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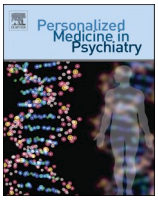

The use of machine learning and deep learning models in detecting depression on social media: A systematic literature review

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ABSTRACT

Depression is regarded as one of the world's primary concerns. Recent researchers use artificial intelligence techniques like machine learning and deep learning to identify depressive symptoms automatically. This literature review focuses on using machine learning and deep learning models in depression detection on social media. Advances in deep learning have improved methods for identifying depression, which is one of the illnesses that affect the health of individuals. Some researchers employ a variety of deep-learning approaches to improve the diagnosis, detection, and prediction of depression to support expert decision-making. The researchers identified the available prediction techniques and tools used to detect, forecast, compare, and classify depression in victims systematically. Twenty-eight (28) articles relevant to machine learning and thirty-two (32) articles linked to deep learning were chosen and considered using boolean keyword searches in different publishing databases and filters. A significant number of the studies, according to the conclusions of the analysis, used machine learning techniques such as decision trees, K-nearest neighbours, naive bayes, random forests, and support vector machines. The deep learning models that are most frequently utilised include convolutional neural networks, long short-term memory, and recurrent neural networks with different datasets to detect subjects suffering from depression using social media data. The datasets used in these studies include Twitter, Facebook, Reddit, tweets from the Kaggle website, and clinic patients' records. These datasets can include posts, comments, audio, video, images, and interviews. The results of this study revealed that, recently, several approaches have focused on using deep learning for depression detection. The paper highlighted that most research focuses on the detection and identification of depression. Prospects for cutting-edge studies in the detection of depression and other illnesses that are related to health were also suggested.

1. Introduction

Depression is a widespread and severe mental health disease that is characterised by protracted feelings of melancholy, worthlessness, and loss of interest in or enjoyment from activities. It can seriously hinder a person's ability to go about their everyday lives and engage in activities like work, studying, eating, sleeping, and enjoying life. Depression is more than just feeling down temporarily; it is a clinical condition that requires proper diagnosis and treatment[18]. Depression is one of the major contributing factors to suicide globally. A recent study by the World Health Organisation states that 1 in 8 people worldwide has a mental illness [67–68]. Within a year of the COVID-19 epidemic, over 26 % more people reported having symptoms of depression or anxiety [42]. However, many depression cases remain undetected and, consequently, untreated. Previous research has shown that messages posted on social media platforms by people suffering from major depression can be analysed to predict whether or not they are depressed [18]. Kumbhar et al. [38] define depression as a prevalent mood and anxiety disorder. Sadness, decreased interest, guilt or low self-worth, and difficulties focusing are the main contributors to depression [38]. According to Tyshchenko [59], memory loss, lack of attention, difficulty in concentrating, difficulty in making decisions, lack of interest in leisure activities and hobbies, including sex, overeating and excess weight, reduction of appetite, and thoughts of suicide are among the main clinical symptoms of depression. It could be long-term or recurring, with an impact on families and even society. Depression can strike at any time [38]. However, certain factors and events that put depression at risk, such as growing up, having a child, losing a loved one, and retiring, can all result in physical and mental changes that, for some people, may contribute to the development of depression.

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Identifying individuals experiencing depression symptoms is crucial for providing appropriate interventions and treatments. Early detection of depression and mental health issues is crucial since, if left untreated, they can become fatal [60]. For this purpose, researchers employ various methods and tools, from self-report questionnaires to digital technologies that analyze speech patterns and social media activity. Kour [60] states that the distinction between depressed people and non-depressed people is a challenging endeavour because there is no practical method for doing so. Furthermore, there are insufficient resources and educated medical personnel to treat depression. Machine learning (ML) and deep learning (DL) are some methods for diagnosing depression. The identification of depression from user-generated content on the internet has long been a subject of interest for researchers, offering psychologists proper screening instruments[13]. With the large number of users and their actions on social media platforms such as Facebook, Twitter, Reddit, Instagram, and Snapchat, researchers can detect depression using ML and DL models.

The extensive use and rich data provided by social media make it a possible platform for recognising symptoms of depression. For more than a decade, social media has become an integral part of the lives of adolescents[55]. Social media data involves analysing text, linguistic patterns, and social interactions. Social media platforms like Facebook, Twitter, Reddit, and YouTube have become popular ways for people to communicate with one another, share information, and exchange ideas in a variety of sectors [47]. Losada et al. [41] state that social media can be a source of risk in certain situations, such as when a user sends, posts, or shares harmful content about someone else. It can also reflect risks that occur offline, such as when an adolescent experiencing depression starts posting suicidal thoughts online. Natural language processing (NLP) and deep learning have gained popularity in recent years as tools for textual data analysis and the detection of mental health issues, including depression, anxiety, and suicidal thoughts, from user-generated content. With user-generated material, these computational methods offer exciting potential for automated and scalable tools to detect individuals with mental health issues, such as depression, anxiety, or suicide ideation, or those who are at risk.

Researchers have explored various methods of detecting depression using ML and DL models. Therefore, this study focused on the use of machine and deep learning models to detect depression on social media. The researchers systematically identified the existing models and tools used to detect, predict, compare, and classify depression in subjects on social media. Thirty-two (32) publications related to the use of deep learning methods and twenty-eight (28) relating to the use of machine learning were selected and considered using Boolean keyword searches in various journal databases that include Google Scholar, Springer, Pubmed, Elsevier, Hindawi, and filters.

The contributions of this paper are as follows:

- Review existing deep and machine learning techniques for depression detection.
- A systematic method of analysing existing techniques
- Understanding the limitations of the existing techniques and the size of the data used to detect depression.

The rest of the article is organized: Section 2 points out the research questions. The methodology deployed in this article for reviewing the existing literature is discussed in Section 3. Section 4 reviews machine learning techniques for depression detection. Section 5 reviews depression detection using deep learning algorithms. Section 6 discussed the research gap that neither machine learning nor deep learning studies have been able to resolve. Section 7 presents the data, analysis, and findings from the reviews' analysis to address the research questions in graphical form. Section 8 discusses the outcome of the review study. Prospects for future research discussed the possible future research applying ML and DL related to depression detection as a desirable and probable future focus in Section 9. Section 10 restates a more realistic method of diagnosing depression and provides closure to the review.

2. Research questions

1. What are the ML and DL research trends for detecting depression from 2016 to 2023?
2. What has been the focus of ML and DL in detecting depression?
3. What ML and DL techniques have been applied to study depression detection?
4. Which datasets were used to train ML and DL for depression detection?

3. Methodology

Medical and health informatics research widely uses a framework known as Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[43]. This study adopted a systematic literature review approach by Keathley-Herring et al. [34] based on two variables. This study primarily focuses on bibliometric analysis, which refers to quantitative assessments of published works. Keathley-Herring et al. [34] included three essential steps- problem definition, scoping study, and search strategy- that were not addressed by the PRISMA research approach. These three steps update the systematic literature review process. Keathley-Herring et al. [34] and Zumbuka et al. [70] applied the seven-step systematic literature review methodology. The steps include problem definition, scoping investigation, search strategy, exclusion criteria, data collection, analysis, and reporting.

3.1. Problem definition

Artificial intelligence (AI) techniques for identifying, detecting, diagnosing, and forecasting illnesses have expanded since algorithmic breakthroughs. Researchers have studied using machine learning (ML) and deep learning (DL) models in detecting depression on social media. However, there are only a few systematic studies that employ AI techniques to steer researchers towards the study of mental health diseases and depression cases. For example, Jayanthi et al. [32] and Ashraf et al. [11] reviewed the application of machine algorithms in depression detection. This study reviewed the use of ML and DL research to detect depression on social media and provide prospects for future research.

3.2. Scope of the study

This study searches the databases at Google Scholar, Science Direct, IEEE, Springer, Research Gate, PubMed, MDPI, SSRN Library, ACM Digital Library, and Academia. The researchers searched the web by entering keywords related to depression detection using machine learning and deep learning on social media to search for relevant publications. The study focused on research articles published in English, peer-reviewed journals, and conference proceedings between 2016 and 2023. The number of related journals and conference articles was selected and arranged according to the years of publication and presentation. The studies imply that devoting time to reviewing articles during the study period would yield valuable data that would further encourage research on depression detection.

3.3. Search strategy

The authors use Google Scholar, Science Direct, the Institute of Electrical and Electronics Engineers (IEEE) Library, Springer, Research Gate, PubMed, the Multidisciplinary Digital Publishing Institute (MDPI) Library, the Social Science Research Network (SSRN) Library, the Association of Computing Machinery (ACM) Digital Library, and Academia to search for articles. Initial search terms used to source articles are depression detection, depression detection and machine learning, depression detection using machine learning, depression detection and

deep learning, depression detection using deep learning techniques, depression detection using social media, depression detection and social media, depression detection using social media, depression detection using Twitter data, depression detection using deep learning algorithms, depression detection using eRisk deep learning algorithms, and deep learning. Depression detection using Reddit, depression detection in social media using deep learning algorithms, and rephrasing of these words. Boolean operators such as and or were also included in the search criteria to get access to peer-reviewed academic journals and conference proceedings written in English. These search terms were tested and modified to improve the search's sensitivity, boolean phrases, and related words such as artificial intelligence, DL, ML, prediction, detection, and depression. The full-text availability of every article was checked, and authors read through the abstract of each paper and then classified whether the article's content in context aligned with the purpose of this review.

3.4. Exclusion criteria

The study excludes publications from conference proceedings and academic peer-reviewed journals that are not in English and do not directly relate to AI or the use of ML and DL models in social media to detect depression. The study excludes publications that fail to incorporate ML or DL methods on social media. The study also excludes papers with no results, duplicate publications, and non-quantitative publications that do not include machine learning or deep learning. The study also excluded publications from before the year 2016.

3.5. Data collection

The search produced 114 related publications; after removing the abstract-only and duplicate publications, 60 publications related to DL and ML remained. The publications consist of Google Scholar = 15, Science Direct = 8, IEEE = 13, Springer = 6, Research Gate = 4, MDPI = 3, SSRN Library = 2, ACM Digital Library = 3, PubMed = 2, and Academia = 4. The study further evaluated the articles based on their titles, abstracts, keywords, and exclusion criteria. The study found that 32 articles pertain to DL and 28 to ML. The study used the articles to address the research questions in Tables 1 and 2. Fig. 1 is a bar chart displaying the sources of publications for both ML and DL.

The bar chart in Fig. 1 illustrates the quantity of ML and DL-related publications from conference proceedings and academic peer-reviewed journals utilised in the review. The researchers accessed and downloaded the papers from various sources, including Google Scholar, Science Direct, Research Gate, the SSRN Library, PubMed, Springer, the ACM Digital Library, MDPI, Academia, and the IEEE Library, as depicted in Fig. 1.

4. Review of machine learning techniques for depression detection

In a study conducted by Adarsh et al. [1], titled "Fair and Explainable Depression Detection in Social Media," the researchers aimed to identify individuals experiencing depression by analyzing their social media posts. The objective of the study was to identify and evaluate individuals who are susceptible to the development of a mental condition while also examining potential indicators of suicidal ideation and behaviours in their early stages. The study's data was acquired using Reddit's Application Programming Interface (API). Following data collection and text pre-processing, the study used a rudimentary neural machine translator (NMT) to eliminate noise from the gathered data. Following data cleansing, the researchers analysed the data for potential class imbalances. The disparity in engagement among various age groups and demographic categories is equalized using the one-shot choice strategy. Once the data has undergone the process of filtration, it is subsequently directed towards a clustering procedure known as a Gaussian mixture model, which incorporates K-means clustering. The algorithm partitions the data into two distinct categories: those exhibiting suicidal ideation and individuals not exhibiting suicidal ideation. To verify the groups in the primary data's levels of participation exhibited, the idea of participation dynamics is employed to analyze the two clustered groups. The research utilizes a novel ensemble model that integrates support vector machines (SVM) and K-nearest neighbours (KNN) algorithms, incorporating inherent interpretability. The study incorporates methods for correcting noisy labels. This technique offers a pioneering way to differentiate between symptoms of depression and suicidal ideation effectively. The study achieved a final classification accuracy of 98.05 %. The Ensemble Model, which was recommended, ensured that the data classification was unbiased.

Vasha et al. [65] employed machine learning techniques to investigate the identification of depression among social media comments. Facebook text, comments, and single-line messages written in the Bangla language gathered a dataset of 10,000 distinct data points on the subject of depression and non-depression. The study assigned a score of 1 to indicate the presence of depression and a score of 0 to indicate the absence of depression. The researchers eliminated all superfluous information. The study identified approximately 300 duplicate records in the collected dataset. The researchers separated the information into two groups. The field of data training is a significant area within machine learning. Data mining techniques were employed to assess the data and ascertain its depressive nature. Another categorization pertains to the outcomes derived from the testing process. The training phase necessitated the utilisation of 80 % of the available data, while the testing phase used the remaining 20 %. The method is a systematic approach encompassing sequential stages of data preprocessing, data extraction, text processing, and using classification models. A vectorizer for calculating inverse document frequency (IDF) and term frequency (TF) subsequently annotated the data for machine learning (ML). Furthermore, the researchers employed various classifiers, including random forest (RF), logistic regression (LR), decision tree (DT), support vector machine (SVM), K-nearest neighbours (KNN), and multinomial naive bayes (NB), to predict instances of depressive remarks. The term frequency inverse document frequency of records (TF-IDF) feature combination is employed to attain optimal classification results. The SVM model had the highest precision rates and F1 scores, measuring 0.77 and 0.78, respectively. The study successfully detected depression by employing classifiers on 10,000 distinct data points extracted from various posts and comments on profiles belonging to individuals from different categories. Although the study may have potentially achieved more efficiency and productivity, the researchers made a deliberate decision to refrain from utilising larger datasets. The use of machine learning techniques in the investigation may have resulted in more precise predictions of depression compared to deep learning methods.

According to Angskun et al. [9], there was a substantial rise in the prevalence of depression cases amidst the COVID-19 pandemic. Many individuals diagnosed with depression use social media platforms as a means to openly articulate their authentic emotions. Therefore, the utilization of big data analytics on social networks is suggested as a means of promptly identifying instances of depression. This study employed a method that examined demographic characteristics and opinions expressed by Twitter users over two months after they completed the Patient Health Questionnaire-9, which was used as a metric for assessing depression. This research examines five distinct machine learning methodologies: SVM, DT, RF, naive bayes (NB), and deep learning (DL). The findings from the trial indicate that the Random Forest technique had a higher level of accuracy in detecting depression compared to alternative strategies. This research contributes to the existing literature by proposing an innovative model incorporating demographic variables and Twitter users' text sentiment. The model can accurately represent the depressive moods experienced by individuals with depression. Consequently, this study represents a significant advancement in efforts to reduce suicide rates associated with

Table 1
Summary of Machine Learning Review.

Authors/ Year	Research Title	Techniques	Dataset	Outcome	Limitation/Weakness
[1]	Fair and Explainable Depression Detection in Social Media	KNN & SVM	Reddit	The presented ensemble approach ensures that the data classification is not skewed, leading to the study's ultimate classification accuracy of 98.05 %.	Men from the United States between 18 and 49 make up most of Reddit users.
[65]	Depression Detection in Social Media Comments Data Using Machine Learning Algorithms	DT, K-NN, LR, RF, SVM, & MNB classifiers	Facebook posts and comments in the Bangla language	The result found that SVM is the best machine learning (ML) algorithm with accuracy.	The study was limited to data from comments and posts on Facebook in the Bangla language.
[9]	Big Data Analytics on Social Networks for Real-time Depression Detection	DL, DT, NB, RF, SVM	Twitter	The experimental findings revealed that the RF approach was more accurate than other ML techniques at detecting depression.	The model cannot retrieve private information like direct messages or information users do not wish to publish.
[26]	Psychological Analysis for Depression Detection from Social Networking Sites	DT, K-NN, LSTM, MLR & SVM	Tweets	The LSTM classification model performs better than the other baseline models for balanced and unbalanced data.	Many people do not use social media, and because of that, they remain undiagnosed.
[32]	Depression Detection Using Machine Learning Algorithms	Chatbots, LR, NB, DT, RF, SVMs, KNNs	Survey	The analysis showed that Random Forest achieved its highest accuracy of 84 % in predicting depression.	The dataset was insufficient to provide efficiency and effectiveness for the models tested.
[16]	Depression Detection from Social Media Posts Using Multinomial Naive Theorem	NB	Facebook	The research's conclusion led to the classification of depression's degree and severity using NB.	The study focused on the classification of the level and degree of depressed Facebook posts.
[18]	A Textual-Based Featuring Approach for Depression Detection Using Machine Learning Classifiers and Social Media Texts	LR, LSVM, MLP, DT	Twitter, Reddit & Victoria's Diary	The findings show that the suggested method may accurately identify depression in texts using social media.	The strategy is restricted to training the classifiers using annotated datasets.
[28]	Detection of Child Depression Using Machine Learning Methods	RF, XGB, DT, Gaussian NB	The second Australian Child and Adolescent Survey of Mental Health and Wellbeing 2013–2014	Regarding predicting pediatric and teenage depression, the RF-based prediction model is more reliable and instructive.	The study was limited to detecting depression in children and young people between the ages of 4 and 17 years.
[38]	Depression Detection Using Machine Learning	SVM, RF, DT, K-NN & NB	Tweets	The findings indicate that DT has 98.55 % accuracy after a processing time (sec) 3.40.	The use of more datasets will provide more efficiency and effectiveness.
[23]	Depression Detection Using Machine Learning Techniques on Twitter Data	NB	Twitter	The NB Tree identifier correctly distinguishes between depression and non-depressive tweets with a 97.31 % accuracy rate.	The study's outcome is limited to the text only and does not target specific tweets.
[54]	Using Twitter Social Media for Depression Detection in the Canadian Population	GBDT, LR, RF, SVM, & XGBoost	Twitter	XGBoost delivers the highest accuracy and precision of 96.4 % and 0.956, respectively.	The study objective was limited to detecting depression in the Canadian population.
[6]	Machine Learning-Based Approach for Depression Detection in Twitter Using Content and Activity Features	LSVM, DT & NB	Twitter	The best outcomes are provided by SVM-linear, with an accuracy of 82.5 % and an F-measure of 0.79.	The study did not consider ML models, which are very rare, to overfit the data given and develop a more reliable method to quantify the influence of features.
[50]	Predicting Anxiety, Depression and Stress in Modern Life Using Machine Learning Algorithms	DT, RFT, NB SVM & K-NN	DASS 21 via Google forms	RF was found to have a better model, whereas NB was shown to have the highest accuracy.	The study used a limited dataset of 348 participants to test the models.
[3]	Depression Detection by Analyzing Social Media Posts of Users	NB & SVM	Twitter & Facebook	This result shows that the model's accuracy is 74 %, and the precision is 100 %.	The model requires a user's username and examines their postings to predict their level of depression.
[10]	Mining Twitter Data for Depression Detection	Multinomial NB & SVR	Tweets	The outcome of the study shows that multinomial NB has 78 % accuracy and SVR has a higher accuracy when classifying health tweets for depression, with 79.7 %.	The study used two class labels, such as positive and negative tweets, to determine the accuracy of MNB and SVR classifiers.
[25]	Cooperative Multimodal Approach to Depression Detection in Twitter	CNN & GRU	Twitter	The experiment results show that the suggested method outperformed existing methods by a significant margin (over 30 % error reduction).	The study narrowed its focus on detecting depression using tweets that include text and graphics.
[37]	Anxious Depression Prediction in Real-Time Social Data	Multinomial NB, RF, Gradient Boosting, Ensemble Vote Classifier	Twitter	This result recommends a prediction model based on supervised learning.	The model was tested using only one-month tweets from 100 sampled users.
[39]	Depression Recognition Using Machine Learning Methods with Different Feature Generation Strategies	RF, K-NN, SVM, CNN	HCGSN & MINI	The results demonstrate the effectiveness of the suggested techniques and demonstrate that EEG is a valid signal for identifying depression.	A limited dataset was used in the study. There were only 28 participants total, 14 of whom had depression and 14 of whom did not.

(*continued on next page*)

Table 1 (*continued*)

Authors/ Year	Research Title	Techniques	Dataset	Outcome	Limitation/Weakness
[56]	Detection of Depression-Related Posts in Reddit Social Media Forum	Ada boost, LR, MLP, RF & SVM	Reddit	The findings show that the MLP classier had the highest performance degree for spotting the presence of depression on Reddit, with 91 % and a 0.93 F1 score.	Only information from posts on Reddit was the subject of the investigation.
[5]	Detecting Depression with Audio/Text Sequence Modeling of Interviews	LSTM	Interview, i.e., Audio and Text-based	The study shows that F1 is 0.44 and precision is 0.59 %.	The research focused on the modelling of audio and text Interviews.
[30]	Depression Detection from Social Network Data Using Machine Learning Techniques	DT, SVM, Ensemble & KNN	Facebook	DT is more effective in depression detection compared to SVM, Ensemble, and KNN	The researcher focuses only on Facebook posts
[31]	Detecting Depression Using K-Nearest Neighbours (KNN) Classification Technique	KNN	Facebook	The results demonstrate that the outcomes of various KNN techniques and the ground truth dataset vary by 60 % −70 % depending on the metric level.	The researchers focused only on the KNN classification technique.
[33]	Facebook Social Media for Depression Detection in the Thai Community	DL, RF & SVM	Facebook	The research outcome indicates that RF and DL performed better, with an accuracy of 84.6 % and 85 %, respectively.	The sample size for this study is relatively small due to Facebook restrictions, and the procedure for getting the dataset has become difficult.
[4]	Predicting Depression Levels Using Social Media Posts	Rapidminer, SVM & NB	Twitter and Facebook	The study had the least accuracy while achieving good precision.	The researcher focuses on the sentiment, SVM, and NB results.
[21]	Depression Detection Using Emotion Artificial Intelligence	NB & SVM	Twitter	According to the study, multinomial NB fared the best, with an F1 score of 83.29, whereas SVM scored lower, at 79.73.	The supervised learning classification has a restriction and cannot provide accuracy comparable to that of a human being using text data.
[24]	Design for Emotion Detection of Punjabi Text Using Hybrid Approach	Rule-based engine, SVM & NB	Punjabi Textual	The findings of the proposed design demonstrate that it is capable of accurately identifying the emotions inherent in Punjabi text.	The study is restricted to minimally sized regional Punjabi language texts.
[45]	Identifying Depression on Twitter	DT, SVM, NB & LGR	Tweets	Compared to the other procedures, NB and LGR deliver superior outcomes.	Twitter was employed only for evaluating and forecasting major depressive illnesses in individuals.
[17]	Depression Detection and Prevention System by Analysing Tweets	NB & SVM	Twitter	NB and SVM based classifiers give 85 % accuracy for sentiment analysis classification tasks.	The dataset used for the analysis was limited. A large dataset will provide a more efficient result for the analysis.

depression.

Gupta et al. [26] conducted a study that focused on the psychological analysis of social networking sites to detect symptoms of depression. The study observed that the proliferation of the Internet has led to the widespread use of social networks such as Twitter, Facebook, Telegram, and Instagram as platforms for individuals to express their views, psychological tendencies, and feelings. Psychologically analysing text involves looking at it in a planned way to find and pullout facts, unique features, and essential information from user opinions. Based on the findings of the study, social networks offer valuable insights into an individual's cognition at the outset of depression. These insights include diminished social interactions, engagement in medical treatment, heightened self-focus, and increased activity levels throughout the day and night. The researchers employed five machine learning classifiers, including DT, KNN, SVM, LR, and LSTM, to detect depression in tweets. The researchers obtain the dataset in two variations: balanced and imbalanced, focusing on applying technical oversampling approaches. The results show that the LSTM classification model does a better job than the other baseline models at finding depression in the healthcare field, regardless of whether the data is balanced or not distributed evenly.

Jayanthi et al. [32] employed machine learning techniques such as chatbots, LR, NB, DT, RF, SVM, and KNN to predict whether a person is depressed. The study attempted to identify the most common causes of depression. The researcher developed a dataset that included 23 socio-demographic and psychological characteristics of 1429 adults to screen for depression. They have used various feature selection strategies to extract the most essential demographic and psychosocial characteristics that contribute to the development of depression. Based on using five different machine learning classifiers, their results show that the random forest classifier is nearly perfect for predicting depression in participants. It has 84 % accuracy. Advanced feature selection models can improve accuracy. This study defined depression using a broader range of characteristics and factors.

In their study, Chatterjee et al. [16] employed the multinomial naive theorem to identify signs of depression within social media messages. Based on the findings of the study, it is imperative to address the issue of depression promptly by identifying risk factors and leveraging social media platforms. The objective of the study was to ascertain individuals experiencing depression through online platforms, thereby facilitating the identification and provision of support to those in need of professional assistance but hindered by the obstacles mentioned above. The dataset utilized in the study was derived from comments on Facebook and tweets on Twitter. The study integrated the datasets and generated a training set by utilising a portion of the data while reserving the remaining portion as a testing set. The data is derived from analysing emotional, linguistic, and temporal characteristics. The subsequent processing is conducted autonomously using several types of features. The dataset underwent analysis via the NB classifier due to their simplicity and high efficiency as linear classifiers. The utilisation of the Bayes theorem is integral to constructing the probabilistic model for NB classifiers. The epithet "naive" is attributed to mutually independent datasets. The research revealed that the NB algorithm exhibits a precision value of 0.86, a recall value of 0.31, an F-score value of 0.459, and an accuracy value of 0.766.

To identify depression, Chiong et al. [18] adopted a textual-based feature method that relies on machine learning classifiers and social media texts. The study investigated various techniques for preprocessing

Table 2
Summary of Deep Learning Review.

Authors/ Year	Research Title	Techniques	Dataset	Outcome	Limitation/Weakness
[13]	It's Just a Matter of Time: Detecting Depression with Time-Enriched Multimodal Transformers	EmoBERTa	Reddit and Twitter	The study shows a 0.931 average F1 score on the Twitter depression dataset. Using the Set Transformer, the study obtains a 0.902 F1 score on MultiRedditDep.	The method proposed in this paper is trained on data with demographic bias.
[22]	A Deep Learning Model for Accurate and Robust Internet Traffic Classification	CNN	USTC-TFC2016	Better results were obtained by the proposed CNN, which had an average maximum accuracy of 83.55 %.	The study did not validate the effectiveness of the dataset on Internet traffic classification problems.
[35]	Deep Learning for Depression Detection Using Twitter Data	MDHAN	Twitter	The suggested MDH-PWO architecture gains 99.86 % accuracy, which is more significant than frequency-based deep learning models, with a lower false-positive rate.	This study focused only on a text dataset of Norwegian young people's information on the internet channel.
[58]	Deep Learning for Depression Recognition from Speech	CNN	DAIC-WOZ dataset	Testing and result analysis showed that the voice-based diagnosis of depression was as high as 87 %	The study focused only on speech recognition using CNN.
[63]	Deep Learning-Based Early Depression Detection Using Social Media	RNN	Twitter	The system proposed an NLP approach for data pre-processing and data normalization.	The authors did not test the accuracy of the model created.
[64]	A Hybrid Model for Depression Detection Using Deep Learning	CNN, LSTM & Bi-LSTM	Patients' interviews and PHQ scores	These findings show that audio CNN is a helpful model for detecting depression. Compared to other models, Bi-LSTM has a higher learning rate.	Only some audio and text features are extracted and applied using CNN and LSTM algorithms.
[7]	Deep Learning for Depression Detection from Textual Data	LSTM & RNN	Twitter	The method achieves remarkable results for early detection, demonstrating the viability of RNN and LSTM.	There is substantially less testing data. Only a subset of the text and audio materials are extracted and applied.
[8]	Deep Learning-Based Depression Detection from Social Media Text	GRU, LSTM, Bi-LSTM & RNN	Twitter tweets using Kaggle	The study's findings revealed that Bi-LSTM performs effectively with an accuracy of 99.6 %.	Even when users are accurately categorized, detecting them as depressed takes too long.
[12]	An Optimized Deep Learning Approach for Suicide Detection Through Arabic Tweets	BERT and USE	Arabic Tweets	The result of the study shows that the USE models have the best-weighted sum metric (WSM) of 80.2 %, and BERT models have the best WSM of 95.26 %.	The study only focused on Arabic Tweets datasets, which may not present a more comprehensive opinion.
[14]	Large-Scale Textual Datasets and Deep Learning for the Prediction of Depressed Symptoms	LSTM & RNN	Suicide datasets for young users were taken from Kaggle	Depressive symptoms are more common than they are specific.	The dataset has a small size. A valuable system to be researched in deep learning requires a large dataset.
[36]	A Hybrid Deep Learning Approach for Depression Prediction from User Tweets Using Feature-Rich CNN and Bi-directional LSTM	CNN, biLSTM & RNN	Twitter	According to the studies, the CNN-biLSTM model had the best accuracy and precision (94.28 % and 96.99 %, respectively).	The model was developed using only the Twitter raw dataset.
[44]	Depression Detection Based on Hybrid Deep Learning SSCL Framework Using Self-Attention Mechanism: An Application to Social Networking Data	LSTM, CNN & GRUs	Tweets	With an accuracy of 97.4 % for binary-labeled data and 82.9 % for ternary-labeled data, the system exceeded the existing techniques in detecting the explicit and implicit context.	This study studied several feature extraction methods coupled with machine learning and deep learning models, with a primary focus on the data annotation of tweets.
[46]	Detection of Depression from Social Media Using Deep Learning Approach	CNN and LSTM	Twitter tweets	With a 97 % accuracy rate, the model enhances predictive performance for early detection of depression.	The study concentrated on a freely accessible Kaggle dataset of Twitter posts.
[57]	Depression Detection from Social Media Text Analysis using Natural Language Processing Techniques and Hybrid Deep Learning Model	CNN & LSTM	Real-world datasets utilized in the literature	The FCL model was created to attain higher accuracy than the state-of-the-art method for accurately detecting depression.	Focus on integrating LSTM and CNN to create FCL.
[62]	Deep learning for Prediction of Depressive Symptoms in a Large Textual Dataset	LSTM & RNN	Facebook,ung.no (pu)	Compared to conventional general word frequency-based techniques, the proposed depressive symptom feature-based approach performs better.	The study is only based on information about young people in Norway.
[69]	Explainable Depression Detection with Multi-aspect Features Using a Hybrid Deep Learning Model on Social Media	MDHAN	Twitter	The experiments show that MDHAN outperforms several popular and robust baseline methods with 89 % in F1, demonstrating the effectiveness of combining deep learning with multi-aspect features.	The study is only based on information about Twitter user's posts and profile information.
[19]	Multimodal Depression Detection on Instagram Considering the Time Interval of Posts	CNN, LSTM, RNN, RF	Instagram data	The suggested techniques can detect depressive users with an F1-Score of up to 0. It can act as a precursor to depression detection.	Proposed models are assessed using a single dataset, casting doubt on the importance of each model.

(*continued on next page*)

Table 2 (*continued*)

Authors/ Year	Research Title	Techniques	Dataset	Outcome	Limitation/Weakness
[20]	Improving Depression Prediction Using a Novel Feature Selection Algorithm Coupled with Context-Aware Analysis	DCNN & DNN	Audio, video, and semantic features	With a precision of 1.00 on the development set and an F1-score of 0.96 (0.67), the study performed best in classifying depression (test set).	A few depression samples from the database were used in the study. The second phase of feature selection takes some time.
[29]	Deep Learning for Depression Recognition with Audiovisual Cues: A Review	Appearance-DCNN and Dynamics-DCNN have been introduced.	Audio and video	The findings of the reviews that have already been done solely consider aural or visual signals for assessing the depression scale.	The multi-modal audiovisual approaches for depression recognition are still missing.
[60]	An Emotion and Cognitive Based Analysis of Mental Health Disorders from Social Media Data	CNN and RNN	eRisk Reddit	The study showed that deep learning models can be helpful for successfully detecting social media users who risk developing a mental disorder.	The semiautomatic annotation process is an additional evident constraint imposed by the datasets, which relies on self-reported diagnoses without expert medical confirmation.
[40]	SenseMood: Depression Detection on Social Media	CNN & BERT	Images and tweets from Twitter	The suggested model considerably enhanced the performance of depression detection, achieving 88.39 % accuracy and a 3.60 % F1 score.	Only one or two tweets and photographs from each user were used in the study. It discovers that the models cannot accurately detect these users.
[51]	Depression Detection of Tweets and A Comparative Test	LSTM, NB, LSV, Linear-SVM, LR, TF-IDF Classifies	Tweets	According to the study, LSTM-RNN has the highest accuracy when detecting depressive tweets on Twitter.	The study uses a limited dataset to test the models.
[53]	Multi-Modal Social and Psycho-Linguistic Embedding via Recurrent Neural Networks to Identify Depressed Users in Online Forums	LSTM	2017 CLPsych from ReachOut.com	With an F1-measure of 0.64, the psycholinguistic features generated from user posts and network features are good predictors that outperformed baselines.	Timely detection of depressed participants in online forums was not the study's primary objective.
[52]	Predicting Depression Using Deep Learning and Ensemble Algorithms on Raw Twitter Data	CNN & LSTM	Twitter tweets using Kaggle	The studies show the test accuracy for LSTM at 0.93 % and CNN at 0.95 %, respectively.	The study did not employ a large dataset, which might have enhanced the study's accuracy in making a better diagnosis.
[66]	Recognition of Audio Depression Based on Convolutional Neural Network and Generative Antagonism Network Model	CNN & GAN	Audio	The research developed a unique deep-learning model for extracting speech signals and obtaining non-personalized depression features from two neighbouring parts of local audio.	The selection of speech segments significantly impacts the final recognition outcomes.
[2]	Deep Learning with Convolutional Neural Network and Long Short-Term Memory for Phishing Detection	CNN & LSTM	Images and frame elements	According to the experimental data, the proposed model gained an accuracy rate of 93.28 %.	The study developed characteristics based on URLs, images, and website elements.
[15]	Understanding Emotions in Text using Deep Learning and Big Data	CNN, GBDT, LSTM, SVM & SS-BED	Twitter, ISEAR, SemEval2007, WASSA'17SS	Work produces the best F1 score and requires the most training time.	The work employed deep learning and big data to develop a "Sentiment and Semantic-Based Emotion Detector" (SS-BED).
[27]	Deep Learning Algorithms Applied to the Classification of Video Meteor Detections	RNN	Video meteor imagery	When using a CNN, the results improve to 99.94 % recall and only 0.4 % leakage.	The study focused on deep learning for video meteor imagery classification.
[61]	Depression Analysis from Social Media Data in Bangla Language Using Long Short-Term Memory (LSTM) Recurrent Neural Network Technique	RNN & LSTM	Bangla tweets	The results indicate that the LSTM can detect depression with high accuracy on small datasets.	The research looked at depression in Bangla social media data.
[5]	Detecting Depression with Audio/Text Sequence Modeling of Interviews	CNN, LSTM & SVM	Audio and text	The findings suggest that depression can be detected using sequential modelling of interaction with little information about the interview structure.	A limited dataset of 142 individuals from DAIC was used.
[48]	Deep Learning for Depression Detection of Twitter Users	CNNs & RNNs	Tweets (CLPsych2015 and Bell Lets Talk)	The study found that the proposed CNN-based models outperformed RNN-based models.	A limited dataset from CLPsych2015 and Bell Let Talk was used for the analysis.
[49]	Neural Network-Based System to Detect Depression in Twitter Users via Sentiment Analysis	CNN	Twitter	The proposed algorithm can effectively differentiate between general posts and those that indicate depression.	The model uses a binary sigmoidal function, which restricts the output for each node.

text and extracting features from textual data. Additionally, it examined different machine learning classifiers, both individual and ensemble models, to provide a comprehensive model for identifying depression from social media messages. This study involves the training and evaluation machine learning models utilising two publicly available Twitter datasets. Additionally, three non-Twitter datasets, obtained from Facebook, Reddit, and an electronic diary, are utilized to assess the effectiveness of the learned models in analyzing depression-related content across various social media platforms. The empirical findings demonstrate that the suggested model can identify indications of depression within social media texts, even in instances where the training datasets do not contain explicit terms such as "depression" and "diagnosis" and when unrelated datasets are employed for testing purposes.

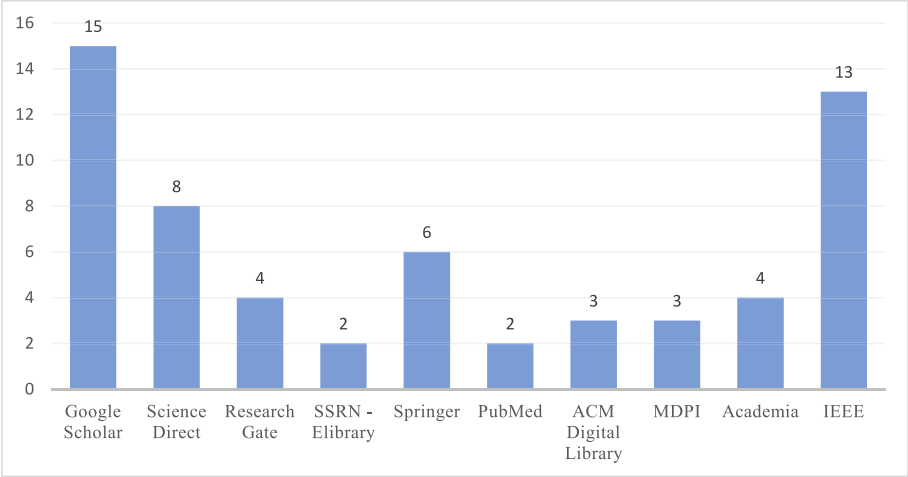

Fig. 1. Publication Source. Internet Sources

Haque et al. [28] proposed using an RF prediction model to forecast child and adolescent depression. The authors assert that this model exhibits enhanced accuracy and informativeness compared to alternative approaches. The model has superior performance in terms of both execution time and all four performance criteria of the confusion matrix. The primary aim of the study was to employ machine learning techniques to detect child depression. Based on existing research, it has been observed that there is a lack of studies employing machine learning (ML) methodologies to detect depression in children and adolescents aged 4 to 17. Specifically, investigations are scarce using a meticulously curated high-prediction dataset such as Young Minds Matter (YMM). It is argued that the identification of appropriate warning signs is crucial for the early and accurate diagnosis of mental illnesses, specifically depression, in children and adolescents to mitigate long-term consequences. The present study uses data from the second Australian Child and Adolescent Survey of Mental Health and Wellbeing conducted in 2013–2014. The variables exhibiting a binary (yes/no) value and demonstrating a weak connection with the target variable, namely depression state, have been excluded from the analysis. The Boruta method, in conjunction with an RF classifier, has been employed to identify the most significant features to detect depression within a dataset, including strongly correlated variables with the target variable. The Tree-based Pipeline Optimization Tool (TPOTclassifier) has been employed to select appropriate supervised learning models. Based on the research findings, it has been determined that eleven (11) primary attributes can be employed to ascertain the presence of depression in children and adolescents. These characteristics encompass feelings of unhappiness, diminished pleasure in life, irritability, reduced interest, fluctuations in weight, disturbances in sleep patterns, alterations in psychomotor activity, fatigue, difficulties in thinking, concentration, or decision-making, suicidal thoughts or actions, and manifestation of any of these five symptoms. The Random Forest method has shown superior performance to other algorithms in accurately predicting depressed classes, with a remarkable 99 % success rate. This prediction accuracy was accompanied by a precision rate of 95 % and a rapid processing time of 315 ms. It is worth noting that the model's performance exhibited modest variability in terms of processing time.

Kumbhar et al. [38] presented a paper on depression detection using machine learning at the International Conference on Smart Data Intelligence (ICSMDI 2021). Their paper aimed to extract and summarise the unusual but potentially valuable factors that cause depressive symptoms from social media data. For the analysis, they used tweets generated from Twitter. They obtained the Twitter dataset by logging into a Twitter account and using the API to access the Twitter database. The API extracts data from the database and saves it to a text file. The study compares individual words from tweets with sentiments, assigning values of 1 for positive words, 0 for neutral words, and −1 for negative words. After training the models, they used the remaining data to test and predict the results. Once the models undergo testing, they generate the confusion matrix and calculate their accuracy. After 3.40 s of processing time, the decision tree has the highest accuracy of 98.55 %.

Govindasamy and Palanichamy [23] assert that the prevalence of depression has emerged as a significant concern in contemporary times, with a steady increase in the number of individuals affected by this mental health condition. The study employed Twitter data to investigate the detection of depression using Nave Bayes and NBTree machine learning methodologies. The objective of this study was to identify indicators of depression among individuals by analyzing the information they disclose on social media platforms. The datasets used in this study were collected using Twitter scraper tools and subsequently stored in the.csv file format. The initial dataset underwent preprocessing and cleansing procedures. As a component of the normalization procedure, the data underwent tokenization, stemming, and lemmatization. Subsequently, sentiment analysis was employed to analyze the data and produce a word score. The data is inputted into two distinct classifiers, namely NBTree and NB. A comparative analysis was conducted to ascertain the optimal method for identifying depression, wherein the findings were evaluated based on the highest accuracy metric. The findings indicate that the Nave Bayes and NBTree algorithms exhibit comparable performance, yielding an identical accuracy rate of 97.31 %.

As these social media posts frequently provide a platform for people to openly share their emotions, thoughts, interests, and viewpoints, Skaik and Inkpen [54] explore the challenge of identifying indicators of depression in tweets. The researchers employed personal narratives obtained from individuals who self-identified as experiencing depression to construct a model with the ability to forecast depression within a sample of Twitter users that accurately reflects the demographics of the Canadian population. The training dataset has a total of 1,402 individuals who voluntarily disclosed their experience of depression in 2016. The study used standard machine learning methods like SVM, LR, RF, Gradient Boosting Decision Trees (GBDT), and Extreme Gradient Boosting (XGBoost), along with 10-fold cross-validation to get the F1-score of 0.961. This study used the CLPsych 2015 dataset as its test dataset. The deep learning models employed in the analysis yielded a notable F1-score of 0.898. Subsequently, the researchers employed the identical model on a representative population sample, yielding outcomes aligned with the depression statistics reported by Statistics Canada for 2015.

In their study, Alsagri and Ykhlef [6] employed a machine-learning

technique to forecast the occurrence of depression among individuals on Twitter. This prediction was made by analyzing the users' network behaviour and the content of their tweets. The machine learning algorithms are SVM with linear kernels, DT and NB. The data from Twitter users who experience depression was subjected to analysis by academics. The collection of self-reports is facilitated by the use of a regular expression that scans the Twitter platform for instances of individuals disclosing their diagnosis of depression. The individuals are subjected to manual filtration, following which their most recent tweets are systematically retrieved in real-time through the Twitter Search API. The data collection process involves retrieving tweets from both depressed and non-depressed accounts, as well as gathering user account and activity information. The data includes followers, number of followings, total number of posts, timestamps, mentions, and retweets. Subsequently, a user's tweets are aggregated and consolidated into a unified text. The researchers employed a model that used variables derived from network activity and tweets to train and evaluate classifiers to discern the presence or absence of depression in a given user. To ascertain that the discussions on depression are centred around the users' personal experiences and not those of their acquaintances or relatives, a human annotator reviews these tweets. Various R packages and R version 3.3 perform tasks, including data preparation, feature extraction, and classification. The classifiers undergo training using a 10-fold cross-validation technique to mitigate the issue of overfitting. Subsequently, the models are evaluated by subjecting them to a held-out test set. The viability of this automated prediction was evaluated and cross-validated using conventional metrics such as accuracy (Acc), precision (P), recall (R), and F1 scores, as well as the confusion matrix (CM) and receiver operating characteristic curves (ROCs). The results of the study demonstrate that SVM-L and NB exhibit enhanced accuracy, achieving a performance level of 82 % for SVM-L and 80 % for NB. In SVM-L, the F measure is also raised, reaching 0.79. The SVM model has achieved combinations of accuracy metrics that are considered optimal. Nevertheless, the paper's authors have failed to consider machine learning models with a low probability of overfitting the provided data and neglect to explore other methods for accurately assessing the influence of the characteristics.

Priya et al. [50] delivered a scholarly presentation at the esteemed International Conference on Computational Intelligence and Data Science (ICCIDS 2019). Their study focused on the application of machine learning algorithms to forecast anxiety, depression, and stress levels in contemporary society. The researchers examined pertinent literature on anxiety, depression, and stress, as well as the methodologies and approaches employed in previous investigations. Machine learning algorithms were employed to ascertain five distinct levels of severity of anxiety, depression, and stress. The researchers used a standardized questionnaire, specifically the Depression Anxiety Stress Scales-21 (DASS-21), to gather data about the prevalent symptoms of anxiety, sadness, and stress. Three hundred forty-eight people were surveyed using Google Forms to acquire the necessary data. Subsequently, five distinct classification techniques were employed: DT, RFT, NB, SVM, and KNN. While Random Forest was determined to be the optimal model, it was observed that naive Bayes exhibited the highest level of accuracy. Due to the presence of imbalanced classes, the selection of the optimal model was determined by considering the F1 score, a metric commonly employed in scenarios involving imbalanced data partitioning.

Asad et al. (2019) presented a study that focused on the detection of depression through the analysis of user-generated social media content in a scholarly publication. The study's objective was to present a data-analytic framework for identifying depression in individuals. The data for this suggested model is collected from user-generated content on two prominent social media platforms, Twitter and Facebook. The depression degree of a user was assessed by analyzing their social media posts. The identification of depression was accomplished by utilising natural language processing (NLP), SVM, and NB techniques. The utilisation was more practical and efficient. The machine learning model has undergone training to effectively categorise depression criteria into six distinct classifications, namely normal, mild, moderate, borderline, severe, and excessive. When the percentage exceeds the predetermined threshold, the outcome is deemed unfavourable, specifically when it exceeds 55 %. The model analyses the gathered tweets and Facebook posts, categorising the user as either exhibiting symptoms of depression or not. The analysis of data extracted from tweets and Facebook postings indicates the manifestation of symptoms associated with depression disorder by the user. The investigations, as mentioned earlier, have shown the correlation between depression and the development of profound psychiatric disorders, including suicide. Additionally, these studies have demonstrated the efficacy of employing a machine learning method to identify signs of depression among individuals using social media platforms. The study introduced a conceptual framework that necessitates the utilisation of a user's account name and examines the user's social media comments to ascertain the user's susceptibility to depression. A question-and-answer session is employed as a manual classification method to classify users as either experiencing depression or not. The researchers assessed the model's accuracy, which yielded a result of 74 %, and analyzed its precision, which was 100 %. This strategy has the potential to assist those experiencing depression by enabling their friends and family members to gain knowledge about their mental state and subsequently respond appropriately.

Arora and Arora [10] conducted a study where they aimed to examine health-related tweets about depression and anxiety. The researchers employed multinomial naive bayes (MNB) and support vector regression (SVR) algorithms as classifiers to analyse a diverse range of tweets. The researchers extracted the dataset from Twitter's streaming service, which included all tweets. However, the researchers selectively classified tweets that included specific phrases such as depression, anxiety, and mental illness to fulfil their research objective. The researchers used various feature extraction approaches, such as stemming, generating POS vectors, and sentiment extraction, to ascertain the positive and negative sentiment scores. The researchers employ the MNB and SVR classifiers to categorise health-related tweets, including a mixture of tweets on depression and anxiety extracted from a database. The results indicate that the classification of health tweets for depression achieved an accuracy rate of 78 % for MNB and 79.7 % for SVR. This research introduces a novel method for effectively discerning tweets related to depression and anxiety from a heterogeneous pool of tweets, thereby enabling individuals to assess their mental health condition within a real-world context. This novel platform facilitates patient engagement, enabling active involvement in the decision-making process to enhance healthcare treatment outcomes.

Chavan et al. [17] suggested a depression detection and prevention system that can identify any terms or phrases from tweets that are associated with depression and, if found, determine the type of depression. The proposed system's primary objective is to identify depressed tweets. Additionally, the method can identify a specific form of depression. The algorithm appropriately identifies negative postings when they are negative and positive posts when, they are positive. The suggested approach deleted the tweets from Twitter, categorised them using SVM and NB while accounting for emoticons, and then plotted a graph of the classified tweets over time. The researchers' classification of depression into the two main groups of major depression and bipolar was aided by the graphs and data they produced. The suggested strategy will aid in both the detection and prevention of depression. The study's findings demonstrate an NB-based SVM classifier that theoretically provides 85 % accuracy for sentiment analysis classification tasks. This hybrid technique performs admirably with both shorter and longer excerpts.

According to Gui et al. [25], there are two obstacles to be solved for the successful early diagnosis of depression in people who use social media. The first is that reliable conclusions regarding depression must take into account both textual and visual evidence. The second difficulty

is that many pertinent indicator phrases and images are challenging to extract due to the range of content types users provide. The researcher suggested using a brand-new cooperative multi-agent model to deal with these issues. The suggested approach can automatically choose related indication texts and photos from users' past postings. Experimental results show that the proposed strategy performs significantly better than state-of-the-art methods, with a 30 % error reduction. The study also confirms in several trials and instances that the chosen posts can successfully and thoroughly signal user despair, and the model can achieve reliable performance in real-world circumstances.

Kumar et al. [37] have developed a prediction model based on supervised learning to identify anxious depression disorder. The model analyses tweets from the initial 100 followers of the MS India student forum using a range of linguistic, semantic, and activity variables. The authors considered the utilisation of anxiety-related vocabulary as a linguistic indicator, whereas the quantification of negative tweets and the polarity distinction of tweets were considered semantic indicators. This study analyses tweets' temporal and frequency patterns to detect deviations from typical patterns. Additionally, sentiment analysis is conducted to discover any inconsistencies in posting behaviour based on the polarity of opinions expressed in the tweets. The three machine learning classifiers employed in this study were multinomial naive bayes, gradient boosting, and random forest. The ultimate prediction is produced by employing an ensemble vote classifier that utilizes a majority voting process. The dataset was partitioned into 80 % training and 20 % testing sets. Additionally, a 10-fold cross-validation was conducted. The development of a predictive model for anxiety and depression in users considered temporal aspects, including the time and frequency of user posts. The accuracy of the suggested Alzheimer's disease (AD) prediction model is 85.09 %, indicating its ability to classify AD cases correctly. Additionally, the F-score of 79.68 % highlights the model's performance in balancing precision and recall for AD prediction. The model yields encouraging outcomes and offers predictions for those experiencing anxious depressive disorder.

Li et al. [39] proposed a model to automate the prediction of clinical outcomes in individuals with depression. The method employed plays a pivotal role in enhancing the precision of depression identification and treatment. The use of machine learning techniques, in conjunction with the manipulation of electroencephalogram (EEG) features, enhances the accuracy of depression detection. A total of 28 individuals were enlisted as participants in an experimental study with a task focused on emotional face stimuli. These participants' electroencephalogram (EEG) data were recorded using Net Station software, utilizing the 128-channel HydroCel Geodesic Sensor Net (HCGSN). Psychiatrists commonly employ the Mini International Neuropsychiatric Interview (MINI) as the established protocol for diagnosing individuals with depression. The auto-regress model and the Hjorth algorithm were employed to extract the original spectral density and activity features by utilizing different periods.The characteristics underwent processing through two distinct methodologies: deep learning and ensemble learning. This study employed an ensemble learning approach, utilizing SVM as the classifier. A deep forest algorithm was also applied to transform the original features into novel representations, potentially enhancing the feature engineering process. Spatial information from the EEG caps was incorporated into the features of the deep learning method by picture conversion. Subsequently, a convolutional neural network (CNN) was employed to discern and classify these features. The efficacy of both systems was evaluated in terms of their performance in both individual frequency bands and the overall frequency range. Consequently, upon implementing the ensemble model and utilizing power spectral density, the maximum accuracy was 89.02 %. The deep learning algorithm achieved a maximum accuracy of 84.75 % based on the activity conducted. The experimental results presented in this study provide evidence supporting the efficacy of the proposed techniques. Moreover, these findings imply that electroencephalography (EEG) has the potential to serve as a reliable measure for identifying individuals with depression. Consequently, this study paves the way for developing portable EEG-based systems to recognise depression.

Tadesse et al. [56] investigated the detection of posts relating to depression in a Reddit social media forum. The study's primary aim was to analyse the posts made by Reddit users to identify any variables that would indicate the presence of depressive attitudes within the online community. To achieve these objectives, the researchers utilise natural language processing (NLP) methodologies and machine learning algorithms to train the dataset and assess the effectiveness of the suggested approach. Using the SVM classifier with the Bigram feature proves to be highly effective in identifying depression, exhibiting an accuracy rate of 80 % and F1 scores of 0.80. The successful demonstration of the combined features of Linguistic Inquiry and Word Count (LIWC), Linear Discriminant Analysis (LDA), and Bigram (LIWC + LDA + Bigram) is most effectively achieved using the Multilayer Perceptron (MLP) classifier. The highest level of performance attained in the diagnosis of depression yielded an accuracy rate of 91 % and F1 scores of 0.93. According to the research findings, using prudent feature selections and exploring different combinations of these features can yield significant performance enhancements.

Alhanai et al. [5] investigated detecting depression with audio and text sequence modelling of interviews as a result of medical experts diagnosing depression by evaluating the responses of individuals to a variety of questions, investigating lifestyle changes, and collecting continuous thoughts. By simulating audio and text sequences of a conversation between a human subject and a virtual agent, the research's primary goal was to identify depression. Given the potential value of such methodologies, the researchers were inspired to conduct the data-driven modelling without the requirement to condition the question expressly. The study showed an automated depression-detection system that learns from sequences of questions and responses rather than requiring explicit topic modelling of the content. The algorithm simulates an interview between a person and an agent. The study used the Long-Short Term Memory (LSTM) neural network model to simulate the interactions between audio and text characteristics to detect depression. The study used data from 142 people who underwent depression screening. The findings imply that depression can be identified by sequential modelling of an encounter, with little knowledge of the interview's structure. The outcomes were compared to methods that modelled the subjects of the responses to questions.

Islam, Kabir, et al. [30] study looked at how to use data from social networks to apply machine learning techniques to detect depression. It has been asserted that while the utilization of social network data to study the history of depression has achieved considerable recognition, there remain specific dimensions that have yet to be identified. The study's objective was to examine the phenomenon of depression by utilising Facebook data obtained from a publicly accessible online source. The data collection was done via the social media platform Facebook. The dataset has five emotional variables: negative, positive, sad, angry, and nervous. The analysis was conducted using MATLAB 2016b. The study employed four primary classifiers: SVM, K-KNN, DT, and Ensemble. The study proposed using machine learning technology as a viable and scalable method for investigating the implications of depression identification. The study evaluated the efficacy of the suggested method by utilising a range of psycholinguistic characteristics. The investigation results indicate that the proposed technique can potentially decrease the rate of classification errors and enhance accuracy significantly. In addition, the results show that the Decision Tree algorithm is more accurate in many tests than other machine learning methods for finding disorders related to depression. Machine learning technologies have been found to yield excellent solutions for addressing mental health issues within the population of Facebook users.

Islam, Kamal, et al. [31] examined the prevalence of depression issues among different Facebook users. Islam, Kamal, et al. [31] maintain that precise detection using social network data is necessary despite the investigation and implementation of numerous strategies to identify

depression. The study explores the potential use of Facebook data and applying KNN classification methods to identify depressive feelings. The study used Facebook as a data source because NCapture is a potent tool for qualitative data analysis today. The researchers used LIWC2015 to analyse the dataset after gathering the data from Facebook. The data record includes three temporal categories (present focus, past focus, and future focus), nine common linguistic aspects (i.e., articles, prepositions, auxiliary verbs, adverbs, conjunctions, pronouns, verbs, and negations), and five emotional variables (positive, negative, sad, angry, and anxiety). The researchers used MATLAB 2016b to conduct the experiment. KNN classifiers, such as Fine KNN, Medium KNN, Coarse KNN, Cosine KNN, Cubic KNN, and Weighted KNN, were used in the study. The effectiveness of using Facebook data for depression detection was investigated using several KNN algorithms. According to the findings, the outcomes of various KNN techniques and the ground truth dataset vary by 60 % to 70 % for various metrics levels. The researchers are hopeful that their study and method may help users of online social networks become more conscious.

Katchapakirin et al. [33] found that around 1.5 % of Thai individuals, and this number is rapidly increasing, suffer from depression. According to Katchapakkirin et al. (2018), less than 50 % of people who experience this emotional difficulty have access to mental health services, although it is a major psychological issue. Due to these difficulties, the authors participated in a study that examined the viability of identifying depression in the Thai community via Facebook social media. Facebook was chosen because it is Thailand's most widely utilized social networking site. This study tested whether the proposed algorithm could tell from a person's posts on Facebook whether they were depressed or not. This research uses natural language processing (NLP) approaches to create a depression detection algorithm for the Thai language on Facebook, which people utilise as a platform for exchanging ideas, emotions, and life events. Eight cross-validations were used to estimate model prediction performance. The evaluation's findings demonstrate that the SVM model's accuracy was marginally superior to the majority vote, which served as the evaluation's benchmark. According to the model, people who post a lot of neutral microblogs on Monday may experience despair.

In their study, Aldarwish and Ahmad [4] examined the use of social media posts as a means for predicting levels of depression. The researchers' objective was to ascertain the potential of utilising social networking site (SNS) users' posts to classify their mental health levels. The researcher proposed a method that utilises social networking sites (SNS) as a primary data source and screening mechanism, employing artificial intelligence techniques to classify individuals based on the information they make on SNS, commonly referred to as user-generated content (UGC). There exist two distinct categories of datasets. The first dataset consists of a training dataset of 2,073 posts expressing depression and an equal number of posts that do not indicate depression. These posts were manually curated and labelled for training purposes. Furthermore, the dataset consists of three columns. The third column contains the training posts, while the second column represents the depression category. It is important to note that depressed emotions are classified into one of nine categories. The initial column represents the binomial sentiment, specifically categorised as depressed or not depressed. The second dataset consists of the patient's social networking service (SNS) postings, modified for each user to evaluate the model's predictive capabilities. The research conducted in this paper aimed to construct a model that utilizes two SVM classifiers and an NB classifier to categorize user-generated content (UGC). The researchers propose the development of a web-based application that can classify users of SNS into several levels of depression, comprising four categories. This online application can be used by psychiatrists, the patient's family, and acquaintances. UGC is collected by the web application from the social media accounts of the patients, specifically their Facebook and or Twitter accounts. The suggested method exhibited satisfactory precision but poor accuracy and recall.

Deshpande [21] is engaged in a research effort that employs emotion-based artificial intelligence on the Twitter platform to diagnose depression. The paper aims to analyse emotions in Twitter feeds, explicitly focusing on depression, utilising natural language processing techniques. The dataset comprises tweets that were collected using the Twitter API. The training and test datasets were generated using a combined total of 10,000 tweets. The acquired data has been partitioned into training and test datasets, employing an 80:20 ratio. SVM and NB classifiers have been employed. Every tweet is categorized into one of two distinct groups, neutral or negative, by utilizing a carefully curated lexicon for discerning indications of depression. The findings indicate that multinomial Naive Bayes achieved the highest performance in the classification task, exhibiting an F1 score of 83.29. In contrast, SVM yielded a comparatively lower F1 score of 79.73. The performance of SVM is comparatively worse than that of multinomial naive bayes in terms of precision and recall.

In their study, Grover and Verma [24] examine the potential of social media as a tool for early identification of major depressive disorder (MDD) in individuals' online identities before its overt manifestation. The method employed involves using a crowdsourced approach to compile a roster of Twitter users who assert their own experiences of being diagnosed with depression. The researchers employ a bag-of-words method to quantify individual tweets by utilising a corpus of social media posts over up to one year. The study employed various statistical classifiers to assess the likelihood of depression. The article presents a novel approach to constructing classifiers by reframing the analysis of social media networks as a text-classification challenge rather than a behavioural one. The classification of the 2.5 million tweets utilised in the investigation yielded an accuracy rate of 81 % and a precision score of 86 %. Based on the research findings, this method exhibits potential efficacy in developing predictive instruments for assessing an individual's susceptibility to depression. Consequently, these tools can be employed by medical professionals, concerned individuals, and healthcare institutions to facilitate diagnosing the condition. It has the potential to enable those experiencing depression to adopt a proactive stance in their efforts to restore their mental well-being. The study conducted by the researchers demonstrated the capacity of Twitter as a viable instrument for assessing and predicting significant depressive disorders in individuals.

Nadeem et al. [45] research on social media use divides attitudes into positive, negative, and neutral groups. However, none of these experiments has produced a social media programme recognising user emotions, especially on Twitter. This research created a text-mining tool to identify the six emotions that Twitter users can express, including happiness, sorrow, anger, contempt, fear, and surprise. The application used a text-mining technique that involved three key stages: preprocessing, processing, and validation. During the preprocessing phase, the application used morphological analysis to perform tasks such as case folding, cleaning, stop word removal, emoticon conversion, negation conversion, and tokenization of the training and test data based on sentiment analysis. Using the NB method, they subjected the validated model to weighting and classification during the preprocessing stage. The study used a 10-fold cross-validation technique to assess the application's correctness level during the validation phase. The research revealed that for 105 tweets, the programme can reach 83 % accuracy. A better model in the training data is necessary to obtain greater accuracy. Using the Twitter API, the text mining application can successfully extract data from online Twitter. The test result demonstrated that specific phrases and more training data will result in greater accuracy in identifying emotions because they can better and more thoroughly capture the emotional events that occur in our daily lives.

The review paper has examined various techniques for detecting and preventing depression using machine learning algorithms. The majority of this research paper primarily concentrated on the identification of early-stage depression symptoms within the context of social media platforms. The exploration of depression symptoms through textual data

holds significant potential in research, representing a formidable obstacle in the data collection process for depression detection. The researchers predominantly utilized a single machine-learning method, while a minority chose to hybridize two or more traditional machine-learning approaches. However, this paper focused on the review of both machine learning and deep learning.

5. Review of depression detection using deep learning algorithms

According to Bucur et al. [13], widespread use of social media provides the ideal environment for examining how users' posts and interactions reflect mental health issues. The majority of the approaches used today to identify depression from social media posts focus on text processing; very few also make use of user-posted photos. Two of the most widely used social media sites where people opt to discuss their mental health issues are Reddit and Twitter. The Reddit and Twitter datasets include posts in languages other than English, including Spanish, German, Norwegian, Japanese, and Romanian. The researchers proposed a flexible, time-enriched multimodal transformer architecture to identify individuals on social media who have experienced depression in the past. The study would use pre-trained models to pull out text and image embeddings. The authors used the Twitter multimodal depression dataset and the multiRedditDep experiment as benchmarks for the strategy. The models use EmoBERTa and CLIP to extract embeddings. The researchers trained Time2VecTransformer on a window size of 512 posts while trained VanillaTransformer and SetTransformer on 128 sampled posts. By employing time-vec positional embeddings, the study enriches the model, which functions directly at the user level, with the relative time between posts. The study also proposes an additional model version suitable for unordered and randomly sampled postings to enhance the model's resilience to dataset noise. The model, which combines EmoBERTa and CLIP embeddings, outperforms other approaches on two multimodal datasets, yielding state-of-the-art scores of 0.902 F1 on the sole multimodal Reddit dataset and 0.931 F1 on a well-known multimodal Twitter dataset.

Fu et al. [22] study a deep learning model for precise and reliable internet traffic classification. The paper uses deep learning algorithms to attempt highly accurate and reliable results in encrypted and unencrypted networks. The study employs the convolutional neural network (CNN) algorithm. This study made use of the USTC-TFC2016 dataset. It holds a collection of traffic datasets classified as benign or malicious. The Benign dataset includes data streams from daily applications like Gmail, Weibo, and Outlook. The malware collection also contains botnets created by Geodo's Phishing Attack and banking worms from CRIDEX, Miuref Trojan, Tinba Trojan, and Zeus Trojan. The researchers examined the traffic dataset to determine whether the packets in USTC-TFC2016 were benign or malicious. The researchers compare the performance of the suggested CNN with that of the traditional LeNet-5 networks. According to experimental findings, the suggested CNN-based classifier performed better when dealing with encrypted and unencrypted datasets, averaging a maximum accuracy of 83.55 %. Additionally, it is superior in robustness because it is not sensitive to hyper-parameter selections. The network classifier based on CNN can increase accuracy and stability compared to conventional network classifiers.

Khafaga et al. [35] classified the depression data using a unique Deep Learning Multi-Aspect Depression Detection with Hierarchical Attention Network (MDHAN). Tokenization, stop word removal, stemming, lemmatization, and punctuation mark removal were the first steps in pre-processing Twitter data. The Grey Wolf and adaptive particle optimisation techniques are applied for feature selection. The MDHAN categorises Twitter data and makes predictions about people who are depressed and those who are not. Finally, the suggested model is contrasted with already-in-use techniques, including MDHAN, Minimum Description Length (MDL), Support Vector Machine (SVM), and Convolutional Neural Network (CNN). The proposed MDH-PWO architecture achieves 99.86 % accuracy with a decreased false-positive rate. The result is a significant improvement over frequency-based deep learning models. The features included in this study will improve machine learning's decision-making and promote user satisfaction for improved results Khafaga et al. [35]. When compared to other current algorithms, the suggested technique performs better. It attains 90.90 % F1 measured, 93.45 % precision, 91.95 % recall, and 99.86 % accuracy. The experimental results demonstrate that the suggested strategy improves accuracy, precision, recall, and F1-measure. Moreover, it cuts down on execution time. In the future, researchers can combine swarm intelligence approaches with deep text analysis tools.

Depression has been a significant worry since it can lead to suicidal thoughts and other serious negative outcomes in depressed individuals [58]. Tian et al. [58] examine a multi-information joint decision algorithm model created using emotion recognition. The model is used to evaluate the patient's representative data to determine whether a subject has depression. This work performs an extensive study of speech-assisted depression diagnosis based on the speech data in the DAIC-WOZ dataset, based on an exploration of the speech characteristics of individuals with depressive disease. Preprocessing includes speech signal pre-emphasis, framing windowing, endpoint identification, noise reduction, and other techniques. Furthermore, speech signal features are extracted using OpenSmile, and the speech features that the features may reflect are thoroughly examined and analysed. The next step is to pick features based on how speech features and feature combinations affect the diagnosis of depression. The dimensions of the data characteristics are then reduced using principal component analysis. Ultimately, modelling, testing, and result analysis using the convolutional neural network revealed that up to 87 % of voice-based depression diagnoses were made.

Vaidya et al. [63] studied the use of social media for deep learning-based early depression identification. The research goal was to suggest a data-analytic approach for identifying depression in any human. Twitter user posts were the source of the data for the proposed model. The researchers collected all the data for various Twitter accounts using an API, adhering to predetermined criteria. Every text has been edited, labelled, and assigned to a single category during pre-processing. The study split the corpus into a training set and a testing set. The researchers eliminated all unnecessary text elements, such as stop words, lexical analysis, punctuation, and unreadable text. The study extracted the right combination of elements from the provided document to enhance overall performance. The authors have identified a user's level of depression based on their social media posts. A fully or partially structured interview is the most common way to identify depression in a person. These techniques require much information from the person. Data analysis of tweets and posts reveals how the user's depression and illness symptoms are manifesting. This study uses machine learning to process the scraped data gathered from SNS users. Deep learning and the Naive Bayes technique classify natural language processing (NLP), potentially simplifying and improving the detection of depression. The study proposed a system using various techniques to describe feature extraction and selection approaches. The system proposed a natural language processing (NLP) approach for data pre-processing and normalisation.

In their study, Vandana et al. [64] introduced a novel automatic depression detection method that utilises deep learning techniques. Three models have been designed and put forth for consideration. The initial model is CNN, which focuses exclusively on textual information during training. The second approach involves utilizing an audio CNN model, where the model is exclusively trained using audio features. On the other hand, the third approach is a hybrid model that integrates audio and textual models, employing Long Short-Term Memory (LSTM) techniques. The Researchers developed the Bi-LSTM model as an enhanced iteration of the LSTM model. The utilization of the model was also incorporated into the suggested study. The study results suggest

that deep learning proves to be a more effective method for detecting depression. The textual CNN models achieved an accuracy rate of 92 %, while the audio CNN models achieved an accuracy rate of 98 %. Additionally, the textual CNN models exhibited a loss of 0.2, whereas the audio CNN models showed a loss of 0.1. The findings above suggest that the use of audio CNN proves to be a proficient approach to detecting depression. The performance of the latter model, when compared to the textual CNN model, is superior. The Bi-LSTM model exhibits a comparatively elevated learning rate compared to alternative models, demonstrating an accuracy of 88 % and a validation accuracy of 78 %. The evaluation of the models involved the assessment of various characteristics, including precision, F1-score, recall, and support. The study's findings were visually represented through graphs depicting the training loss, validation loss, and validation accuracy. The results showed that textual CNN models, audio CNN models, LSTM models, and bi-LSTM models exhibit a discernible confusion matrix with the comparison between true and predicted labels. The research conducted by the authors centred around an amalgamation of audio and textual models referred to as the "hybrid model." This model incorporates the utilisation of both CNN and LSTM algorithms. Nevertheless, the research primarily concentrated on a subset of audio and text features retrieved and implemented using CNN and LSTM algorithms.

Amanat et al. [7] employed an LSTM model comprising two hidden layers, a substantial bias, and two thick layers of recurrent neural networks (RNN). The primary objective of this paper was to detect depression based on textual data and to provide support to individuals in mitigating mental health disorders and suicidal ideation. The researchers were presented with a substantial, imbalanced dataset of tweets via the Kaggle website. Before commencing data pre-processing, the dataset underwent balancing and cleaning procedures. The subsequent stage in the normalisation process encompassed the data's segmentation, stemming, and lemmatization. Subsequently, the data was examined for a numerical word quality assessment. To forecast text tweets that indicate depression and those that do not, the dataset was inputted into machine-learning classifiers. The datasets were partitioned into training and testing sets to facilitate the classifier's learning process. The training data was used to construct the sample framework. The study employed the RNN and LSTM techniques to classify depressive symptoms in text data. It was achieved by implementing a multivariate human depression prognosis strategy utilizing a one-hot methodology. Many techniques were employed, including stemming, lemmatization, and a robust one-hot Principal Component Analysis (PCA) approach to perform data cleaning and feature extraction on the dataset. Subsequently, to replicate two distinct emotional conditions, namely depression and non-depression, the use of one-hot features was employed to train a deep recurrent neural network (RNN) with LSTM architecture. The model was utilized to predict textual data. The recommended approach was successfully implemented, resulting in a 99 % accuracy rate and a decrease in false positive occurrences. The evaluation findings indicate that the framework exhibits superior accuracy, precision, recall, and F1 measures compared to the NB, SVM, CNN, and DT algorithms. The features in this research can greatly enhance the decision-making process in machine learning and contribute to developing a proficient user interface that enhances service quality.

Anbukkarasi et al. [8] use deep learning to identify depressed individuals in social media texts. They see that those social media platforms and their users have the same objectives, and on multiple levels, these platforms reflect the user's personal life. Datasets were obtained from the social media comments on Kaggle. There are almost 4,000 English texts in the entire dataset, where 40 % of the texts served as testing datasets and 60 % as training datasets. Labels N and Y are indicated. The study used RNN, LSTM, GRU, and bi-LSTM models. Bidirectional LSTM (Bi-LSTM) was utilized to extract a person's depression from social media remarks. The RNN can only store contextual information for a brief amount of time. Adopting LSTM, which employs a memory block instead of a straightforward RNN unit, can alleviate this issue. The study uses the GRU model to train the dataset as soon as feasible compared to LSTM. URLs, emojis, mentions, and stop words were removed to clean up the dataset. The text in each dataset row was then divided into tokens or words through tokenization. Following tokenization, the words were subjected to lemmatization and stemming. The stemmed input text was subjected to the one-hot approach to derive features from it. The researchers examined and compared four different deep-learning architectures. During testing, the suggested bi-LSTM-RNN model achieved 99.6 % accuracy. RNN has a 98.0 % accuracy rate, while other LSTM architectures have a 99 % accuracy rate, as does GRU. In terms of accuracy, Bi-LSTM performed better than all of these designs. The study's findings showed that Bi-LSTM operates efficiently with 99.6 % accuracy.

Baghdadi et al. [12] optimised a deep-learning approach for suicide detection through Arabic tweets. Major depressive disorder (MDD) is one of the various mental disorders that impact people globally, affecting their thoughts, behaviour, and quality of life[12]. Arabic Twitter datasets were used in the study. Arabic is a language with a complicated grammar that is widely spoken, but depression detection techniques have not been extended. The initial dataset of tweets was scraped and annotated in Arabic. This study proposed a comprehensive framework for classifying tweet inputs into two classes (e.g., normal or suicide). The authors used the "Twint" Python library to scrape the data from Twitter. Twint is a sophisticated OSINT and Twitter scraping tool. The authors scraped six keywords that are local to the English word "suicide," both with and without hashtags. The paper compares lemmatization, stemming, and other lexical analysis techniques with a proposed Arabic Twitter preparation algorithm. Twitter data taken from the Internet is used in the experiments. Five different people have annotated the data. Performance metrics are presented on the recommended dataset using the most recent Universal Sentence Encoder (USE) and Bidirectional Encoder Representations from Transformers (BERT) models. The measured performance measures are balanced accuracy, specificity, F1-score, IoU, ROC, Youden Index, NPV, and weighted sum metric (WSM). The best-weighted sum metric (WSM) for Arabic BERT models is 95.26 %, whereas the best WSM for USE models is 80.2 %.

Chakraborty et al. [14] employed LSTM-based RNN models in their investigation to identify textual descriptions of self-perceived depressive symptoms. The newly established channel encompasses textual inquiries from adolescents, focusing on a substantial dataset on the detection of suicide and depression. The researchers sourced this dataset, which includes 233,337 entries, from Kaggle. Medical and psychiatric practitioners employ a one-hot procedure to identify prominent characteristics associated with potential depression symptoms. The characteristics of this approach surpass conventional methods that rely on word frequency rather than symptoms to comprehend the underlying occurrences in text messages. A deep learning system can identify symptoms of depression based on inputs that do not originate from individuals experiencing depression. The RNN ultimately generates a prediction regarding depression. The prevalence of depressive symptoms exceeds their level of specificity in the proposed approach. The researchers can use the technique mentioned above on diverse depression datasets to achieve precise annotations and feature extraction based on symptoms with high accuracy. The study can facilitate collaboration between chatbots and depression prediction.

Analyzing individuals' social media posts makes it possible to gain insights into their behaviour, considering the widespread adoption of diverse social media platforms, their societal implications, and the psychological factors that influence human beings[36]. In a scholarly publication authored by Kour and Gupta [36], the research work entitled "A Hybrid Deep Learning Approach for Depression Prediction from User Tweets Using Feature-Rich CNN and Bi-directional LSTM" was presented. The primary objective of the researchers was to ascertain the feasibility of predicting an individual's mental health by differentiating between users with depressive tendencies and those without, utilising data derived from the social media platform Twitter. Deep learning

models were employed to analyse the semantic context of the textual material within the user's tweet and generate textual narratives. The RNN, CNN, and baseline approaches are contrasted with the CNN-biLSTM model. Based on the analysis of several performance measures, the experimental results suggest that utilising the model enhances predictive performance. The study aimed to undertake a comprehensive investigation of the variations in linguistic representation between depressive and non-depressive material. According to the research findings, the CNN-biLSTM model had the highest level of accuracy at 94.28 %, precision at 96.99 %, F1-score at 94.78 %, specificity at 96.35 %, and area under the ROC curve (AUC) score at 95.43 %.

Depression has emerged as a prevalent mental health concern in contemporary society [44]. Their article was published regarding a state-of-the-art system for the diagnosis of depression using textual data, employing NLP and deep learning methodologies, in consideration of the disease's significant prevalence. A group of subject matter experts constructed a corpus of tweets and conducted manual annotations to encompass implicit and explicit contextual elements related to depression. The dataset was created in two formats, one incorporating binary labels and the other with ternary labels. In this study, the researchers provide a novel categorization framework called the Hybrid Sequence, Semantic, and Context Learning (SSCL) framework. This framework is built upon deep learning techniques and incorporates a self-attention mechanism. The proposed system uses GloVe, a pre-trained word embedding model, to extract features from tweets. It employs LSTM and CNN to capture the sequence and semantics of the tweets. GRUs and the self-attention mechanism also emphasize contextual and implicit information within the tweets. The system demonstrated superior performance to earlier methods by achieving an accuracy of 97.4 % for binary-labelled data and 82.9 % for ternary-labelled data, effectively recognising both explicit and implicit context. The SSCL framework proposed in the paper was assessed by employing synthetic data (randomly generated tweets), resulting in an F1-score of 94.4. The researchers validated the proposed framework using the "News Headline Dataset" to detect sarcasm. This validation included the consideration of a dataset from a distinct domain to emphasise the framework's benefits. The current approach exhibits superior performance in cross-domain validation compared to prior methodologies.

In a recent study conducted by Narayanan et al. [46], a novel approach was proposed for utilising deep learning techniques in identifying depression through the analysis of social media data. The objective of this study was to ascertain the feasibility of utilising Twitter data to forecast an individual's mental state, namely by categorising them as either exhibiting symptoms of depression or not. On Kaggle, a dataset of Twitter posts was utilized. Over 1.58 million tweets are included in the dataset. The sample includes tweets that are both depressed and not depressed. Non-depressive tweets are labelled as "1," while depressive tweets are marked with the number "0." Pre-processing is used to enhance the performance of the suggested model by removing unnecessary features and processing raw posts before word embedding recognition. Deep learning models were used to evaluate the language context of the theme narratives based on the topic substance of the user's tweet. The planned model combined CNN and LSTM into a hybrid CNN-LSTM architecture, which, after being tuned, achieves 97 % accuracy on a benchmark depression dataset comprising tweets. Experimental data based on a range of performance metrics show that the model enhances predictive performance for early detection of depression.

Tejaswini et al. [57] analysed a wide range of earlier studies that employed learning approaches to recognise depression. Better model representation issues make it difficult for the currently used methods to identify depression in text accurately. The present study addresses the challenges above by proposing a novel hybrid deep learning neural network architecture known as the "Fasttext Convolution Neural Network with Long Short-Term Memory (FCL)". This article aims to enhance textual representations. Moreover, this research leverages the advantages of natural language processing (NLP) to streamline the text analysis procedure in building the model. The FCL model incorporates CNN structures to extract global information. It employs LSTM architecture to capture local features that exhibit interdependence. Furthermore, the model utilises quick text embedding techniques to enhance text representation by incorporating semantic information and addressing out-of-vocabulary (OOV) scenarios. The present study implemented real-world datasets to conduct the research. The current study employs two separate datasets from reputable sources to identify depression through text. The dataset was created from tweets and Reddit postings retrieved through the Kaggle website. The suggested method achieves higher accuracy in detecting depression than the state-of-the-art method. For identical Twitter data, the CNN model achieves 86.7 % accuracy, the LSTM-RNN model achieves 86.7 % accuracy, and the FCL model achieves 88 % accuracy with fast text embedding.

According to Uddin et al. [62], a viable approach for identifying texts that discuss individuals' self-perceived symptoms of depression involves utilising a recurrent neural network (RNN) that is based on a long-short-term memory (LSTM) architecture. The method employed in this study involves utilising a substantial dataset obtained from a publicly accessible Norwegian youth information website. The dataset consists of textual inquiries made by young individuals regarding this particular source of knowledge. Subsequently, the following section presents robust elements derived from reflecting prospective depression symptoms specified by medical and psychological professionals. The features mentioned earlier provide superior performance compared to conventional approaches that predominantly rely on word frequencies. In these approaches, the most frequently occurring words are chosen as features from the full-text collection and employed to represent the underlying events in each text message rather than focusing on symptoms. The RNN deep learning approach is utilized to train the time-sequential characteristics to distinguish between texts that indicate depression symptoms and those that do not (non-depression posts). The trained RNN is capable of automatically predicting posts that exhibit depressive characteristics. The system's performance is evaluated compared to conventional procedures, demonstrating its superiority over all of them. The linear discriminant space exhibits superior clustering performance compared to conventional features, showcasing these features' resilience. Furthermore, since the characteristics are derived from possible indicators of depression, the system can generate insightful rationales for the decision made by utilizing the Local Interpretable Model-Agnostic Explanations (LIME) method, which is a part of the field of Explainable Artificial Intelligence (XAI). When compared to current broad-word frequency-based strategies, where the frequency of the features is given more weight than the specific symptoms of depression, the proposed depression symptom feature-based approach performs better. The suggested strategy can be applied to depression datasets in other languages, provided they have accurate annotations and utilize symptom-based feature extraction. It indicates that the technique is applicable and practical across different linguistic contexts, as demonstrated by its successful implementation on a Norwegian dataset. Hence, using the depression prediction method holds promise for facilitating the development of enhanced technological solutions for mental healthcare, such as implementing intelligent conversational agents.

To identify depressed individuals on social media automatically and provide an explanation for the model prediction, Zogan et al. [69] suggested explainable Multi-Aspect Depression Detection with Hierarchical Attention Network MDHAN. The researchers have considered enhancing user posts with additional Twitter functionality. The study employed a real-world dataset of both depressed and non-depressed consumers. The study took into account 4,208 users, of whom 51.30 % had depression, and 48.69 % did not. The researchers randomly divided the dataset into training (80 %) and test (20 %) groups. The study used five-fold cross-validation to report the experimental results. The work computes the relevance of each tweet and word, applies two layers of attention mechanisms at the tweet and word levels to encode user postings, and extracts semantic sequence features from user

timelines (posts). This study's primary contribution is a novel hybrid computational model that can help explain real-world data and model it efficiently. The study examines users' tweets, taking into account attitudes and themes simultaneously, to validate each DSM-IV criteria for depression. The study allocates a multi-aspect attribute that reflects user behaviour to the MLP and user timeline postings into HAN to determine the significance of each tweet and phrase and extract semantic sequence characteristics from user timelines (posts). The authors designed the hierarchical attention model to identify patterns that yield interpretable outcomes. The study used Tensorflow 2.1.0 and Python 3.6.3 to create the implementation. The results demonstrate the usefulness of combining multi-aspect features with deep learning, as MDHAN surpasses numerous well-known and reliable baseline approaches. The study's results also demonstrate that the model enhances predictive performance in identifying depression in individuals who publish content on social media platforms. MDHAN performs exceptionally well and ensures enough data to support the forecast. With an 89 % performance in F1, MDHAN was the most successful, suggesting that using HAN in conjunction with a multi-aspect technique for user timeline semantic features is adequate for Twitter depression detection.

The goal of the Chiu et al. [19] study was to identify Instagram users who may be depressed. To automatically gather information from people who are depressed and those who are not, the researchers developed a depression lexicon. To predict the aggregated depression score of each Instagram post, the researchers built a multimodal system that uses image, text, and behaviour information. They suggest a two-stage detection approach for identifying depressed people based on the period between posts. According to experimental findings, the suggested approaches can identify depressive users with an F1 score of up to 0.835. Therefore, it can serve as an early warning sign of depression, allowing for treatment before it worsens.

Dai et al. [20] developed a new two-stage feature selection method to do a context-aware analysis of the DAIC-WOZ dataset's high-dimensional (over 30,000 features) characteristics. The datasets include audio, video, and semantic features. The researchers used seven reference models to compare the prediction performance. With the maintained characteristics, the chosen subjects and feature categories were studied. The suggested strategy was used to choose sparse subsets (tens of characteristics) in each prediction scenario. The F1-score for depression classification was 0.96 (0.67), the precision was 1.00 (0.63), and the recall was 0.92 (0.71), giving the researchers the best result on the development set (test set). With a root mean square error (RMSE) of 4.43 (5.11) and a mean absolute error (MAE) of 3.22 (3.98), the study had a somewhat better estimate of depression severity than the best reference model (random forest with "selected text" features). While the three feature categories contributed approximately equally to evaluating severity, the audio features outweighed the other categories in the depression classification.

He et al. [29] thoroughly analyse deep neural network-based automatic depression detection systems, analyse the difficulties, and suggest future research possibilities. The study also examined deep learning techniques for automatically extracting depression representations from audio and video. The authors introduced pre-existing databases frequently used for depression identification in the publications under consideration. The most challenging aspect of depression research is gathering data, which necessitates recruiting numerous people from hospitals or psychological clinics. As previously discussed, the depressed participants or health controls are evaluated under the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV). Many researchers in the realm of active computing have extensively used the Distress Analysis Interview Corpus/Wizard-of-Oz set (DAIC-WOZ) dataset for Automatic Depression Estimation (ADE). However, because the data pertains to sensitive personal characteristics associated with mental diseases, the publisher of DAIC-WOZ finds it challenging to transmit the data as raw video clips. Therefore, experts urge all studies to provide raw data, not just the finished product. The reviewers define objective indicators for ADE and introduce the databases. Despite the significant progress made in recent years, more work needs to be done to collect additional data, investigate other approaches, and build and implement ADE systems for clinical use cases. This study recommends creating automated, impartial systems that will be valuable for academic research and clinical application by collecting a multi-modal database that includes audio, video, text, and physiological signals.

Uban et al. [60] analyze social media data on mental health illnesses using emotion and cognitive theory. Each user's social media activity makes it appropriate to assess early detection and analyze how symptoms change, including texts written before the user receives a mental health diagnosis. The hierarchical attention network's success in predicting all three illnesses suggests that a hierarchical representation of social media activity may be helpful. The study gathered a dataset from Reddit comments and posts from specific, relevant subreddits. The algorithmic detection of self-stated illnesses annotates users with mental disorders, followed by a manual curation step. The study suggests investigating more complex deep architectures, such as transformers and hierarchical attention networks, in addition to RNNs and CNNs. Although transformer performance is good considering the limited number of parameters trained for this task, most experiments show that the built models provide better results, suggesting additional features are needed. The ablation experiments validate that the study's usage of stopwords, emotions, and LIWC traits plays a significant role in accurately identifying users. With the CNN + LSTM model, they achieve better F1 outcomes.

Recent research aims to use social media to detect depression, as how opinions and thoughts are expressed in both text and photos might, in some ways, reveal users' mental health. To show how effectively users with depression can be identified and studied using the suggested method, Lin et al. [40] created a system called SenseMood. A deep visual-textual multimodal learning approach has been put forth to shed light on users' psychological states in social networks. Depression identification has been carried out using the tweeted photographs and tweet data from individuals with and without depression on Twitter. A binary CNN-based classifier is trained as the feature extractor to provide discriminative visual features for individuals who have depression and those who do not. Two image datasets are gathered to train the classifier and separately extract visual features. Users' profile pictures and publicly shared photos are gathered as an image set to extract textual features from tweets. The deep features from the user-posted images and texts are extracted using the CNN-based classifier and Bert. Then, text and graphic elements are merged to mirror consumers' emotional expressions. The analysis report is prepared automatically after the system has classified the depressed and typical users using a neural network. The proposed model has achieved 88.393 % accuracy and a 93.599 % F1-score, significantly improving depression detection on social networks.

Rajaraman et al. [51] engaged in a project to develop a deep learning model utilising NLP to anticipate such mental illnesses. The study focused on detecting depression in tweets and a comparative test. The datasets used to create the model are Sentiment 140, tweet scrap from TWINT, and Google Word2Vec. The study made use of several models from various algorithmic families. In this study, classifiers with both machine learning and deep learning were utilized. The models included LR, LSV, NB, LSTM, and TF-IDF classifiers. The study is a comparison and contrast. Python 3.1 was used to implement the study, and libraries including Numpy, Scikit Learn, Matplot, NLTK, WordCloud, and Keras were also employed. The study provided a novel method for classifying tasks using word embedding to find sad posts on Twitter. The researchers have compared five methods: TF-IDF, NB, LSTM, LR, and LSV. LSTM-RNN was shown to have the most incredible accuracy of 0.995 for identifying depressive tweets on Twitter out of all five approaches.

Shrestha et al. [53] made an effort to solve the issue of spotting depressed people in online forums. The ReachOut.com online community offers a safe space for young people to talk about common problems,

including depression. The researchers study user behaviour there. The study used the 2017 CLPsych shared task dataset, available at https:// clpsy ch.org/share d-task-2017/ - postings from the ReachOut.com platform's branded forums. The dataset includes 147,619 forum posts, of which 1,588 have undergone careful annotation. The study employed an autoencoder with LSTM. The paper suggests an unsupervised method based on anomaly detection and recurrent neural networks to identify depressed users. The study examines the language used in user posts and network-based elements that simulate how forum users interact. The findings on identifying sad users demonstrate that both network data and psycho-linguistic variables extracted from user posts are reliable indicators of people who are depressed. Additionally, by integrating these two sets of characteristics, the study achieves an F1-measure of 0.64 and outperforms baselines.

Shetty et al. [52] analysed raw Twitter data to predict depression using ensemble techniques and deep learning. The suggested study's objective was to explicitly use a person's activity on Twitter to predict depression in that person. Two primary phases make up this process. First, a person's Twitter messages are subjected to sentiment analysis to forecast binary classes such as depressed or not depressed. The tweets were acquired using the Twitter API from a developer's Twitter account. The LSTM algorithm, a deep learning module, was used. The proposed LSTM model was trained and validated using a Kaggle dataset of tweets on depression. Preprocessing was carried out, including the deletion of empty tweets, the elimination of punctuation, the creation of a dictionary to map words to numeric values, and the determination of the tweets' maximum length. The model receives the final generated features trimmed to the sequence length. After compilation, the model is fitted using the previously created features and tested against the dataset's labels. This model is trained for five epochs with a validation split of 0.3 (70 % training data, 30 % test data). The model is then saved in a JSON file for later usage. The studies show that the test accuracy for LSTM is 0.93 % and CNN is 0.95 %, respectively.

In their publication, Wang et al. [66] introduced a novel approach for audio-based depression recognition, utilising a CNN in conjunction with a generative adversarial network (GAN) model. The dataset is preprocessed by the researcher through the removal of long-term mute parts, followed by the splicing of the remaining segments into a new audio file. Subsequently, the audio difference normalization algorithm is employed to extract the properties of the speech signal, including Mel-scale Frequency Cepstral Coefficients (MFCCs), short-term energy, and spectral entropy. The database utilized for model training consists of an extracted matrix vector feature dataset, which accurately captures the distinct properties of the individual's voice. The research on depression recognition involves the development of a model called DR AudioNet, which utilizes a combination of CNN and GAN. The utilization of DR AudioNet optimizes the previous model. At the same time, recognition classification is accomplished by using the normalization features of the two adjacent segments preceding and following the current audio segment. The empirical findings obtained from the AViD-Corpus and DAIC-WOZ datasets demonstrate that the proposed approach significantly mitigates the error associated with depression recognition compared to alternative methodologies. Moreover, the root mean squared error (RMSE) and mean absolute error (MAE) metrics achieved on both datasets exhibit an improvement of over 5 % when contrasted with the performance of the comparative algorithm.

Adebowale et al. [2] research focused on designing and implementing a deep learning-based phishing detection solution that uses website content, including graphics and frame elements, and the Universal Resource Locator (URL). A dataset comprising legitimate and phishing URLs was created to train the LSTM and CNN. A total of 1 million URLs were employed to train the LSTM. Half of the dataset was made up of real sites from Common Crawl, a corpus of web crawl data, and the other half was made up of phishing sites from PhishTank, a website that serves as a repository for phishing URLs. The researchers gathered more than 10,000 photos from both trustworthy and fraudulent websites to train CNN. This dataset was utilized to train and test the network using holdout cross-validation of 70 % and 30 %, respectively. The raw data from URLs and photos varied in length and size and contained much background information. Therefore, to make this data available for model training, the researchers had to preprocess it. They eliminated the incorrect image after cropping photographs from the sites based on the springy box for the CNN architecture. In Microsoft Excel, they compile several URLs for the LSTM architecture and save them as comma-separated values, with just the URL in one column and their category name in the other. The study's outcome, a binary number indicating whether the input sequences are genuine or fraudulent, used the LSTM layer and the CNN to extract features from various websites (phishing). The CNN and LSTM are combined to create the intelligent phishing detection system (IPDS), a hybrid model that can categorize phishing websites. The deep learning toolkit was used to create the model in Matlab version 9.5. The study findings revealed that the suggested model had a 93.28 % accuracy rate.

A unique deep learning-based method to identify the emotions of happiness, sadness, and anger in textual dialogues was proposed by Chatterjee et al. [15]. The core of this strategy is the integration of sentiment-based and semantic representations to improve emotion recognition. The paper aimed to propose a unique method for identifying emotions in textual chats using a deep-learning system named Sentiment and Semantic-Based Emotion Detector (SS-BED). The researchers compare the efficacy of several deep learning techniques and embeddings to recognise emotions in real-world textual interactions using machine learning algorithms, including SVM, DT, and NB. Semi-automated methods collected large-scale training data using a variety of emotional expressions to train the suggested model. This method greatly outperforms existing pre-built deep learning models and classic machine learning baselines, according to analysis of real-world dialogue datasets.

Gural [27] stated that deep learning has been demonstrated to perform incredibly well, sometimes even better than human performance, and it is anticipated that it will eventually replace the need for visual inspection and analysis of gathered meteoric footage. When utilized to analyze time series data of meteor track centroid positions and integrated intensities collected from each video frame, RNN has achieved 98.1 % recall. In this study, the number of false positives wrongly labelled as the RNN limited meteors to 2.1 % leakage. The goal was to maximise recall to prevent missed orbit estimations and minimise false alarms seeping through to the multisite trajectory and orbit estimation's next processing stage. These findings increase to 99.94 % recall and only 0.4 % leakage when two-dimensional spatial imagery is given or the temporal visual sequence can be reconstructed using CNN. It has been expanded with identical results from a baseline of interleaved analogue video to contemporary progressive scan digital imaging. The trained CNN, MeteorNet, is being investigated as a potential upstream meteor detector and will be utilized for automatic post-detection screening of prospective meteor paths.

Using the LSTM-RNN approach, Uddin et al. [61] analysed depressed individuals using Bangla-language social media data. The authors used data from Bangla social media to analyse depression using an LSTM Deep Recurrent Network. They stratified a small dataset of tweets in Bangla. On a small dataset of Bangla social media, the authors have demonstrated the effects of hyper-parameter tuning and how it might be helpful for depression analysis. LSTM-RNN models need large datasets to achieve high accuracy. Since there was no dataset for depression analysis in Bangla, they had to create their own, which was a small dataset compared to what was required for LSTM model training. The outcome demonstrates that for stratified datasets with recurrent sampling, excellent depression detection accuracy can be achieved using five layered LSTMs of size 128 with batch sizes of 25 and learning rates of 0.0001 across 20 epochs. This finding will assist psychologists and other researchers in identifying people who are depressed from their online social interactions and in taking the appropriate precautions to

stop negative behaviours brought on by depression.

Alhanai et al. [5] demonstrated an automated depression-detection algorithm that mimics an interview between a person and an agent and learns from sequences of questions and responses. The study aimed to model audio and text sequences of an interaction between a human subject and a virtual agent to detect depression. Given the potential benefits of such methodologies, the authors conduct this modelling in a data-driven manner without officially assuming that a particular question has been answered. The authors used 142 people's audio and text transcriptions from depression screenings conducted by a human-controlled virtual agent. The virtual agent asked each person a subset of 170 potential questions, such as "How are you?" and "Do you consider yourself to be an introvert?" as well as dialogic comments like "I see" and "That sounds wonderful." The data, which includes audio and text transcriptions of the spoken exchanges, was taken from the distress analysis and interview corpus (DAIC), which is freely accessible. The data was divided into three sets: training (57 %, 107 individuals), development (19 %, 35 subjects), and testing (25 %, 47 subjects). Since the DAIC public release did not include test set annotations, all models were assessed using the development. To identify depression, the authors used an LSTM neural network model to simulate the interactions between audio and text elements. The results showed that depression could be identified by sequential interaction modelling, with little knowledge of the interview's structure. They were equivalent to methods that explicitly modelled the themes of the questions and replies.

In their study, Orabi et al. [48] investigated a limited number of deep neural network designs to identify mental diseases, with a specific focus on depression, among individuals who use the social media platform Twitter. The main objective of this study was to identify depression by employing the most efficient deep neural architecture derived from two prominent deep learning methodologies in natural language processing, namely CNNs and RNNs. The researchers tested the method in two experiments. Depression detection on the CLPsych2015 dataset and generalisation ability on the study's Bell Let's Talk datasets. The researchers experimented with deep neural network models using various word embeddings. In the first experiment, they compare the chosen models for depression detection. Because the dataset was imbalanced in the second experiment, they used 5-fold cross-validation with stratified sampling to report results. For each split, data points are shuffled while maintaining the class distribution. Following that, the generalization ability of the selected models was tested, with 80 % and 20 % of the data used for training and development, respectively. The final analysis shows the trained models used to evaluate unseen data, which is Bell Let's Talk with 154 users. The paper presented a novel approach to word-embedding optimisation for classification tasks. The researchers conducted a user-level comparison of some of the most widely used deep learning models for depression detection from tweets. Compared to RNN models, the results of CNN models are competitive, and the best-performing RNN model achieved 91.425 % accuracy.

Pranav [49] developed a sentiment analysis-based neural network system to identify depression in Twitter users. The system uses Twitter scraper programmes to collect over 4,000 tweets without initial emotional labels. The researchers used pages related to mental health to identify encouraging situations and negative pages from various sources. The swamp of words concept avoids precise grammar and considers cases where users speak directly about themselves or a topic [49]. Pranav [49] states that a CNN reduces ambiguity and analyzes patterns to determine depression. The algorithm effectively distinguishes between general and despair-signifying posts.

6. Research gap

A lot of research papers and journals were examined for this review. They talked about detecting depression [63,64,48], prediction [14,62,20], classifications [22,27], recognition [29,66], and analysis [57]). Deep learning enabled the researchers to implement several methodologies and algorithms. Researchers use datasets such as text [44,36,8,14,7]; images [40]; audio [66]; video [27]; audio/video [29,20]; image/frame [2]; and audio/text [5]. The majority of the studies employ various classifiers to detect depression. However, most researchers obtained their datasets from social media sites. Few researchers use single classifiers [22,63,27,49]. Most used two classifiers [7,14,46,57,62,20,52,66,2,61,48]; others use three classifiers [64,36,19,5]; and only four studies used four or more classifiers [8,44,51,15]. This shows only very few studies use more than four or more algorithms to analyse datasets in their studies.

Furthermore, the field of extracting depression symptoms from textual data holds great potential for future research. Detecting major depression just based on concise sentences remains a formidable challenge. A substantial collection of datasets is necessary to train and evaluate deep learning models effectively. A substantial amount of data provides a more accurate and better result. To diagnose depression, some researchers used a hybrid deep-learning learning method [64,36,44,57] to provide a better and more efficient method of detecting depression. Thus, there is a need for more research that will improve the conventional deep learning models based on a hybrid approach for depression detection on social media posts.

There is a need to stress using four or more algorithms to evaluate the effectiveness of existing conventional deep learning models. Thus, to address the constraints inherent in the current body of literature, a large dataset must be used to test and verify the results of the classifiers. There is a need for a study that will suggest using a flag or another symbol on depressed messages on social media posts, which can serve several important purposes, such as visibility, awareness, inspiring action, preventing suicidal behaviour, and promoting empathy and understanding.

No study uses a multi-layer deep learning depression detection model for early signs of depression in social media posts. Performance evaluation metrics can be used to analyse model efficiency. Furthermore, there is a need for a study that will evaluate the accuracy value to decide which algorithm is best suited to detect depression on social media posts.

7. Data analysis and reporting

This section uses a graphical representation to present the findings from the reviews' analysis and address the research questions. Based on the study questions above, the analysis of data and reporting are discussed below.

Question 1: What are the ML and DL research trends for detecting depression from 2016 to 2023?

Fig. 2 shows that the use of ML approaches in depression detection tends to decrease between 2016 and 2017, based on the papers reviewed in this study. There was a steady increase from 2017 to 2019. 2019 saw a higher number of publications on depression detection in ML research. There was a decrease from 2019 to 2020 and a slight increase in 2021. The years 2022–2023 show a continuous decrease in ML use due to a shift to DL.

Fig. 3 shows an increase in the use of DL approaches for depression detection, although the patterns tend to increase from 2017 to 2019. There is a slight decrease between 2019 and 2020. However, there was an increase in research from 2021 to 2022, with a decrease in 2023. The highest number of publications in DL was in 2022. The recent development of AI technologies that can predict depression and related mental disorders in a large sample has contributed to the growing research interest in the use of DL for depression detection. Fig. 3 depicts the research trends during the study periods.

Question 2: What has been the focus of ML and DL in detecting depression?

Fig. 4 depicts that most of the emphasis on ML research is on depression detection. 77 % of the studies were concerned with detecting

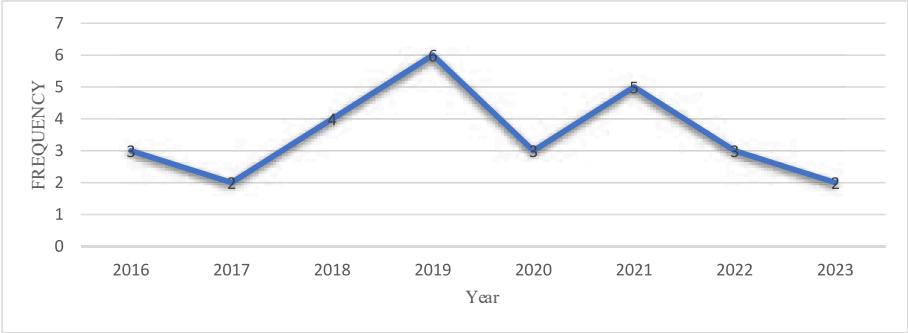

Fig. 2. Research Trends of ML.

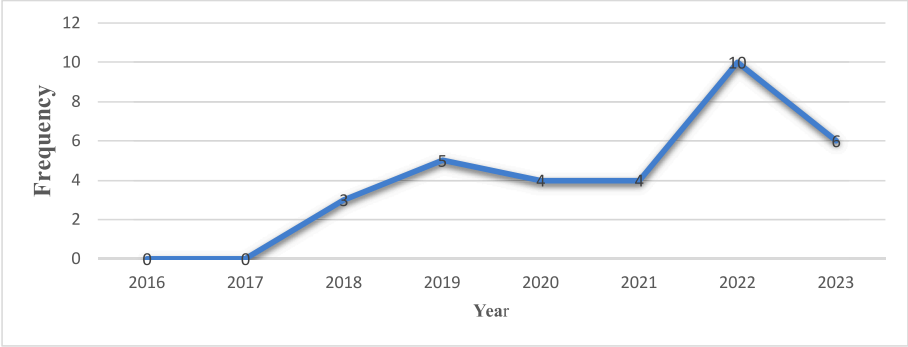

Fig. 3. Research Trends of DL.

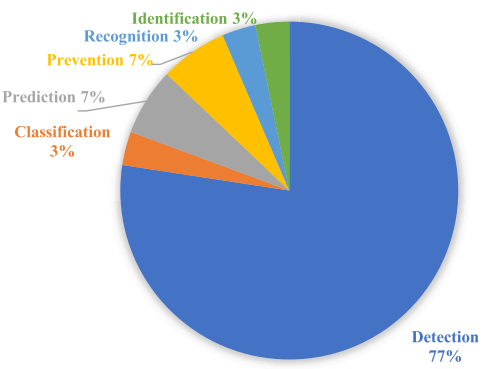

Fig. 4. Research Focus in ML.

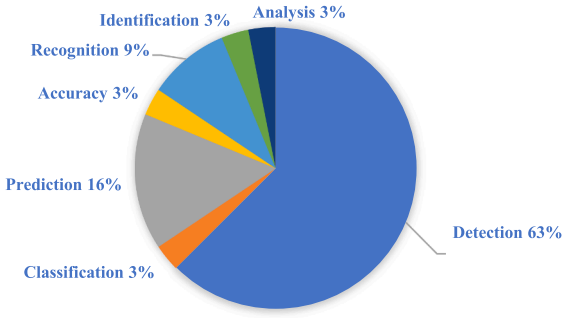

Fig. 5. Research Focus in DL.

depression. This discovery can offer information on individuals with depression, which will help the health worker provide attention at a very early stage and possible prevention mechanisms. Detecting depressed individuals can provide detailed information on related mental disorders and diseases that contribute to mental health challenges and life loss. 7 % of the research focused on predicting and preventing depression using ML. Identification, classification, and recognition of depression have only 3 % each. According to the findings, depression detection is the primary focus of most ML research.

Recently, there has been an emphasis on depression detection using DL. Fig. 5 shows that much of the focus of DL research is on depression detection; 63 % of the studies have an early depression detection component. This early detection can provide information on individuals with depression, which will help provide medical attention and prevention. Furthermore, the detection of depressed people can provide information about other related mental disorders and diseases that are attributed to severe mental health challenges and loss of life. 16 % of the research focused on the prediction of depression using DL, while 9 % focused on recognition. Analysis, accuracy, classification, and identification of depression have only 3 % each. This finding indicates that the majority of DL research focuses on the early detection of depression.

Question 3: What ML and DL techniques have been applied to study depression detection?

Fig. 6 shows researchers' use of ML algorithms in depression detection. Researchers have applied ML techniques to study depression detection. The chart above shows that researchers use 21 % of support vector machine ML techniques, while 16 % use NB. The analysis revealed that 13 % of the study used random forests, and 12 % used decision trees. K-Nearest Neighbours has 11 % and Logistic Regression has 6 %, respectively. Only very few, consisting of 4 %, use multinomial Naive Bayes, while others use 2 % and 1 %, respectively, in their studies. Most of their studies used at least two ML models.

Fig. 7 shows researchers' use of DL techniques in depression detection. Recently, researchers have applied the most frequent DL techniques to study depression detection. According to the graph above, just

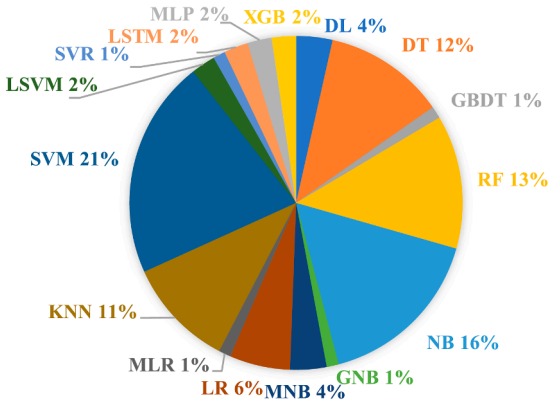

Fig. 6. ML Techniques.

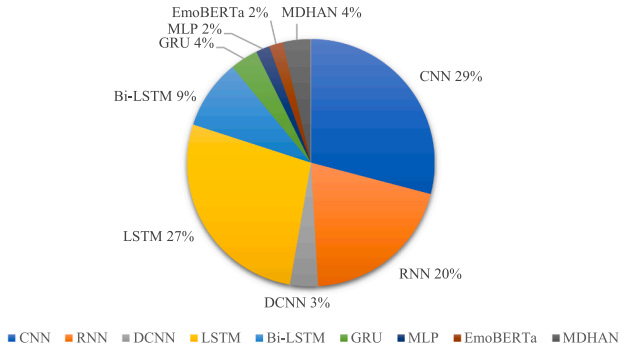

Fig. 7. DL Techniques.

9 % of researchers employ bidirectional long short-term memory, whereas 27 % use techniques from the long short-term memory network. The analysis revealed that 29 % of the study used convolutional neural networks, and 20 % used recurrent neural networks. Deep convolutional neural networks have 3 %. Gated recurrent units and Multi-aspect Depression Detection Hierarchical Attention Network have 4 %, respectively. Only very few, consisting of 2 %, use multilayer perceptron and EmoBERTa in their studies. Most studies using a single DL model used CNN, RNN, LSTM, or a combination of any of them. Other studies use three or even more models for predicting, detecting, and classifying depression using social media data or records from health systems.

Question 4: Which datasets were used to train ML and DL for depression detection?

Fig. 8 shows the source of the dataset used to detect and predict depression using ML. The data sources were from social media sites. The analysis revealed that Twitter accounted for 55 % of the data sources. 20 % of the data was from Facebook, and 10 % was from Reddit. This result means that most of the data used for depression detection came from Twitter. Getting large datasets from Twitter for free using the Twitter API was easier. Large datasets provide a high degree of accuracy when testing the model.

Fig. 9 depicts the source of the dataset used to detect, forecast, categorize, and assess the effectiveness of the use of DL models for detecting depression. The data sources were from the internet. The analysis revealed that 63 % of the data source was obtained from tweets and comments on Twitter. 7 % of the data was from Facebook, and 2017CLPsych used 6 %. Reachout.com, CLPSych2015 & Bell Lets Talk, DAIC-WOZ, USTC-TFC2016, Instagram, Patient Interview & PHQ Scores, eRisk Reddit, and Reddit used 3 % of the data. This result means that most of the data used for depression detection came from Twitter. Larger datasets from Twitter are more accessible using the Twitter API. Large datasets offer a high level of accuracy in the model testing process. Researchers did not often use other data sources because of the difficulties of data accessibility. Sufficient data will help in providing detailed information for detecting depression and other related mental diseases.

8. Discussion

There are many compelling reasons why ML is essential in the study of depression detection. Depression is a severe mental health problem that affects both individuals and society at large. Early and accurate detection is essential for effective treatment and support. ML algorithms provide an objective assessment of depression symptoms. Algorithms consistently and impartially analyze data, unlike human judgment, which is susceptible to biases and subjectivity. This objectivity can lead to more accurate and reliable results. Researchers mostly use ML models like DT, KNN, NB, RF, and SVM to identify signs of depression at an early stage, even before noticeable symptoms manifest. Early detection can prevent the condition from worsening and improve the chances of successful treatment. It is necessary since many individuals with depression do not seek help until their condition becomes severe.

Researchers have used DL algorithms to detect depression. Researchers have recently conducted advanced studies on patients suffering from depression and related mental health diseases. Various models have used DL approaches to identify, predict, and categorise depression. AI research has recently increased to deliver a high degree of accuracy. Researchers frequently use DL methods such as CNN, LSTM, RNN, and others as a single or hybrid model to identify their strengths

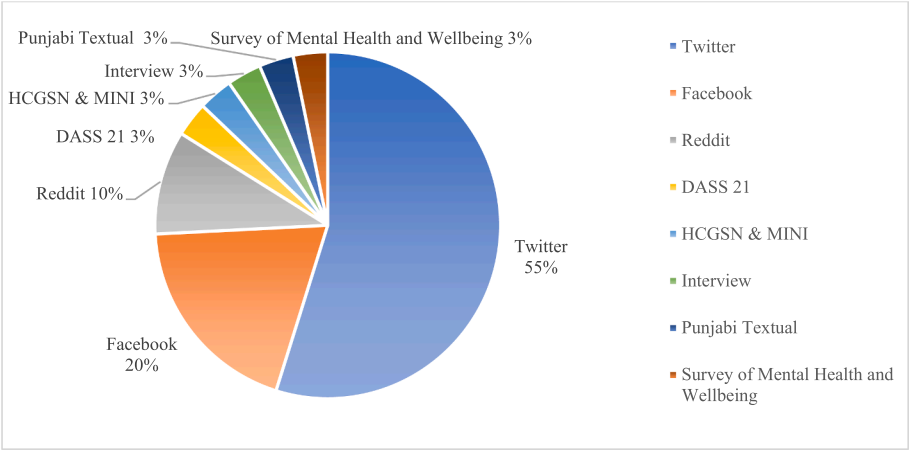

Fig. 8. Data Source of ML.

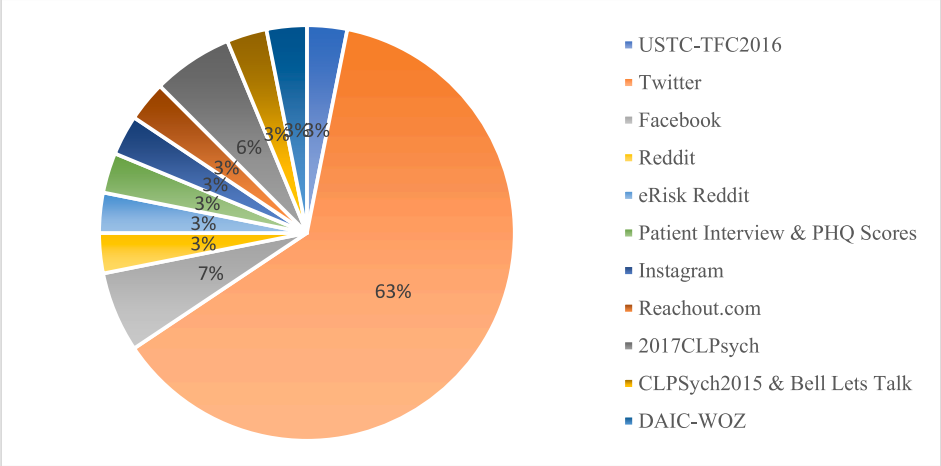

Fig. 9. Data Source of DL.

and shortcomings in these areas. Many studies are using DL to accurately predict depression using data retrieved from social media sites like Facebook, Twitter, Instagram, and ReachOut.com.

This study shows that there has been a decline in research on depression using ML between 2021 and 2023 as attention has been shifted to DL, as shown in Fig. 2. The highest level of research related to ML was in 2019. The recent development in the use of DL to predict depression has contributed to the decrease in the use of ML in research interest in AI. Fig. 3 shows that there has been an increase in the use of DL to detect depression. From 2017 to 2019, there has been a steady increase, even though there was a drop in 2020. 2022 provides the highest level of research with DL. The level of research in 2023 has dropped slightly. Figs. 4 and 5 show that the most emphasis on both ML and DL research was on depression detection. 77 % of ML and 63 % of DL research focused on depression detection. Fig. 6 shows that the frequently used ML techniques in the study of depression detection are SVM with 21 %, 16 % NB, 13 % RF, and 12 % DT. The DL techniques often used by researchers in depression detection, as shown in Fig. 7, are 27 % LSTM network techniques, 29 % CNN, 20 % RNN, and 9 % use bi-LSTM. Fig. 8 shows that most data sources used in ML research for depression detection were from social media sites, with 55 % from Twitter, 20 % from Facebook, and 10 % from Reddit. The analysis for DL in Fig. 9 revealed that 63 % of the data sources were obtained from Twitter, 7 % from Facebook, and 6 % from 2017 CLPsych.

DL is a subset of ML that has attracted considerable interest and appeal due to its capacity to handle challenging problems and large datasets. DL can automatically learn and extract relevant features from raw data. It can offer several advantages over traditional ML methods in detecting depression, such as automatic feature extraction, complex data handling, scalability, non-linear relationships, transfer learning, multi-modal fusion, and adaptability.

9. Prospects for future research

Most of the research has been on early detection. There has been little research on identifying such individuals by other individuals, such as family and friends, who are likely to provide early help before the medical practitioners. In most situations, even after the research, medical practitioners have done little to meet and attend to such patients to provide medical attention. There is also a need to improve the ability to detect the severity, frequency level, and other aspects of depression to assist doctors and healthcare providers in their everyday work. Some studies used Twitter datasets to diagnose depression using both ML and DL techniques; however, other datasets are needed because not everyone uses Twitter. To provide a broader scope, data from social media platforms like Facebook, YouTube, WhatsApp, Instagram, WeChat, TokTok, Telegram, Reddit, and eRisk should be used in addition to Twitter. Datasets from hospitals and psychiatric facilities are being analyzed to see if they might provide insights regarding the occurrence of depression and other mental health illnesses.

DL techniques are increasingly being used in the detection of depressed individuals, according to new research. However, few comparison studies have determined which DL approaches and input datasets can achieve high accuracy. It is necessary to utilise a hybrid technique to compare multimodal datasets, i.e., two or more data sources, to identify, detect, evaluate, predict, compare, analyse, and classify depression to assist doctors, psychiatrists, and other relevant clinicians with depression cases and other linked mental illnesses. Many studies used both ML and DL-supervised learning methods in their research, where both inputs and predicted outputs were known. More research is needed to assess the efficiency and accuracy of additional DL approaches in predicting and detecting depression in individuals.

10. Conclusion

DL techniques have been demonstrated to be a more realistic method of diagnosing depression. Depression is among the most common diseases and is viewed as one of the deadliest issues presently afflicting people around the globe. Most researchers and healthcare managers use ML and DL approaches to improve detection, prediction, and decision-making. In the systematic literature review, an investigation was made on research trends that focused on ML and DL techniques and social media datasets that were commonly used. The results show that research using the DL technique has grown, and new methods are emerging as AI technologies develop. The most common methods for predicting, categorizing, and comparing research findings were CNN, LSTM, and RNN. Furthermore, Facebook, Reddit, and Twitter tweets are the study's most frequently used datasets.

CRediT authorship contribution statement

Wadzani Aduwamai Gadzama: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Danlami Gabi:** Methodology. **Musa Sule Argungu:** Visualization. **Hassan Umar Suru:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Adarsh V, Arun Kumar P, Lavanya V, Gangadharan GR. Fair and explainable depression detection in social media. Inf Process Manag 2023;60(1):103168. https://doi.org/10.1016/j.ipm.2022.103168.

[2] Adebowale, M. A., Lwin, K. T., & Hossain, M. A. (2019). Deep Learning with Convolutional Neural Network and Long Short-Term Memory for Phishing Detection. 13th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), March 2018, 1–8.

[3] Al Asad N, Mahmud Pranto MA, Afreen S, Islam MM. Depression detection by analyzing social media posts of user. In: 2019 IEEE International Conference on Signal Processing, Information, Communication & Systems (SPICSCON); 2019. p. 13–7.

[4] Aldarwish, M. M., & Ahmad, H. F. (2017). Predicting Depression Levels Using Social Media Posts. *Proceedings - 2017 IEEE 13th International Symposium on Autonomous Decentralized Systems, ISADS 2017*, 277–280. 10.1109/ISADS.2017.41.

[5] Alhanai, T., Ghassemi, M., & Glass, J. (2018). Detecting Depression with Audio/Text Sequence Modeling of Interviews. Proceedings of the Annual Conference of the International Speech Communication Association, INTERSPEECH, 2018-Septe (September), 1716–1720. 10.21437/Interspeech.2018-2522.

[6] Alsagri, H. S., & Ykhlef, M. (2020). Machine Learning-based Approach for Depression Detection in Twitter Using Content and Activity Features. In *IEICE Transactions on Information and Systems* (Vol. E103D, Issue 8). Institute of Electronics, Information and Communication, Engineers, IEICE. 10.1587/transinf.2020EDP7023.

[7] Amanat A, Rizwan M, Javed AR, Abdelhaq M, Alsaqour R, Pandya S, et al. Deep Learning for depression detection from textual data. Electronics (Switzerland) 2022;11(5). https://doi.org/10.3390/electronics11050676.

[8] Anbukkarasi S, Jeevapriya S, Kaaviyaa A, Lawvanyapriya T, Monisha S. Deep Learning based depression detection from social media text. Appl Comput Eng 2023;2(1):655–61. https://doi.org/10.54254/2755-2721/2/20220632.

[9] Angskun J, Tipprasert S, Angskun T. Big data analytics on social networks for real-time depression detection. Journal of Big Data 2022;9(1). https://doi.org/10.1186/s40537-022-00622-2.

[10] Arora P, Arora P. Mining twitter data for depression detection. International Conference on Signal Processing and Communication (ICSC) 2019;2019:186–9.

[11] Ashraf, A., Gunawan, T. S., Riza, B. S., Haryanto, E. V., & Janin, Z. (2020). On the Review of Image and Video-Based Depression Detection Using Machine Learning. Indonesian Journal of Electrical Engineering and Computer Science, 19(3), 1677–1684. 10.11591/ijeecs.v19.i3.pp1677-1684.

[12] Baghdadi NA, Malki A, Balaha HM, Badawy M, Elhosseini M. An optimized deep Learning approach for suicide detection through arabic tweets. Mdd 2022;1–26. https://doi.org/10.7717/peerj-cs.1070.

[13] Bucur, A. M., Cosma, A., Rosso, P., & Dinu, L. P. (2023). It's Just a Matter of Time: Detecting Depression with Time-Enriched Multimodal Transformers. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 13980 LNCS, 200–215. 10.1007/978-3-031-28244-7_13.

[14] Chakraborty S, Mahdi HF, Ali Al-Abyadh MH, Pant K, Sharma A, Ahmadi F, et al. Large-scale textual datasets and deep Learning for the prediction of depressed symptoms. Comput Intell Neurosci 2022;2022. https://doi.org/10.1155/2022/5731532.

[15] Chatterjee A, Gupta U, Chinnakotla MK, Srikanth R, Galley M, Agrawal P. Understanding emotions in text using deep Learning and big data. Comput Hum Behav 2019;93:309–17. https://doi.org/10.1016/j.chb.2018.12.029.

[16] Chatterjee R, Gupta RK, Gupta B. Depression detection from social media posts using multinomial naive theorem. IOP Conference Series: Materials Science and Engineering 2021;1022(1). https://doi.org/10.1088/1757-899X/1022/1/012095.

[17] Chavan J, Indore K, Gaikar M, Shedge R. Depression detection and prevention system by analysing tweets. Conference on Technologies for Future Cities (CTFC) 2019;5(3):116–9. http://ssrn.com/link/2019-CTFC.html.

[18] Chiong R, Budhi GS, Dhakal S, Chiong F. A textual-based featuring approach for depression detection using machine Learning classifiers and social media texts. Comput Biol Med 2021;135. https://doi.org/10.1016/j.compbiomed.2021.104499.

[19] Chiu CY, Lane HY, Koh JL. Multimodal depression detection on instagram considering time interval of posts. J Intell Inf Syst 2021;56:25–47. https://doi.org/10.1007/s10844-020-00599-5.

[20] Dai Z, Zhou H, Ba Q, Zhou Y, Wang L, Li G. Improving depression prediction using a novel feature selection algorithm coupled with context-Aware analysis. J Affect Disord 2021;295(May):1040–8. https://doi.org/10.1016/j.jad.2021.09.001.

[21] Deshpande, M. (2017). Depression Detection using Emotion Artificial Intelligence. 2017 International Conference on Intelligent Sustainable Systems (ICISS), Iciss, 858–862.

[22] Fu, T., Sun, B., & Zhang, C. (2023). A Deep Learning Model for Accurate and Robust Internet Traffic Classification. Proceedings of the 3rd International Conference on Signal Processing and Machine Learning, 0, 854–859. 10.54254/2755-2721/6/20230939.

[23] Govindasamy, K. A. L., & Palanichamy, N. (2021). Depression Detection Using Machine Learning Techniques on Twitter Data. Proceedings - 5th International Conference on Intelligent Computing and Control Systems, ICICCS 2021, Iciccs, 960–966. 10.1109/ICICCS51141.2021.9432203.

[24] Grover S, Verma A. Design for Emotion Detection of punjabi text using hybrid approach. International Conference on Inventive Computation Technologies 2016;2:1–6.

[25] Gui, T., Zhu, L., Zhang, Q., Peng, M., Zhou, X., Ding, K., & Chen, Z. (2019). Cooperative Multimodal Approach to Depression Detection in Twitter. *The Thirty-Third AAAI Conference on Artificial Intelligence (AAAI-19)*, 110–117.

[26] Gupta S, Goel L, Singh A, Prasad A, Ullah MA. Psychological analysis for depression detection from social networking sites. Comput Intell Neurosci 2022;2022. https://doi.org/10.1155/2022/4395358.

[27] Gural PS. Deep Learning algorithms applied to the classification of video meteor detections. MNRAS 2019;5118:5109–18. https://doi.org/10.1093/mnras/stz2456.

[28] Haque, U. M., Kabir, E., & Khanam, R. (2021). Detection of Child Depression Using Machine Learning Methods. *PLoS ONE*, *16*(12 December 2021). 10.1371/journal.pone.0261131.

[29] He L, Niu M, Tiwari P, Marttinen P, Su R, Jiang J, et al. Deep Learning for depression recognition with audiovisual cues: a review. Information Fusion 2021;80:56–86. http://arxiv.org/abs/2106.00610.

[30] Islam MR, Kabir MA, Ahmed A, Kamal ARM, Wang H, Ulhaq A. Depression detection from social network data using machine Learning techniques. Health Information Science and Systems 2018;6(1):1–12. https://doi.org/10.1007/s13755-018-0046-0.

[31] Islam, M. R., Kamal, A. R. M., Sultana, N., Islam, R., Moni, M. A., & Ulhaq, A. (2018). Detecting Depression Using K-Nearest Neighbors (KNN) Classification Technique. International Conference on Computer, Communication, Chemical, Material and Electronic Engineering, IC4ME2 2018, March 2019, 1–4. 10.1109/IC4ME2.2018.8465641.

[32] Jayanthi K, Deepika K, Rupanjali K, Tharun K, Chowdary D, Sai Eswar K. Depression detection using machine Learning algorithms. International Journal of Advanced Research in Science, Communication and Technology (IJARSCT 2022;2(1). 10.48175/568.

[33] Katchapakirin, K., Wongpatikaseree, K., Yomaboot, P., & Kaewpitakkun, Y. (2018). Facebook Social Media for Depression Detection in the Thai Community. Proceeding of 2018 15th International Joint Conference on Computer Science and Software Engineering, JCSSE 2018, 1–6. 10.1109/JCSSE.2018.8457362.

[34] Keathley-Herring H, Aken EV, Gonzalez-Aleu F, Deschamps F, Letens G, Orlandini PC. Assessing the maturity of a Research area: bibliometric review and proposed framework heather. Scientometrics 2016;109:927–51. https://doi.org/10.1007/s11192-016-2096-x.

[35] Khafaga, D. S., Auvdaiappan, M., Deepa, K., Abouhawwash, M., & Karim, F. K. (2023). Deep Learning for Depression Detection Using Twitter Data. Intelligent Automation and Soft Computing, 36(2), 1301–1313. 10.32604/iasc.2023.033360.

[36] Kour H, Gupta MK. An hybrid deep Learning approach for depression prediction from user tweets using feature-rich CNN and bi-directional LSTM. Multimed Tools Appl 2022;81(17):23649–85.

[37] Kumar A, Sharma A, Arora A. Anxious depression prediction in real-time social data. SSRN Electron J 2019;2019:1–7. https://doi.org/10.2139/ssrn.3383359.

[38] Kumbhar, M., Dube, R., Barbade, M., Kulkarni, M., Konda, M., & Konkati, M. (2021). Depression Detection Using Machine Learning. International Conference on Smart Data Intelligence (ICSMDI 2021). https://ssrn.com/abstract=3851975.

[39] Li X, Zhang X, Zhu J, Mao W, Sun S, Wang Z, et al. Depression recognition using machine Learning methods with different feature generation strategies. Artif Intell Med 2019;99. https://doi.org/10.1016/j.artmed.2019.07.004.

[40] Lin, C., Hu, P., Su, H., Li, S., Mei, J., Zhou, J., & Leung, H. (2020). SenseMood: Depression Detection on Social Media. ICMR 2020 - Proceedings of the 2020 International Conference on Multimedia Retrieval, 407–411. 10.1145/3372278.3391932.

[41] Losada DE, Crestani F, Parapar J. The challenge of Early risk prediction on the internet. Studies in Computational Intelligence 2022;1018:9–29. https://doi.org/10.1007/978-3-031-04431-1_2.

[42] Ḿarmol-Romero, A. M., Moreno-Mũñoz, A., Plaza-del-Arco, F. M., Molina-Gonźalez, M. D., Marťın-Valdivia, M. T., Ureña-Ĺopez, L. A., & Montejo-Ŕaez, A. (2023). Overview of MentalRiskES at IberLEF 2023 : Early Detection of Mental Disorders Risk in Spanish. Procesamiento Del Lenguaje Natural, 329–350. 10.26342/2023-71-.

[43] Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Japanese Pharmacology and Therapeutics 2015;47(8):1177–85.

[44] Nadeem, A., Naveed, M., Satti, M. I., Afzal, H., Ahmad, T., & Kim, K. (2022). Depression Detection Based on Hybrid Deep Learning SSCL Framework Using Self-Attention Mechanism : An Application to Social Networking Data. 1–28.

[45] Nadeem, Moin, Horn, M., & Coppersmith, G. (2016). Identifying Depression on Twitter. 1–9. http://arxiv.org/abs/1607.07384.

[46] Narayanan SR, Babu S, Thandayantavida A. Detection of depression from social media using deep Learning approach. Journal of Positive School Psychology 2022;6(4):4909–15.

[47] Onyeaka H, Firth J, Ajayi KV, Muoghalu C, Holmes K, Nkemjika S, et al. Association between social media use and health promotion among individuals with depression and anxiety: insights from the 2017–2020 health information National Trends Survey. Journal of Mood and Anxiety Disorders 2023;1(May):100006. https://doi.org/10.1016/j.xjmad.2023.100006.

[48] Orabi, A. H., Buddhitha, P., Orabi, M. H., & Inkpen, D. (2018). Deep Learning for Depression Detection of Twitter Users. The Fifth Workshop on Computational Linguistics and Clinical Psychology: From Keyboard to Clinic, 88–97.

[49] Pranav, K. (2018). Neural Network Based System to Detect Depression in Twitter Users via Sentiment Analysis. International Research Journal of Engineering and Technology, 05(09), 1449. www.irjet.net.

[50] Priya A, Garg S, Tigga NP. Predicting anxiety, depression and stress in modern life using machine Learning algorithms. Procedia Comput Sci 2020;167:1258–67. https://doi.org/10.1016/j.procs.2020.03.442.

[51] Rajaraman PV, Nath A, Akshaya PR, G, c. b.. Depression detection of tweets and a Comparative test. International Journal of Engineering Research & Technology (IJERT) 2020;9(03):422–5. http://www.ijert.org.
[52] Shetty NP, Muniyal B, Anand A, Kumar S, Prabhu S. Predicting depression using deep Learning and ensemble algorithms on raw twitter data. International Journal of Electrical and Computer Engineering (IJECE) 2020;10(4):3751–6. https://doi.org/10.11591/ijece.v10i4.pp3751-3756.
[53] Shrestha A, Serra E, Spezzano F. Multi-modal social and psycho-linguistic embedding via recurrent neural networks to identify depressed users in online forums. Network Modeling Analysis in Health Informatics and Bioinformatics 2020;9(1). https://doi.org/10.1007/s13721-020-0226-0.
[54] Skaik R, Inkpen D. Using twitter social Media for Depression Detection in the Canadian population. ACM International Conference Proceeding Series 2020; 109–114. https://doi.org/10.1145/3442536.3442553.
[55] Steinsbekk S, Nesi J, Wichstrøm L. Social media behaviors and symptoms of anxiety and depression. a four-wave cohort study from age 10–16 Years. Comput Hum Behav 2023;147(July). https://doi.org/10.1016/j.chb.2023.107859.
[56] Tadesse MM, Lin H, Xu BO, Yang L. Detection of depression-related posts in reddit social media forum. *IEEE*. Access 2019;7(c):44883–93. https://doi.org/10.1109/ACCESS.2019.2909180.
[57] Tejaswini V, Babu KS, Sahoo B. Depression detection from social media text analysis using natural language processing techniques and hybrid deep Learning model. ACM Trans Asian Low-Resour Lang Inf Process 2022. https://doi.org/10.1145/3569580.
[58] Tian H, Zhu Z, Jing X. Deep Learning for depression recognition from speech. Mobile Netw Appl 2023. https://doi.org/10.1007/s11036-022-02086-3.
[59] Tyshchenko, Y. (2018). Depression and Anxiety Detection from Blog Posts Data. Nature Precis. Sci, Institute of Computer Science, University of Tartu, Tartu, Estonia.
[60] Uban AS, Chulvi B, Rosso P. An emotion and cognitive based analysis of mental health Disorders from social media data. Futur Gener Comput Syst 2021;124: 480–94. https://doi.org/10.1016/j.future.2021.05.032.
[61] Uddin, H., Durjoy, B., & Arif, A. S. M. (2019). Depression Analysis from Social Media Data in Bangla Language using Long Short Term Memory (LSTM) Recurrent Neural Network Technique. 2019 International Conference on Computer, Communication, Chemical, Materials and Electronic Engineering (IC4ME2), 1–4.
[62] Uddin MZ, Dysthe KK, Følstad A, Brandtzaeg PB. Deep Learning for prediction of depressive symptoms in a Large textual dataset. Neural Comput & Applic 2022;34 (1):721–44. https://doi.org/10.1007/s00521-021-06426-4.
[63] Vaidya T, Yeole R, Paitwar G, Watpade A, Kale N. Deep Learning-based Early depression detection using social media. International Journal of Innovative Research In Technology (IJIRT) 2023;9(10):974–7.
[64] Vandana, Marriwala N, Chaudhary D. A hybrid model for depression detection using deep learning. Measurement: Sensors 2023;25. https://doi.org/10.1016/j.measen.2022.100587.
[65] Vasha ZN, Sharma B, Esha IJ, Al Nahian J, Polin JA. Depression detection in social media comments data using machine Learning algorithms. Bulletin of Electrical Engineering and Informatics 2023;12(2):987–96. https://doi.org/10.11591/eei.v12i2.4182.
[66] Wang Z, Chen L, Wang L, Diao G. Recognition of audio depression based on convolutional neural network and generative antagonism network model. IEEE Access 2020;8:101181–91. https://doi.org/10.1109/ACCESS.2020.2998532.
[67] World Health Organization. (2022). *Mental Disorders*. https://www.who.int/newsroom/ fact-sheets/detail/mentaldisorders Accessed: 2024-02-15.
[68] World Health Organization. Depression and other common mental health Disorders. Global Health Estimates 2023.
[69] Zogan H, Razzak I, Wang X, Jameel S, Xu G. Explainable depression detection with multi-aspect features using a hybrid deep Learning model on social media. World Wide Web 2022;25(1):281–304. https://doi.org/10.1007/s11280-021-00992-2.
[70] Zumbuka S, Gambo Y, Sarjiyus O. Application of machine learning in lung cancer. International Journal of Innovative Science, Engineering & Technology 2021;9(9). www.ijiset.com.