings related to mental state such as adolescent stress, bipolar disorder, etc., to make sure that the main topics in mental health were incorporated in the literature. The following two subsections discuss the data collection and methodologies from the selected research, while the results or outcomes of those studies have been discussed in the methodologies section (3.2).

3.1. Data Assemblage

Data assemblage is a systematic procedure of gathering and analysing data regarding indicators, allowing researchers to determine questions for research, make predictions and assess outcomes. We used some keywords, such as 'stress detection', 'anxiety', 'depression', etc., for searching the publications that are related to mental health or mental disorder. We specified the query of research for each topic based on existing studies on ML, social media and mental illness. Our research only considered the materials which were published in English language. Amongst the literatures reviewed in this study, most of the them used online social media, such as Twitter, Weibo, Facebook and Reddit, as their data source for detecting mental health problems. That being said, their methods were different from each other. Amongst these social platforms, Reddit and Twitter are the mostly used ones - utilised by many researchers as their data sources. A wide range of clinical data, such as ECG, electroencephalogram (EEG) signal [28, 33, 52], EMG, Respiration, GSR and sensor data, were also used for stress detection. AI systems are also used in psychosocial research in order to make predictions based on the voice of the patients, choice of words and duration of conversation. The authors in [16] looked at previous research on depression that had used neuroimaging indicators, movement records and a multi-modal fusion of sounds, visuals and texts. The authors in [17] proposed a system which used Pakistani dataset of 500 women in their antenatal period. Furthermore, different online web resources, such as Amazon's MTurk and WESAD, were also utilised.

Table 1 presents a critical analysis of the articles focusing on the mental illness prognosis on the online social media platforms:

Table 1. Critical Analysis of Mental Illness Prognosis on Online Social Media

Author(s)	Ref.	Publication Year	Mental health types	Data source	Durations	Data set
Thelwall *et al.*	[21]	2017	Stress and relaxation	3066 tweets Collected from Twitter	July 2015 (1 month)	Collected 3,000 stress-related tweets using the 1-5 scale system.
Shuai *et al.*	[24]	2017	Stress	3126 OSN from Amazon's MTurk	Not specified	SNMDD – 3126 OSN users included data for classified training and testing of participants: 1790 males and 1336 females.
Deshpande *et al.*	[51]	2017	Frustration	10,000 tweets From Twitter	Not specified	Two rows and two columns consist of false negatives and positives as well as true positives and negatives, where the F1 score can be analysed for SVM and NB.
Kandis *et al.*	[45]	2017	Stress	Extracted data from Facebook	Not specified	The collected dataset includes (1) 405 fully crawled users, (2) 12346 user groups, (3) 98256 liked objects, (4) 171054 statuses and (5) 250027 comments.
Wongkoblap *et al.*	[48]	2018	Depression	424,619 posts From Facebook	Not specified	424619 posts: 1,249 life satisfaction users and 2,038 life dissatisfaction users.
Tariq *et al.*	[20]	2019	Mental illness (ADHD, depression, bipolar and anxiety)	Up to 3922 posts were collected from Reddit	Not specified	Used Python (API) for Reddit; download the top 1000 posts top 5 comments per sub-Reddits post like r/Depression, r/ADHD, r/Anxiety, r/Bipolar.
Kim *et al.*	[7]	2020	Mental illness	633,385 posts were collected from Reddit	January 2017 – December 2018	An aggregate of 228,060 user data, including 488,472 posts, was utilised for the analysis.
Zhao *et al.*	[50]	2020	(SGMs) mental health	over 20 million data from tweets	17th January, 2015 to 12th May, 2015	2,395 Self-identifying users who were annotated into various SGM subcategories, such as gay (20), transwoman (138), straight (38), lesbian (6), genderfluid (142) and transman (45).
Chintalapudi *et al.*	[10]	2021	Mental illness during Covid-19	3090 data from Twitter	23rd March 2020 to 15th July 2020	Investigators were manually coded as a four-section sentiment and each feeling is mapped to 0 to 3 (sadness: 1, fear: 0, joy: 3 and anger: 2).
Nooripour *et al.*	[46]	2021	Stress	755 data from Internet ads, forums e-mails, and (SMS)	Not specified	Married (389), singles (366), inflected with covid-19 (666), well (89). According to education level higher school (182), graduated (47), associate's degree (259). Average and standard deviation for respondents' ages were 10.63 and 32.53 years, respectively.

3.2. Methodologies

ML algorithms are becoming a prominent tool for detecting mental health issues. Previously, categorisation techniques [3-4, 11, 13, 19, 20] were employed to predict a variety of matters in Mental health, including stress, suicide, anxiousness and depression. Many methods for analysing data, utilised in the detection of various sorts of mental health problems, have been developed. Authors of [22] utilised tweets by categorising them into word lists to identify frustration trends. Each tweet is categorised using SVM and NB. The results were presented using preliminary classification metrics - evaluated based on F1 score and accuracy. In another similar study [23], the researchers collected data from tweets using CES-D questionnaire to screen for depression and TSQ for PTSD. ML models were then used for the prediction. The model was trained HMM to detect various changes between the distressed and the not distressed groups. A TensiStrength [20] system where ML algorithms were used to detect stress/relaxation energy for comparison with Tensistrenth and the social network mental disorder detection (SNMDD). In this study, the authors detected each type of SNMDs with a binary SVM and proposed a two-phase

framework called SNMDD, where the 1st Phase drained various discriminatory features of the users and the 2nd Phase introduced a new SNMD-based tensor model to generate latent reasons for training and use of TSVM classifiers. The majority of previous studies contrasted several types of ML approaches. Support vector machines [7, 10, 14-15, 22], naive bayes [20-25], logistic regression [2, 10, 21], random forest [20, 23], decision tree [13, 22], gaussian process [12], K nearest neighbour (KNN) [3], ANN [11] and CNN [5-7, 25, 31,33] were the most used ML approaches for estimating mental health-related problems. On the contrary, AdaBoost, gaussian process, the hybrid technique of factor graph model (FGM) with CNN, JRip rule, Markov logic networks (MLNs) were the least used ML approaches. Compared with the previous models based on ML in classification tasks, recently DL has gained significant popularity and has obtained superior outcomes in the detection of mental illness [5, 2]. DL approaches including deep neural network (DNN) and sparse deep neural network (SDNN) have been used in the detection of psychiatric problems in previous studies [4-5, 7, 10, 28, 32-33]. Kumar *et al.* [19] found that RF achieves around 87% accuracy rather than SVM and DT. They further expanded their work with NN or CNN. Another study [34] surveyed social media users where respondents from 10 countries completed 135 surveys and majority of respondents' which approximately 85 percent expressed interest in mental health programs delivered through social media, especially to publicise overall health and wellbeing (72 percent) and to cope with emotional distress (90 percent). The authors in [17] proposed a neural network that was established based on multi-layer perceptron (MLP-NN) predictor to anticipate the risk of distress, strain and anxiety in pregnant ladies. Table 2 represents a comparison of the existing research projects on mental state disorder prediction using various ML and DL Algorithms.

Table 2. A Summary of Existing Works on Mental State Disorder Prediction Using ML and DL Algorithms

Data Source	Ref.	Mental State	ML and DL algorithms	Result
Twitter	[2]	Mental illness, bipolar disorder	Logistic regression	10-fold cross validation, Area under the ROC Curve (AUC) = 0.83
Twitter	[7]	Suicide	CNN, SVM	Precision = 0.78, AUC= 0.74, Recall= 0.96, F1=0.83
Reddit	[6]	11 mental disorder themes	FF, SVM, Linear regression, CNN	Binary classification, AUC: 91.08 and multiclass classification, AUC: 79.8
Reddit	[5]	Mental illness	XGBoost , CNN	AUC = 90.49 (CNN)
Twitter	[10]	Sentiments	BERT model, SVM, logistic regression, LSTM	BERT = 0.89, LR =0.75, SVM=0.7475, LSTM =0.65
Tencent Weibo	[35]	Adolescent distress	RNN	Baseline MSE = 0.25, MSE = 0.19
Twitter	[22]	Depression	NB, SVM	Multinomial naive bayes = 0.83 and SVM =0.79 (F1 score)
Sina Weibo, Twitter, Tencent Weibo	[33]	Stress detection	CNN	AUC= 0.916
Reddit	[37]	Anxiety, bipolar, depression, suicide	RNN	Not Specified
Reddit	[38]	Suicidal risk	RNN	Not Specified
Reddit API	[20]	Chronic mental illness diseases	Random forests, SVM, naive bayes	Not Specified
Facebook data	[22]	Depression detection	Decision tree, KNN, SVM and ensemble	Highest AUC = DT
Twitter	[21]	Stress and relaxation detection	TensiStrength, AdaBoost, J48 tree, Naïve bayes, Deccsion table, JRip rules, logistic regration, SVM	Not Specified
Instagram, Facebook, Twitter, Reddit	[35]	Suicide	LSTM with attention	AUC = 0.94
Twitter	[23]	Depression and PTSD	Random forests, ROC curve, LIWC predictors	N_{depr}=74, 990, N_{ptsd}=54, 19
Twitter posts	[25]	Depression	Tweep, naive bayes (NB), CNN	Not specified
Mood disorder questionnaire	[13]	Bipolar disorder	Decision tree	AUC = 0.88
Questionnaire (656 samples)	[3]	Mental health	Logistic regression, NB, SVM, DT, KNN, ensemble, random forest	AUC=89% (SVM, KNN), AUC=90% (Ensemble, RF)
Database of Stress Recognition in Automobile Drivers	[14]	Stress	Linear SVM, Quadratic SVM, Cubic SVM	AUC = 98.6% (Cubic SVM with gaussian kernel function)

myPersonality (SWLS dataset, CESD dataset)	[1]	Depression	logistic regression, LF model	Not specified
Centers for Disease Control and Prevention, Korea	[8]	Depression Risk	Context DNN, DNN	AUC =0.9546 (CDNN)
Questionnaires	[16]	Mental disorder	SVM, DT, random forests (RF)	AUC= 87.02%(RF)
Survey	[11]	Psychological distress	ANN	Not Specified
Questionnaire from students	[9]	Mental state	Apriori	Not Specified
Ad hoc online questionnaire	[39]	Stress	Multiple linear regression, random forests, logistic regression, NB, SVM	Not Specified
Questionnaires	[40]	Major depressive disorder (MDD)	Extreme gradient boosting, nested cross-validation	Not Specified
EEG (5 min)	[26]	depression	CNN	AUC =0.935% (left hemisphere) and 0.960%(right hemisphere)
EEG (1000 Hz)	[27]	Cross-task mental workload assessment	CNN	AUC = 0.88
EEG (1 sec)	[52]	Mild depression	CNN	AUC = 0.856
EEG Data from Electrical Geodesic Inc. (EGI), USA	[15]	Mental Stress	SVM, NB, logistic regression	Not Specified
Voice data	[29]	Depression	CNN	MAE = 8.2; Baseline MAE = 10.4
Video from webcam	[30]	Depression	CNN and LSTM	AUC = 0.901
Elicited speech voice data	[31]	Short-term detection of mood disorders	CNN and LSTM	AUC = 0.756; Baseline AUC = 0.622
Voice and visual data	[41]	Mental disorder	Auto encoder and LSTM	AUC = 0.692; Baseline AUC= 0.498

4. Discussions, Limitations and Future Research Directions

This paper has critically reviewed various ML and DL techniques used for diagnosing different mental disorders and initiatives to offer effective treatment. The review covers a wide range of articles published between 2017 and 2021. We analysed the outcomes according to the dataset of the articles which includes: social media data, survey questionnaire data, clinical data and research on video and audio data. The selected studies have been summarised in Table-1, according to their data source, focused mental state, used algorithms and results.

A bibliometric analysis of publications related to ML and mental health in social media was conducted in this research. The majority of the publications studied in this article are concerned with diagnosing and detecting depression, suicide risk and cognitive decline. We noticed an increasing number of research articles utilising ML and DL algorithms to explore mental health effects based on the previous findings. In fact, there are significant research opportunities to investigate whether they can detect and diagnose other mental health diseases with equal accuracy, including mood disorders, neurobiological abnormalities and eating disorders. However, we have strictly followed the set inclusion and exclusion criteria, keeping this study limited to the search results thus generated. In future, we plan to conduct systematic literature review to investigate different other aspects of the approaches in this domain.

5. Conclusion

For assessing and resolving mental health issues, several different methodologies and techniques have been devised and developed. There are indeed various opportunities and solutions for continuous improvement in this regard. However, there are still numerous difficulties in discovering and investigating the mental health sector by employing a wide range of essential facts and criteria in machine learning.

The purpose of this study was to investigate current research on the use of ML and DL algorithms in mental health outcome studies. To sum up, research in the field of ML for mental health has made significant progress, particularly in the recent years. Furthermore, we have analysed the systems developed for predicting physiological distress as well as presented a detailed comparison amongst them.

The majority of the articles have focused on machine learning and deep learning approaches which consist of numerous data sources, different feature extraction methods as well as performance of various classifiers. Our review of the selected articles revealed that most of the researchers utilised support vector machine (SVM) classifier amongst the diverse predictive machine learning algorithms and employed CNN amongst the deep learning algorithms. In fact, many studies have widely adopted using online social media data sources, since social media is considered as one of the most used platforms for expressing ones' mental issues. Therefore, researchers used data sources like Facebook, Twitter, Reddit, WhatsApp, e-mail services, Amazon's MTurk. However, in most cases, researchers adopted various datasets generated from Twitter. Overall, it is highly likely that ML may dramatically improve the identification and diagnosis of mental illnesses.

Acknowledgement

This research work was financially supported by the Xiamen University Malaysia Research Fund (Grant No. XMUMRF/2021-C8/IECE/0025).

References

[1] Akkapon Wongkoblap, Miguel A. Vadillo and Vasa Curcin, "A multilevel predictive model for detecting social network users with depression", in *Proceedings of the 2018 IEEE International Conference on Healthcare Informatics (ICHI)*, 4-7 June 2018, New York, NY, USA , E-ISBN:978-1-5386-5377-7, PoD-ISBN:978-1-5386-5378-4, E-ISSN: 2575-2634, DOI: 10.1109/ICHI.2018.00022, pp. 130-135, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8419355.

[2] Alexandra Budenz, Ann Klassen, Jonathan Purtle, Elad Yom Tov, Michael Yudell *et al.*, "Mental illness and bipolar disorder on Twitter: Implications for stigma and social support", *Journal of Mental Health,* Vol. 29, no. 2, 07 Nov 2019, pp. 191-199,Online-ISSN: 1360-0567,Print-ISSN: 0963-8237, DOI: 10.1080/09638237.2019.1677878, Available: https://www.tandfonline.com/doi/abs/10.1080/09638237.2019.1677878.

[3] M. Srividya, S. Mohanavalli and N. Bhalaji, "Behavioral Modeling for Mental Health using Machine Learning Algorithms", *Journal of Medical Systems,* Vol. 42, no. 5, pp. 1–12, 03 April 2018, DOI: 10.1007/s10916-018-0934-5, Published by Springer , Available: https://link.springer.com/article/10.1007/s10916-018-0934-5.

[4] Pramod Bobade , M. Vani, "Stress Detection with Machine Learning and Deep Learning using Multimodal Physiological Data", in *Proceedings of the 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA)*, 15-17 July 2020, Coimbatore, India , E-ISBN:978-1-7281-5374-2 DVD ISBN:978-1-7281-5373-5, PoD-ISBN:978-1-7281-5375-9, DOI: 10.1109/ICIRCA48905.2020.9183244, pp. 51-57, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/9183244.

[5] Jina Kim, Jieon Lee, Eunil Park and Jinayoung Han, "A deep learning model for detecting mental illness from user content on social media", *Scientific Reports,* Vol. 10, no. 1, pp. 1-6, 16 July 2020, Online-ISSN: 2045-2322, DOI: 10.1038/s41598-020-68764-y, Published by nature, Available: https://www.nature.com/articles/s41598-020-68764-y.

[6] George Gkotsis, Anika Oellrich, Sumithra Velupillai, Maria Liakata, Tim J. P. Hubbard *et al.*, "Characterisation of mental health conditions in social media using Informed Deep Learning", *Scientific reports,* Vol. 7, no. 1, pp. 1-11, 22 March 2017,Online-ISSN: 2045-2322, DOI:10.1038/srep45141, Published by nature, Available: https://www.nature.com/articles/srep45141.

[7] Jingcheng Du, Yaoyun Zhang, Jianhong Luo, Yuxi Jia, Qiang Wei *et al.*, "Extracting psychiatric stressors for suicide from social media using deep learning", *BMC medical informatics and decision making,* Vol. 18, No. 2, pp. 77-87, 23 July 2018, DOI: 10.1186/s12911-018-0632-8, Published by Springer, Available: https://link.springer.com/article/10.1186/s12911-018-0632-8.

[8] Ji-Won Baek and Kyungyong Chung, "Context deep neural network model for predicting depression risk using multiple regression", *IEEE Access,* Vol. 8, pp. 18171-18181, 21st January 2020, E-ISSN: 2169-3536, DOI: 10.1109/ACCESS.2020.2968393, Available: https://ieeexplore.ieee.org/abstract/document/8964291.

[9] Anuradha Khattar, Priti Rai Jain and S. M. K. Quadri, "Effects of the disastrous pandemic COVID 19 on learning styles, activities and mental health of young Indian students-a machine learning approach", in *Proceedings of the 2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS)*, 13-15 May 2020, Madurai, India, E-ISBN:978-1-7281-4876-2, PoD-ISBN:978-1-7281-4877-9, DOI: 10.1109/ICICCS48265.2020.9120955, pp. 1190-1195, Available: https://ieeexplore.ieee.org/abstract/document/9120955.

[10] Nalini Chintalapudi, Gopi Battineni and Francesco Amenta, "Sentimental Analysis of COVID-19 Tweets Using Deep Learning Models", *Infectious Disease Reports,* 1 April 2021, Vol. 13, No. 2, pp. 329-339, E-ISSN 2036-7449, DOI: 10.3390/idr13020032, Published by MDPI, Available: https://www.mdpi.com/2036-7449/13/2/32.

[11] Shinwoo Choi, Joo Young Hong, Yong Je Kim and Hyejoon Park, "Predicting Psychological Distress Amid the COVID-19 Pandemic by Machine Learning: Discrimination and Coping Mechanisms of Korean Immigrants in the US" , in *International Journal of Environmental Research and Public Health,* 20 August 2020, Vol. 17, No. 17, p. 6057, E-ISSN 1660-4601, DOI: 10.3390/ijerph17176057, Available: https://www.mdpi.com/1660-4601/17/17/6057.

[12] Leilei Liang, Hui Ren, Ruilin Cao, Yueyang Hu and Zeying Qin *et al.*, "The effect of COVID-19 on youth mental health", *Psychiatric quarterly,* 21 April 2020, Vol. 91, No. 3, pp. 841-852, DOI: 10.1007/s11126-020-09744-3, Published by Springer, Available: https://link.springer.com/article/10.1007/s11126-020-09744-3.

[13] Ranjana Jadhav, Vinay Chellwani, Sharyu Deshmukh and Hitesh Sachdev, "Mental Disorder Detection: Bipolar Disorder Scrutinization Using Machine Learning", in *Proceedings of the 2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence)*, 10-11 Jan. 2019, Noida, India, E-ISBN:978-1-5386-5933-5, CD:978-1-5386-5932-8, PoD-ISBN:978-1-5386-5934-2, DOI: 10.1109/CONFLUENCE.2019.8776913, pp. 304-308, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8776913.

[14] Md Fahim Rizwan, Rayed Farhad, Farhan Mashuk, Fakhrul Islam and Mohammad Hasan Imam *et al.*, "Design of a biosignal based stress detection system using machine learning techniques", in *Proceedings of the 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)*, 10-12 Jan. 2019,Dhaka, Bangladesh, E-ISBN:978-1-5386-8014-8, Print ISBN:978-1-5386-8012-4, USB ISBN:978-1-5386-8013-1, PoD-ISBN:978-1-5386-8015-5, DOI: 10.1109/ICREST.2019.8644259, pp. 364-368, Published by IEEE , Available: https://ieeexplore.ieee.org/abstract/document/8644259.

[15] Ahmad Rauf Subhan, Wajid Mumtaz, Mohamed Naufal Bin Mohamed Saad, Nidal Kamel and Aamir Saeed Malik, "Machine learning framework for the detection of mental stress at multiple levels", *IEEE Access,* Vol. 5, pp. 13545-13556, 05 July 2017, E-ISSN: 2169-3536 DOI: 10.1109/ACCESS.2017.2723622, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/7968419.

[16] Prajwal Kharel, Kalpana Sharma, Sunil Dhimal and Sital Sharma, "Early detection of depression and treatment response prediction using machine learning: a review", in *Proceedings of the 2019 Second International Conference on Advanced Computational and Communication Paradigms (ICACCP)*, 25-28 Feb. 2019, Gangtok, India, E-ISBN:978-1-5386-7989-0, PoD-ISBN:978-1-5386-7990-6, DOI: 10.1109/ICACCP.2019.8882891, pp. 1-7, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8882891.

[17] Fajar Javed, Syed Omer Gilani,Seemab Latif, Asim Waris, Mohsin Jamil *et al.*, "Predicting Risk of Antenatal Depression and Anxiety Using Multi-Layer Perceptrons and Support Vector Machines", *Journal of personalized medicine,* 12 March 2021, vol. 11, no. 3, p. 199, E-ISSN 2075-4426 , DOI: 10.3390/jpm11030199, Published by MDPI, Available: https://www.mdpi.com/2075-4426/11/3/199.

[18] Rohizah Abd Rahman, Khairuddin Omar, Shahrul Azman Mohd Noah, Mohd Shahrul Nizam Mohd Danuri and Mohammed Ali Al-Garadi, "Application of Machine Learning Methods in Mental Health Detection: A Systematic Review", *IEEE Access*, Vol. 8, pp. 183952-183964, E-ISSN: 2169-3536, DOI: 10.1109/ACCESS.2020.3029154, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/9214815.

[19] V. Uday Kumar, Alekhya Savithri, M. Jhansi Bhavani, A. Madhu Priya and K Venkata Sai Bindu Jahnavi *et al.*, "Finding Psychological Instability Using Machine Learning", in *Proceedings of the 2020 7th International Conference on Smart Structures and Systems (ICSSS)*, 23-24 July 2020, Chennai, India,pp. 1-4, E-ISBN:978-1-7281-7223-1, DOI: 10.1109/ICSSS49621.2020.9202009, Available: https://ieeexplore.ieee.org/abstract/document/9202009.

[20] Subhan Tariq, Nadeem Akhtar, Humaira Afzal, Shahzad Khalid and Muhammad Rafiq Mufti *et al.*, "A novel co-training-based approach for the classification of mental illnesses using social media posts", *IEEE Access,* Vol. 7, pp. 166165-166172, 14 Nov. 2019, E-ISSN: 2169-3536 DOI: 10.1109/ACCESS.2019.2953087,Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8901145.

[21] Mike Thelwall, "TensiStrength: Stress and relaxation magnitude detection for social media texts", *Information Processing & Management,* vol. 53, no. 1, pp. 106-121, January 2017, ISSN :0306-4573,DOI: 10.1016/j.ipm.2016.06.009, Published by Elsevier, Available: https://www.sciencedirect.com/science/article/abs/pii/S0306457316302321.

[22] Md. Rafiqul Islam, Muhammad Ashad Kabir, Ashir Ahmed, Abu Raihan M. Kamal and Hua Wang *et al.*, "Depression detection from social network data using machine learning techniques", in *Health Information Science and Systems,* 27 August 2018, Vol. 6, No. 1, pp. 1-12, DOI: 10.1007/s13755-018-0046-0, Published by Springer Nature, Available: https://link.springer.com/article/10.1007/s13755-018-0046-0.

[23] Andrew G. Reece, Andrew J. Reagan, Katharina L. M. Lix, Peter Sheridan Dodds and Christopher M. Danforth *et al.*, "Forecasting the onset and course of mental illness with Twitter data", *Scientific Reports,* 11 October 2017, Vol. 7, No. 1, pp. 1-11, Online- ISSN 2045-2322, DOI: 10.1038/s41598-017-12961-9, Published by Nature, Available: https://www.nature.com/articles/s41598-017-12961-9.

[24] Hong-Han Shuai, Chih-Ya Shen, De-Nian Yang, Yi-Feng Carol Lan and Wang-Chien Lee *et al.*, "A comprehensive study on social network mental disorders detection via online social media mining", in *Proceedings of the IEEE Transactions on Knowledge and Data Engineering,* 25 December 2017, Vol. 30, No. 7, pp. 1212-1225, Print ISSN: 1041-4347, E-ISSN: 1558-2191, CD: 2326-3865, DOI: 10.1109/TKDE.2017.2786695, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8239661.

[25] Chempaka Seri Abdul Razak, Muhammad Ameer Zulkarnain, Siti Hafizah Ab Hamid, Nor Badrul Anuar and Mohd Zalisham Jali *et al.*, "Tweep: a system development to detect depression in twitter posts," in *Lecture Notes in Electrical Engineering*, Print ISBN : 978-981-15-0057-2, Online ISBN:978-981-15-0058-9 pp. 543-552, DOI: 10.1007/978-981-15-0058-9_52, Available: https://link.springer.com/chapter/10.1007/978-981-15-0058-9_52.

[26] U. Rajendra Acharya, Shu Lih Oh, Yuki Hagiwara, Jen Hong Tan, Hojjat Adeli *et al.*, "Automated eeg-based screening of depression using deep convolutional neural network", in *Computer methods and programs in biomedicine*, Vol. 161, pp. 103–113, july 2018 , DOI: 10.1016/j.cmpb.2018.04.012, Published by Elsevier, Available: https://www.sciencedirect.com/science/article/abs/pii/S0169260718301494.

[27] Pengbo Zhang, Xue Wang, Weihang Zhang and Junfeng Chen, "Learning spatial–spectral–temporal eeg features with recurrent 3d convolutional neural networks for cross-task mental workload assessment", *IEEE Transactions on neural systems and rehabilitation engineering*, Vol. 27, No. 1, pp. 31–42, 2018 , Print ISSN: 1534-4320, E-ISSN: 1558-0210, DOI: 10.1109/TNSRE.2018.2884641, Available: https://ieeexplore.ieee.org/abstract/document/8556024.

[28] Zhicheng Jiao, Xinbo Gao, Ying Wang, Jie Li and Haojun Xu, "Deep convolutional neural networks for mental load classification based on eeg data", in *Pattern Recognition*, Vol. 76, pp. 582–595, April 2018 , DOI: 10.1016/j.patcog.2017.12.002, Available: https://www.sciencedirect.com/science/article/abs/pii/S0031320317304879.

[29] Lang He and Cui Cao, "Automated depression analysis using convolutional neural networks from speech",in *Journal of biomedical informatics,* Vol. 83, pp. 103–111, July 2018 , DOI: 10.1016/j.jbi.2018.05.007 , Published in Elsevier, Available : https://www.sciencedirect.com/science/article/pii/S153204641830090X.

[30] Amina Dawood, Scott Turner and Prithvi Perepa, "Affective computational model to extract natural affective states of students with asperger syndrome (as) in computer-based learning environment", *IEEE Access,* Vol. 6, pp. 67026–67034, 05 November 2018, E-ISSN: 2169-3536, DOI: 10.1109/ACCESS.2018.2879619, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8522016.

[31] Kun-Yi Huang, Chung-Hsien Wu and Ming-Hsiang Su, "Attention-based convolutional neural network and long short-term memory for short-term detection of mood disorders based on elicited speech responses", in *Pattern Recognition*, Vol. 88, pp. 668–678, April 2019,DOI: 10.1016/j.patcog.2018.12.016, Published by Elsevier, Available: https://www.sciencedirect.com/science/article/abs/pii/S0031320318304382.

[32] Qi Li, Liang Zhao, Yuanyuan Xue, Li Jin, Mostafa Alli *et al.*, "Correlating stressor events for social network based adolescent stress prediction", in *International Conference on Database Systems for Advanced Applications*h, 22 march 2017, pp. 642–658, DOI: 10.1007/978-3-319-55753-3_40, Published by Springer, Available: https://link.springer.com/chapter/10.1007/978-3-319-55753-3_40.

[33] Huijie Lin, Jia Jia, Jiezhong Qiu, Yongfeng Zhang, Guangyao Shen *et al.*, "Detecting stress based on social interactions in social networks", *IEEE Transactions on Knowledge and Data Engineering,* Vol. 29, No. 9, 22 March 2017, Print ISSN: 1041-4347, E-ISSN: 1558-2191, CD: 2326-3865 pp. 1820-1833, DOI: 10.1109/TKDE.2017.2686382, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/7885098.

[34] Bárbara Silveira Fraga, Ana Paula Couto da Silva and Fabricio Murai, "Online social networks in health care: a study of mental disorders on Reddit", in *Proceedings of the 2018 IEEE/WIC/ACM International Conference on Web Intelligence (WI)*, 3-6 December 2018, Santiago, Chile, E-ISBN:978-1-5386-7325-6, PoD-ISBN:978-1-5386-7326-3, pp. 568-573, DOI: 10.1109/WI.2018.00-36, Available: https://ieeexplore.ieee.org/abstract/document/8609647.

[35] Amanuel Alambo, Manas Gaur, Usha Lokala, Ugur Kursuncu and Krishnaprasad Thirunarayan *et al.*, "Question answering for suicide risk assessment using reddit", in *Proceedings of the 2019 IEEE 13th International Conference on Semantic Computing (ICSC)*, 30 January-1 February 2019, Newport Beach, CA, USA, pp. 468–473, E-ISBN:978-1-5386-6783-5, PoD-ISBN:978-1-5386-6784-2, PoD-ISSN: 2325-6516, DOI: 10.1109/ICOSC.2019.8665525, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8665525.

[36] Luca Flesia, Merylin Monaro, Cristina Mazza, Valentina Fietta, Elena Colicino *et al.*, "Predicting perceived stress related to the covid-19 outbreak through stable psychological traits and machine learning models", in *Journal of clinical medicine*, Vol. 9, No. 10, p. 3350, 19 October 2020, E-ISSN 2077-0383, DOI:10.3390/jcm9103350 , Published by MDPI, Available: https://www.mdpi.com/2077-0383/9/10/3350.

[37] Jakub Tomasik, Sung Yeon Sarah Han ,Giles Barton-Owen, Dan-Mircea Mirea, Nayra A. Martin-Key *et al.*, "A machine learning algorithm to differentiate bipolar disorder from major depressive disorder using an online mental health questionnaire and blood biomarker data", in *Translational psychiatry*, Vol. 11, No. 1, pp. 1–12, 12 January 2021, Online ISSN 2158-3188, DOI:10.1038/s41398-020-01181-x, Published by Nature, Available: https://www.nature.com/articles/s41398-020-01181-x.

[38] Sahar Harati, Andrea Crowell, Helen Mayberg and Shamim Nemati, "Depression severity classification from speech emotion" , in *Proceedings of the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 18-21 July 2018, Honolulu, HI, USA, pp. 5763-5766, E-ISSN: 1558-4615, PoD-ISSN: 1557-170X, PubMed ID: 30441645, DOI: 10.1109/EMBC.2018.8513610, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8513610.

[39] Glen Coppersmith, Ryan Leary, Patrick Crutchley and Alex Fine, "Natural language processing of social media as screening for suicide risk", *Biomedical informatics insights,* Vol. 10, 27 August 2018, ISSN: 1178-2226, Online ISSN:

1178-2226, DOI:10.1177/1178222618792860, Published by SAGE journals, Available: https://journals.sagepub.com/doi/full/10.1177/1178222618792860.

[40] Chang Su, Zhenxing Xu, Jyotishman Pathak and Fei Wang, "Deep learning in mental health outcome research: a scoping review", in *Translational Psychiatry,* Vol. 10, No. 1, pp. 1-26, 22 April 2020, DOI: 10.1038/s41398-020-0780-3, Published by Springer Nature, Available: https://www.nature.com/articles/s41398-020-0780-3.

[42] Muhammed J. A. Patwary, Weipeng Cao, Xi-Zhao Wang and Mohammad Ahsanul Haque, "Fuzziness based semi-supervised multimodal learning for patient's activity recognition using RGBDT videos", *Applied Soft Computing*, Vol. 120, DOI: https://doi.org/10.1016/j.asoc.2022.108655, published by Elsevier. Available: https://www.sciencedirect.com/science/article/abs/pii/S1568494622001326.

[43] Sara Karim, Nazina Akter, Muhammed J. A. Patwary and Md Rashedul Islam, "A Review on Predicting Autism Spectrum Disorder (ASD) meltdown using Machine Learning Algorithms", in *Proceedings of the 2021 5th International Conference on Electrical Engineering and Information & Communication Technology (ICEEICT)*, 18-20 November 2021, Dhaka, Bangladesh, E-ISBN:978-1-6654-9522-6, PoD-ISBN:978-1-6654-9523-3, pp. 1-6, DOI: 10.1109/ICEEICT53905.2021.9667827, Available: https://ieeexplore.ieee.org/abstract/document/9667827.

[44] Md Sakib Bin Alam, Muhammed J. A. Patwary and Maruf Hassan, "Birth mode prediction using bagging ensemble classifier: A case study of bangladesh", in *Proceedings of the 2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD)*, 27-28 February 2021, Dhaka, Bangladesh, E-ISBN:978-1-6654-1460-9, PoD-ISBN: 978-1-6654-4752-2, pp. 95-99, DOI: 10.1109/ICICT4SD50815.2021.9396909, Published by IEEE,Available: https://ieeexplore.ieee.org/abstract/document/9396909.

[45] Miltiadis Kandia, Dimitris A. Gritzalis, Vasilis Stavro and Kostas Nikoloulis, "Stress level detection via OSN usage pattern and chronicity analysis: An OSINT threat intelligence module", *Computers & Security*, Vol. 69, pp. 3-17, August 2017, DOI: 10.1016/j.cose.2016.12.003, Published by Elsevier, Available: https://www.sciencedirect.com/science/article/pii/S0167404816301742.

[46] Roghieh Nooripour, Simin Hosseinianet, Abir Jaafar Hussain, Mohsen Annabestani and Ameer Maadal *et. al*., "How Resiliency and Hope Can Predict Stress of Covid-19 by Mediating Role of Spiritual Well-being Based on Machine Learning", *Journal of religion and health*, pp. 1-16, 04 January 2021, DOI: 10.1007/s10943-020-01151-z, Published by Springer Nature, Available: https://link.springer.com/article/10.1007/s10943-020-01151-z.

[47] Shakhawat Hossain, Zahid Hasan, Muhammed J. A. Patwary and Mohammad Shorif Uddin, "An Expert System to Determine Systemic Lupus Erythematosus Under Uncertainty", in *Proceedings of International Joint Conference on Advances in Computational Intelligence. Algorithms for Intelligent Systems*, Singapore. DOI: 10.1007/978-981-16-0586-4_10, Published by Springer, Available: https://link.springer.com/chapter/10.1007/978-981-16-0586-4_10.

[48] Akkapon Wongkoblap, Miguel A. Vadillo and Vasa Curcin, "A multilevel predictive model for detecting social network users with depression", in *Proceedings of the 2018 IEEE International Conference on Healthcare Informatics (ICHI)*, 4-7 June 2018, New York, NY, USA, pp. 130-135, E-ISSN: 2575-2634, DOI: 10.1109/ICHI.2018.00022, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8419355.

[49] Yan Ding, Xuemei Chen, Qiming Fu and Shan Zhong, "A depression recognition method for college students using deep integrated support vector algorithm", *IEEE Access,* Vol. 8, 13 April 2020, pp. - 75616-75629, E-ISSN: 2169-3536, DOI: 10.1109/ACCESS.2020.2987523, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/9064780.

[50] Yunpeng Zhao , Yi Guo and Xing He et al., "Assessing mental health signals among sexual and gender minorities using Twitter data", *Health informatics journal*, Vol. 26, no. 2, pp. 765-786, April 10, 2019, PMID: 30969146, ISSN: 1460-4582, Online ISSN: 1741-2811, DOI: 10.1177/1460458219839621, Published by SAGE Journals, Available: https://journals.sagepub.com/doi/full/10.1177/1460458219839621.

[51] Mandar Deshpande and Vignesh Rao, "Depression detection using emotion artificial intelligence", in *Proceedings of the 2017 International Conference on Intelligent Sustainable Systems (ICISS)*, 7-8 Dec. 2017, Palladam, India, E-ISBN: 978-1-5386-1959-9, DVD-ISBN: 978-1-5386-1958-2, PoD-ISBN:978-1-5386-1960-5, pp. 858-862, DOI: 10.1109/ISS1.2017.8389299, Published by IEEE, Available: https://ieeexplore.ieee.org/abstract/document/8389299.

[52] Xiaowei Li, Rong La, Ying Wang, Junhong Niu, Shuai Zeng and Shuting Sun *et al*., "EEG-based mild depression recognition using convolutional neural network". *Medical & Biological Engineering & Computing*, Vol.57, pp. 1341–1352, 19 February 2019, DOI: 10.1007/s11517-019-01959-2, Published by Springer, Available: https://link.springer.com/article/10.1007/s11517-019-01959-2.