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Depression detection using emotional artificial intelligence and machine learning: A closer review

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ABSTRACT

Depression is a prevalent mental disorder that can have a significant impact on people's mental health as well as their day-to-day lives. Depression and mental illness are a key problem in society nowadays. It can cause a loss of interest in general activities that can lead to suicidal thoughts. Hence, the need of an automated system that can help in detecting depression in people of various age groups is being realized. In order to detect depression, Researchers have been looking for approaches to effectively identify depression. A number of studies have been proposed in this regard. Here, In this study, we are analysing various existing studies based on Artificial Intelligence (AI) and diverse Machine Learning (ML) techniques being used to detect depression. Apart from it, different approaches used to detect emotion and mood in an individual are discussed. This study analyses how facial expressions, images, emotional chatbots and texts on social media platforms can be effectual in detecting one's emotions and then depression. Naive-Bayes, Support Vector Machines (SVM), Long Term Short Memory (LSTM) – Radial Neural Networks (RNN), Logistic Regression, Linear Support Vector, etc. are the various ML techniques used to recognize emotions from text processing; Artificial Neural Network (ANN) is used for feature extraction and classifications of images to detect emotions through facial expressions. This paper aims to provide the survey of various AI and ML techniques which help in the detection and analysis of emotion and hence depression along with their related research issues.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Artificial Intelligence & Energy Systems.

1. Introduction

Depression can occur in people of all ages. It can be very risky and can lead to anxiety attacks, death after a heart attack and problems like blood pressure and diabetes. Therefore, it is very important to detect it and find causes of the same that can lead to appropriate treatment. There is also a need to remove stigma around depression and mental health therefore Social Network Mental Disorder Detection can be performed which can help in de-stigmatizing it. Tests can be performed based on various artificial intelligence and machine learning algorithms under different scenarios to detect emotional imbalance. With the rise in technology, various AI-based approaches are evolved to make machines emotionally intelligent to detect emotions in human beings. Text-based emotion recognition, for example, sentiment analysis of tweets and posts on various social media platforms can help in detection of the mood and emotion of the user, also help in prediction of suicidal thoughts in user and prevention of suicide by warning the users or their closed ones. For this, various machine learning algorithms like Naive-Bayes, Support Vector Machines (SVM), etc. can be used and results can be evaluated through confusion matrix. The algorithm which performs well will have high precision score and helps in correctly predicting sentiment that can be either positive or negative.

Emotions can be detected through facial expressions, various gestures, speech, text analysis, etc. To cite an example, an AI based driving application which can alert the driver in car if he sleeps while driving and therefore can prove to be a life-saving application. All of this can be done through facial expression detection of the person which captures facial image by camera and identifies that the person is sleeping or not. Similarly, with the help of various gestures of eyes, mouth, nose and hands moods like anger, happiness, sadness, neutral, etc. can be detected via emotion detec-

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tion systems using image and video processing. Emotions can also be detected by chatbots with the help of analysis of text and emoticons user exchanges with the chatbots. If a user is sad then the system will automatically generate a joke or play music to lighten the mood of the user. For this, ML, AI and data mining techniques are being used. The emotion detection application saves data from chat bots of how user responds in a database. This can be helpful in stress management. There are various applications of emotion detection systems. In video gaming to measure fear and excitement in an individual, emotion detection systems can be used. In market research emotions are detected to know what customers are feeling which is very important in businesses. Emotion detection systems can be used to detect emotion of the customer through customer reviews for various products. Utilising emotion analytics in recruitment process companies can easily find prospective candidates for jobs. AI algorithms measure the facial expressions, personality traits and emotions in a video interview based on candidate's responses which leads to an unbiased interview process and makes job of the interviewer easy. In times of COVID-19, there is a need of interactive virtual agent-based health care delivery systems which help in depression detection.

With the help of live video streams and audio streams, sequencing of frames and then with some processing emotions can be detected through various machine learning techniques like Principal Component Analysis (PCA) which helps to extract facial attributes and K-means algorithm through which clusters of facial expression are evaluated. Pre-processing, feature extraction and classification using neural networks are the steps used to extract and recognize emotions from facial expressions. Haar-cascade algorithms, K-Nearest Neighbours (KNN) Classification technique, combining Optical Character Reader (OCR) with AI and artificial neural networks are the various techniques used to detect depression through facial expression. Partial Least Square Algorithm is used to detect emotion from vocal expression. Depression can be detected through tweets with the help of various ML techniques like TF-IDF, Naïve-Bayes, Long Term Short Memory (LSTM) – Radial Neural Networks (RNN), Logistic Regression, Linear Support Vector. Texts from chatbots can be pre-processed and then divided into training and testing data sets and ML algorithms can be applied to detect emotions from text. Sentiment analysis using NLP technique is used to recognize emotions from tweets. The figure given below gives a quick idea of different terminologies related to depression detection discussed in this paper. Fig. 1 depicts various sources and techniques to detect depression.

Fig. 1. Different sources and techniques to detect depression.

In this paper A study of existing approaches based on various AI and ML techniques are done. Section 2 presents literature review. Section 3 discusses analysis and section 4 concludes the paper.

2. Literature review

The literature review of this paper is divided into three subsections as per the detection of emotions with respect to different sources. The first sub-section discusses about the studies conducted to detect depression through sentiment analysis of twitter tweets. The second sub-section converse about detection of depression using facial expression (image and video processing). The last sub-section deals with the use of chatbots, emotional AI and combined inputs (text, audio, image and video) for detecting depression. All these sources to detect depression are discussed in the terms of various machine learning techniques.

2.1. Twitter sentiment analysis and various ML techniques (Text processing)

NLP is a branch of AI that employs the aforementioned computational tools, but it focuses on how computers handle and analyse human language in the form of unstructured text, including language translation, semantic comprehension, and information extraction. Due to the large amount of raw input data in the form of text and conversation, mental health treatment will rely significantly on NLP before being able to undertake other AI approaches. The ability of a computer programme to automatically interpret the meanings of underlying words, despite the ambiguity of human language, is a significant technological achievement that is critical for mental health applications.

The study discussed in [2] talks about the feasibility of consistently identifying, and pursuing the diagnosis of individual tweets is established. A bag of words approach is used to quantify depression through an analysis of word frequencies. Four different types of binary classifiers are used namely decision trees, LSV Classifier, a Logistic Regressive approach and Naïve Bayes algorithm. By using a collection of 2.5 M tweets, 81% accuracy rate in classification is achieved, with a precision score of 0.86. The performance of the proposed system is evaluated through precision, recall and F1-Score. The study claims that their proposed method may be helpful in developing tools to estimate the risk of an individual being depressed. The study found to preferably make use of linear Support Vector Machine experimentally.

The method proposed in [5] makes use of emotional artificial intelligence to detect depression in individuals. It uses Natural Language Processing and sentiment analysis of tweets to detect depression. First the data is collected from Twitter using Twitter APIs. Then keyword search based on wordlist occurs, tweets are filtered in JSON format and then the text element is extracted from the JSON format. Further, the data is cleaned and csv file is generated for train and test set for which the ratio is 80:20. Second step in the training phase is Data Pre-Processing in which training csv file is read for inputs. Tokenisation, Stemming, Stop Words Removal, POS Tagger are the pre-processing methods applied on the data. Then a bag of words model is created which calculates the number of occurrences of each term and it is used as a feature to train a classifier. The trained classifier and count vectorizer objects are dumped to pickle file. Third step is testing phase in which pre-trained model is loaded from the pickle file and text is

pre-processed in the same manner as the training data. Then the test tweets are classified into positive or neutral and confusion matrix is computed. It is observed that Multinomial Naïve Bayes algorithm worked better than SVM in terms of accuracy and F1 score.

According to the study [6] depression levels can be predicted by looking at social media posts. SVM and Naive-Bayes are two distinct classifiers used to classify user-generated content (UGC) from social networking sites (SNS). A method based on social media can be utilised to solve self-reporting issues. The dataset's posts were gathered from three social media sites: Facebook, Live Journal, and Twitter. A web tool is proposed for classifying SNS users into one of four stages of depression (Minimal, Mild, Moderate, Severe). RapidMiner is used to test two classifiers (SVM and Nave-Bayes) to construct a predating depression model. Results are evaluated using confusion matrix and accuracy using precision and recall.

The method suggested in [8] takes a set of tweets as a source of data, performs Senti Strength sentiment analysis to provide training data for the system, and then classifies the tweets into depressive or non-depressive categories using a Back Propagation Neural Network (BPNN) model. The Twitter API is used to gather tweets. After that, sentiment analysis is performed, in which each tweet is given a sentiment value, which is then used as training data for the BPNN model. The NLTK (Natural Language Toolkit) assists in data pre-processing. The suggested system employs a machine learning algorithm for text classification. The test data for the proposed classification model, which is grouped tweets, is classified.

The method proposed in [10] applies ML techniques to detect depression among social media users, particularly Facebook users and also identify high-quality solutions of mental-health problems. The model for Facebook data analysis for depression analysis includes phases such as data collecting, data cleaning, data normalisation, feature extraction, depression categorization, and detection outcome. The dataset is subjected to Linguistic Inquiry and Word Count (LIWC). Three sorts of factors are investigated (emotional process, temporal process, and linguistic style), and a model is trained to use each type of element alone and together. The accuracy of decision trees was found to be higher than that of other machine learning algorithms used to classify the features of comments.

The research proposed in [11] detects depression using K-Nearest Neighbours (KNN) Classification technique. Data is extracted from social media Facebook comments and it is classified to recognize emotions. NCapture is used to collect data, and comments are divided into two categories: depression-indicative comments (1) and non-depression-indicative comments (0). Different forms of KNN classification approaches are utilisedemployed to extract depressive emotional results based on linguistic style, emotional process, temporal process, and all aspects. Out of the several KNN classifiers: Fine KNN, Medium KNN, Coarse KNN, Cosine KNN, Cubic KNN, and Weighted KNN, Coarse KNN is the best performer. 10-fold cross validation is applied on all test datasets. Evaluation parameters such as precision, recall, and F-measure were used to calculate performance.

The study mentioned in [12] conducted sentiment analysis of tweets. A dataset taken with 43,000 tweets and divided as training and test data in the ratio 70:30. Dataset consists of two columns text which is the tweets and sentiment which is either positive (1) or negative (0) and is found using Naïve-Bayes Classifier and Support Vector Machines algorithms. In the pre-processing phase steps like emoji extraction, hyperlink removal, slang substitution, timestamp removal, digits removal, symbols removal, spelling correction, proper nouns removal, lemmatization, stop words removal are carried out. Then the model is trained using bag of words model which identifies the frequency of a term in the text which helps build the predictive model. Then the 30% of the test data is pre-processed and tested and found out if the tweet is positive or negative. Further, the results are evaluated through confusion matrix and concluded that in terms of depression detection Multinomial Naïve Bayes worked better than SVM algorithm.

The research mentioned in [13] analyses depression using various machine learning techniques. In-time perception in depression, Filtering and Classification processes are discussed to analyse depression. Time-perceptron analysis gives a result based on time spent by a person in social media which leads to increased anxiety levels. Various social media posts are analysed, syntax and semantic analysis is done for emotion detection of the person. Detecting through tweets of a person, emotions and thoughts are predicted as suicidal or non-suicidal through ML techniques and depression is identified in all age groups.

In this [17] paper depressive tweets are detected using TF-IDF predictions. Python version 3.1 and libraries like Numpy, Scikit Learn, Matplot, NLTK, WordCloud, Keras are used. The Data acquisition occurs through twitter dataset and then data is pre-processed and then words are embedded into five baseline models and then training and testing occurs and tweets are classified as normal or depressive. Comparative analysis of various techniques like TF-IDF, Naïve-Bayes, LSTM, Logistic Regression, Linear Support Vector and depression through tweets is being detected. It is found that Long Term Short Memory (LSTM)-RNN which is a deep learning classifier has the highest accuracy to detect depression through tweets from twitter. Results are evaluated through confusion matrix which has five major parameters Precision, Recall, F1-Score, Support and Accuracy.

The research proposed in [19] various ML-based approaches are exploited to find whether a twitter user is depressed or not based on his/her social network behaviour and tweets. More the features are extracted, the higher is accuracy and F-measure scores in detection of depressed users. SVM, Naïve-Bayes, Decision Tree are the various classification algorithms used. The SVM-linear classifier demonstrated the best performance out of these. "Depression detection using activity and content features (DDACF)" classification model is used. Features are extracted from the text after pre-processing. Tweet's features visualized as Self-Center, TF-IDF, Feature Selector (possible values as Information Gain and Most Frequent), Sentiment (possible values as Avg and Mixed), Use Words (possible values as Dept-Sent and Non-Sparse) and Account Measures which has possible values As-is, Norm, Categorical.

In the study [20] machine learning classifiers are employed in the twitter dataset to identify whether a person is depressed or not. It is divided into two stages. In the first stage Sentiment analysis is applied on an individual's twitter posts to predict binary classes i.e., depressed/not depressed. LSTM and Convolution Neural Network (CNN) classifiers results are compared. In the second stage machine learning classifiers and a few optimised ensembles are used to improve the outcome of the proposed work in the first stage. Classifiers used are linear support vector classifier (SVC), multinomial naïve-bayes, Bernoulli naïve-bayes, logistic regression along with ensembles like random forest classifier and gradient boosting classifier. The data is split into training and test dataset followed by vectorizing the tweets. It offers three types of vectorizers to classifiers: count vectorizer, TF-IDF, and n-grams. The weighted mean of all second-stage alternatives is included in the final result. This number is compared to the predictions from the first stage. The weights are assigned based on the model's accuracy on the data.

2.2. Facial expressions (Image and Video Processing)

It has now become a serious worry due to an increase in mental health disorders and cases around the world. Depression has far-reaching consequences for both the person suffering from it and

the entire community. With the recent increase in Artificial Intelligence (AI) and Deep Learning technologies, they can be put to good use in the field of healthcare, allowing doctors to better recognise and anticipate mental health conditions like depression early on, and treat them before they cause significant harm [18].

As per study conducted in [1] Face based automatic recognition systems are a useful part of applications to detect emotions and hence depression. Facial muscles of people signal their emotional states. The proposed system in this study used three steps preprocessing, feature extraction and classification. Five different facial expressions Happy, Angry, Surprise, Neutral and Fear were considered. If frontal features were detected, feature extraction was done otherwise gaussian filtering was done to remove unwanted noise and then feature extraction was done. Then the classification tasks were performed using the neural networks. Logarithmic Gabor filters were applied after extracting the features and then optimal subset of features were selected for each expression and then classification was done. Facial Action Coding System (FACS) have been used for recognition and classification of human emotions. This system codifies human facial expression by their appearance on face. Inner brow raises, brow lower, upper lid raise, lip stretch, jaw drop, etc. these muscle movements have been assigned action codes and these help in emotion recognition. The image was collected from the database and the skin part was extracted from the collected image. It is referred to as skin mapping. The part we are interested in was extracted and the extracted image was then converted into a binary image. This is how we get expression of a given image. YALE facial expression database was considered. In the work FACS concepts were used at better efficiency with help of skin mapping, pattern matching and local features of the human face to gain the accurate result for recognizing and classifying of human emotions.

In this [4] paper image processing technique to recognize facial emotions is discussed. Initially videos are taken and converted into frames. MATLAB VideoReader() function is used to convert into video frames of .jpg format. Then image acquisition, preprocessing, face detection, face cropping, image segmentation, morphological processing, masking and mouth area calculation are the various steps done to recognize emotions. Emotions are mainly classified based on mouth regions. Viola-jones algorithm is used to detect the face region. The proposed system is tested on video frames and a video of child with three different emotions is recorded and facial emotion is identified on the basis of filled mouth region. Neutral, Smile and Cry are the three different emotions recognized through a video of child with 810 frames.

The comparative study of different methods conducted in [9] is used to recognize emotion from facial expressions. Face detection, extraction of important features and classification of emotion based on facial features are the steps of the proposed system. Trained neural networks are used for face detection. Feature extraction techniques used in different papers are PCA, Gabor Filters, etc. SVM, K-means clustering are the various ML algorithms used in different papers for classification of emotions.

2.3. Use of chatbots, emotional AI and combined inputs (Text, Audio, Image, Video)

Internet-based cognitive behavioural therapy has been utilised since the 1990s, but it is not as popular as it once was. The chatbot may give CBT in a natural conversational approach, which can help to provide additional benefits. Clinical psychologists at Stanford University created the "woebot" app in 2017. Within a two-week course, this app helped college students minimise depression and anxiety. The app is a digital version of a cognitive behavioural therapy that has been around for 40 years. It is nothing more than highly structured talk psychotherapy that aims to change a patient's negative thought pattern in a minimal number of sessions. However, the best way to use such apps is still unknown.

The piece of research contributed by [3] states that there is a need for interactive virtual agent-based healthcare delivery systems and depression can be detected using Partial Least Square Algorithm from vocal expression. Data from different people are considered and they are asked to fill a questionnaire and share their problem through speech or text input in the application. A chatting application is provided with which the user discusses problems and the chatbot provides human-like responses according to the questionnaire. The anonymity of the user is maintained so that the user feels comfortable discussing problems on the application and it provides a platform to reach out to others seeking help and suffering from mental illness. In this paper speech and text input are analysed for depression detection. Non-verbal features are extracted and speech is converted into text for analysis and the text is then processed and structured. Google Speech API can be used to convert speech to text and it is used for speech recognition. Then the data is passed onto Radial Basis Function Network (RBNF) which searches the database for suggestions and recommends response to the user. Weights are updated according to user ratings in RBFN. It was also found that it is easier for a user to text as compared to speech as it maintains privacy of the user.

The study mentioned in [7], mood is detected through image processing and chatbot using artificial intelligence. The classification technique used is neural networks. The algorithm used for image processing is Haar Cascade Algorithm and works with face detection. The cascade function is trained with many positive(face) and negative(faceless) images. Then feature extraction is done. Along with this classifier is prepared using AdBoost and integral images. The system will also be able to detect emotions by chatting with a chatbot. Accordingly, the system will interact with the user by detecting mood and giving stress bursting responses. For example, the image of the user is captured using the camera or text messages are exchanged and then the mood detecting application i.e., chatbot will detect emotions and play songs or provide a joke to lighten the mood of the user.

The research conducted in [14] provides Artificial Intelligence based Mental Evaluation system which can predict whether the patient is depressed or not through deep learning. The user's behavioural data is collected using video, audio, speech and is combined with demographics for appropriate prediction. Patient health questionnaire is given to the participants which help detect depression through scores. A multi model deep learning model is developed to detect depression. Results are evaluated using confusion matrix.

In this [15] paper it is shown that how AI helps in suicide prevention and has a great role in advance medical healthcare and clinical management efforts. Predictive models in ML can help to detect suicide risk. Conversational agents are NLP-based computer programs which interacts and engages with user to provide therapy for low mood and suicidal behaviours. AI has been linked with social media to detect and analyse depression in social media users. Patient data can be obtained from multiple sources like social media, research databases, audio and video recordings and these data can be used to develop predictive models in ML where patterns of suicidal behaviour and depression can be detected and used to inform clinical management strategies and prediction analytics. Then the patient care systems can be built that provide real-time, integrative support across algorithm informed diagnostics, behavioural therapy, follow-up medications, etc.

The study mentioned in [16] proposes an Expert System for Stress Management (ESSM) plays the role of a virtual councillor to detect stress and depression, provide solutions and appropriate remedies. It saves user's time and cost to visit therapist and works as an Artificial Intelligence therapist and mental health management system. Chatbot is used to take input form the user and user's

Table 1
Study of emotional artificial intelligence and various machine learning techniques to detect and analyse depression.

S. No.	Title of the Paper	Author's Name	Year of Publishing Paper	Objective (Problem addressed)	Criteria/ Source to Detect Depression	Data Set Used	Techniques Used to Detect Depression	Results	Performance Parameters
1.	Identifying depression on Twitter	Nadeem, M.	2016	A method is established by which depression is recognised by analysing large-scale records of users' linguistic histories on social media, particularly Twitter	Text-processing and Twitter Sentiment Analysis	2.5M Tweets	Decision Trees Support Vector Classifier, Naive Bayes w/ 2-grams, Logistic Regression, Naive Bayes w/ 1-grams and Ridge Classifier	A multinomial approach to the Nave Bayes' algorithm provides an A-grade ROC AUC score of 0.94, a precision score of 0.82, and an accuracy of 86 percent; a Bag of Words approach was found to be a helpful feature set, while bigrams offered no substantial advantage over a unigram-based approach.	**ROC AUC score of Logistic Regression** : 0.91, **Linear SVMs:** (0.80), **Ridge Classifiers:** (0.74), **Decision Tree:** (0.64) **Naive Bayes :** 0.94
2.	Depression detection using emotion artificial intelligence	Deshpande, M., & Rao, V.	2017, December	NLP and sentiment analysis of tweets to detect depression.	Text-processing and Twitter Sentiment Analysis	10,000 Tweets	Multinomial Naïve Bayes algorithm, SVM	It was observed that Multinomial Naïve Bayes algorithm worked better than SVM in terms of accuracy and F1 score.	Precision, Recall, F1-Score and Confusion Matrix
3.	Predicting Depression Levels Using Social Media Posts	M. M. Aldarwish and H. F. Ahmad	2017	A system is suggested that leverages SNS as a data source and screening tool to classify users using AI based on user generated content on SNS. SVM and Naïve-Bayes are the two different classifiers used to classify the UGC from SNS.	Text-processing and Twitter Sentiment Analysis	Social Media posts (6773) from: LiveJournal, Twitter and Facebook	SVM and Naïve-Bayes	Results are evaluated using confusion matrix and parameters like accuracy, precision and recall. SNS user is classified into one out of four depression levels (Minimal, Mild, Moderate, Severe).	**SVM** Accuracy: 57% Precision: 67% Recall: 56% **Naive Bayes:** Accuracy: 63% Precision: 100% Recall: 58%
4.	Detecting Depression in Social Media Posts Using Machine Learning.	Biradar, A., &Totad, S. G.	2018, December	To create training data for the system, SentiStrength sentiment analysis has been done, and a BPNN model is utilised to classify the tweets into depressive or non-depressive categories.	Text-processing and Twitter Sentiment Analysis		BPNN and SentiStrength	A hybrid model that uses a sentiment analysis technique like SentiStrength to generate the train data and a BPNN model to categorise it.	
5.	Depression detection from social network data using machine learning techniques	Islam, Md Rafiqul & Kabir, Ashad& Ahmed, Ashir& Kamal, Abu & Wang, Hua &Ulhaq, Anwaar.	2018	An investigation of depression is conducted using Facebook data obtained from an open public source. In Facebook users, machine learning techniques find high-quality solutions to mental health issues.	Text-processing	Facebook data (User's Comments)	Decision Tree, Support vector Machine, Ensemble and K-Nearest Neighbour	In various trials, Decision Tree outperforms other machine learning algorithms in detecting depression.	Precision, Recall and F-measure (to assess emotional process and linguistic styles, Temporal process and all features)
6.	Detecting	Islam, Md	2018	Detecting	Text-	Facebook	Fine KNN,	A model was	Precision,

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Table 1 (*continued*)

S. No.	Title of the Paper	Author's Name	Year of Publishing Paper	Objective (Problem addressed)	Criteria/ Source to Detect Depression	Data Set Used	Techniques Used to Detect Depression	Results	Performance Parameters
	Depression Using K-Nearest Neighbors (KNN) Classification Technique	Rafiqul & Kamal, Abu & Sultana, Naznin& Islam, Robiul&Ulhaq, Anwaar& Moni, Mohammad		Facebook users' moods using the KNN (k-nearest neighbours) classification algorithm. Fine KNN, Medium KNN, Coarse KNN, Cosine KNN, Cubic KNN, and Weighted KNN were employed as KNN Classifiers.	processing	data	Medium KNN, Coarse KNN, Cosine KNN, Cubic KNN and Weighted KNN	trained to use four types of elements (emotional process, temporal process, linguistic style, and all attributes) individually and together. The best performing model among the several KNN classifiers is Coarse KNN, which has a high F-score.	Recall and F-measure (to assess emotional process and linguistic styles, Temporal process and all features)
7.	Depression Detection With Sentiment Analysis Of Tweets	Hemanthkumar M, Latha A.	2019, May	Sentiment analysis of twitter feeds and classification as positive, neutral and negative. Dataset with 43,000 tweets is taken and tweets are divided into ratio 70:30.	Text-processing and Twitter Sentiment Analysis		Multinomial Naïve Bayes algorithm, SVM	Results are evaluated through confusion matrix. Multinomial Naïve-Bayes has high precision and accuracy therefore worked better than SVM.	
8.	Study of Depression Analysis using Machine Learning Techniques	Devakunchari Ramalingam, Vaibhav Sharma, Priyanka Zar.	2019, May	Various machine learning techniques used to detect depression analysing tweets and various social media posts. In-time perception in depression, filtering and classification processes are discussed.	Text-processing		Various ML Techniques	Detecting through tweets of a person, emotions and thoughts are predicted as suicidal or non-suicidal through ML techniques and depression is identified in all age groups.	
9.	Depression Detection of Tweets and A Comparative Test	Rajaraman, Nath, Akshaya.P. R, Bhuja.G	2020, March	Comparative analysis of various techniques like TF-IDF, Naïve-Bayes, LSTM, Logistic Regression, Linear Support Vector and depression through tweets is being detected.	Text-processing and Twitter Sentiment Analysis	Sentiment 140, tweet Scrap from TWINT and google word2vec	TF-IDF, Naïve-Bayes, LSTM, Logistic Regression, Linear Support Vector Deep learning model using NLP	When it comes to detecting depressive tweets, LSTM has the best accuracy. While TF-IDF has the second highest accuracy in detecting sad tweets, LSV has the third best accuracy.	Precision, Recall, F1-score, Support and Accuracy
10.	Machine Learning-based Approach for Depression Detection in Twitter Using Content and Activity Features	AlSagri, H. S., &Ykhlef, M.	2020	Various ML-based approaches are exploited to find whether a twitter user is depressed or not based on his/her social network behaviour and tweets. "Depression detection using activity and content features (DDACF)" classification model is used.	Text-processing and Twitter Sentiment Analysis	Tweets	SVM, Naïve-Bayes and Decision Trees	More the features are used, the higher is accuracy and F-measure scores in detection of depressed users. SVM, Naïve-Bayes, Decision Tree are the various classification algorithms used. SVM-linear classifier demonstrated the best performance out of these.	Precision, Recall, F1-measure and Area Under Curve (AUC)
11.	Predicting depression using deep	Shetty, N. P., Muniyal, B., Anand, A.,	2020	ML classifiers are employed in the twitter dataset to	Text-processing and Twitter	Twitter Data set	LSTM, CNN, linear support vector classifier (SVC),	The results of LSTM and CNN classifiers are	Precision, Recall, F1-measure

Table 1 (*continued*)

S. No.	Title of the Paper	Author's Name	Year of Publishing Paper	Objective (Problem addressed)	Criteria/ Source to Detect Depression	Data Set Used	Techniques Used to Detect Depression	Results	Performance Parameters
	learning and ensemble algorithms on raw twitter data	Kumar, S., & Prabhu, S.		identify whether a person is depressed or not.	Sentiment Analysis		multinomial naïve-bayes, Bernoulli naïve-bayes, logistic regression, random forest classifier and gradient boosting classifier.	compared. Linear support vector classifier (SVC), multinomial nave-bayes, Bernoulli nave-bayes, logistic regression, and ensembles such as random forest classifier and gradient boosting classifier are some of the other classifiers employed.	
12.	Face Based Automatic Human Emotion Recognition	Savadi, V Patil	2014, July	YALE Database is considered. Image processing and emotion recognition through facial expression.	Facial Expressions (Image and Video Processing)	A video of 810 frames	Neural Networks, Logarithmic Gabor filters, FACS, skin mapping, pattern matching, etc.	Facial Action Coding System is used along with skin mapping of image, conversion of image to binary image and finally when the button is clicked resulting emotion is displayed.	Accuracy: Effective (no quantitative value given)
13.	Image Processing Techniques To Recognize Facial Emotions	A. Mercy Rani, R. Durgadevi	2017, August	Recognizing facial emotions based on filled mouth-regions. Viola-Jones algorithm is used.	Facial Expressions (Image and Video Processing)		Neural networks, Viola-Jones algorithm, etc.	Neutral, Smile and Cry are the three different emotions recognized through a video of child with 810 frames.	
14.	Comparative Study on Mood Detection Techniques	Gavde, Megna	2018	Comparative study of different methods to recognize emotion from facial expressions.	Facial Expressions (Image and Video Processing)		PCA, Gabor Filters, SVM, K-means clustering, etc.	Gabor feature extraction is used to extract features from face. Trained neural network is used for face detection. SVM is used for emotions classification.	
15.	Depression Detection and Analysis	Oak, S.	2017, March	Detection of depression in an individual though RBFN. Text and speech input are considered. Partial Least Square algorithm is used to detect depression from vocal expressions.	Use Of Chatbots, Emotional AI and Combined Inputs (Text, Audio, Image, Video)	53 Volunteers	RBFN (Radial basis function networks)	Similarity in results of RBFN model and questionnaire of user in testing positive for depression. Chatbot application is used with which user discusses problems and human-like responses are provided. And it was also found that it is easier to communicate with text as compared to speech for a user.	Accuracy: 71.4%
16.	Review on Mood Detection using Image Processing and Chatbot using Artificial	Thosar, Gothe, Bhorkade, Sanap	2018, March	Mood detection through image processing using Haar-cascade algorithm, chatbots to detect stress through text/speech input.	Use Of Chatbots, Emotional AI and Combined Inputs (Text, Audio,	An image with 6000 features	Haar-cascade algorithm and Ad-boost	The chatbot and system works by sending jokes or playing music to lighten the mood of user.	Precision: Satisfactory

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Table 1 (*continued*)

S. No.	Title of the Paper	Author's Name	Year of Publishing Paper	Objective (Problem addressed)	Criteria/ Source to Detect Depression	Data Set Used	Techniques Used to Detect Depression	Results	Performance Parameters
	Intelligence				Image, Video)				
17.	Detecting depression using a framework combining deep multimodal neural networks with a purpose-built automated evaluation.	Victor, E., Aghajan, Z. M., Sewart, A. R., & Christian, R.	2019	Artificial Intelligence based Mental Evaluation system can predict whether the patient is depressed or not through deep learning.	Use Of Chatbots, Emotional AI and Combined Inputs (Text, Audio, Image, Video)	671 participants recorded by webcam and microphone while responding interview questions	Multimodal Deep Learning Model	Patient health questionnaire is given to the participants which help detect depression through scores. A multi model deep learning model is developed to detect depression. Results are evaluated using confusion matrix.	Precision: 68.61, NPV: 67.95, Sensitivity: 68.59, Specificity: 67.46 and F-Score: 67.66
18.	The utility of artificial intelligence in suicide risk prediction and the management of suicidal behaviours.	Fonseka, T. M., Bhat, V., & Kennedy, S. H.	2019	This study includes an overview of the literature as well as the role of AI in predicting and managing suicide risk.	Use Of Chatbots, Emotional AI and Combined Inputs (Text, Audio, Image, Video)		ML methods, AI and conversational agents.	Predictive models in ML can help to detect suicide risk. AI has been linked with social media to detect and analyse depression in social media users.	
19.	AI Therapist Using Natural Language Processing	Shephali Santosh Nikam, Aishwarya Vijay Patil, Gauri Shashikant Patil, Sharvari Pramod Patil, B. D. Jitkar.	2020, February	An Expert System for Stress Management to provide best recommendation and solution for youth, especially IT professionals. NLP, Naïve-Bayes, collaborative-filtering algorithms are used. Back-propagation method is used to train the system.	Use Of Chatbots, Emotional AI and Combined Inputs (Text, Audio, Image, Video)	Chatterbot Corpus	Naïve-Bayes Algorithm and Collaborative filtering algorithm, chatbots and Back-propagation method	Chatbot is used to take input from the user and user's reply is used to train the system and recognize emotions and recommender system provides reply to user on the basis of user's emotions.	
20.	The Utility of Artificial Intelligence for Mood Analysis, Depression Detection, and Suicide Risk Management.	Zohuri, Bahman & Zadeh, Siamak. (2020).	2020	Detection of depression by various techniques: combining OCR with AI, deep learning models.	Use Of Chatbots, Emotional AI and Combined Inputs (Text, Audio, Image, Video)		Combined application of Image Processing, Voice or speech recognition and AI, deep learning models	Combining Optical Character Reader with AI leads to facial emotion recognition and can detect whether a person in an image or video is smiling or sleeping (eyes closed) and this can lead to early detection of depression and prevention of suicide.	

reply is used to train the system and recognize emotions and recommender system provides reply to user on the basis of user's emotions. There is a backend which helps in recognition of emotions through Natural Language Processing (NLP), emotions are classified using Naïve-Bayes Algorithm and Collaborative filtering algorithm. According to the emotion particular message will be sent from the database to the user. For example, brave stories will be sent if the user is fearful. PyCharm IDE, Python, HTML, CSS, Flask, Chatterbot, Chatterbot corpus, Jinja 2 are the technologies used. With the invent of AI, chatbots provide an interactive two-way communication system between application software and users. Training is given to Chatbot to respond in a particular way. Training is given using Back-propagation method.

The research conducted in [10] states the fact that in the times of COVID-19, depression and anxiety are common and the term social distancing which is very common these days has led to social isolation and anxiety. It is very important to understand the need of physical distancing but not emotional and very important to

Table 2
Accuracy comparison.

S. No.	Classifier Model	Precision	Recall	F1-Measure	Accuracy	AUC	NPV	Sensitivity	Specificity
	Logistic Regression	0.98	0.98	0.98	0.98	0.91	–	–	–
	Linear SVM	0.97	0.99	0.98	0.98	0.8	–	–	–
	Ridge	0.81	0.79	0.78	0.79	0.74	–	–	–
	Decision Tree	0.67	0.68	0.75	0.67	0.64	–	–	–
	Naïve Bayes	0.89	0.99	0.94	0.9	0.94	–	–	–
	Linear SVM	0.83	0.83	0.83	0.82	–	–	–	–
	Naïve Bayes	1	0.58	0.78	63	–	–	–	–
	RBFN	–	–	–	0.71	–		–	–
	Deep Learning Model	0.68	0.67	0.67	–	–	0.68	0.69	0.67
	LSTM	0.99	0.99	0.99	0.99	–	–	–	–

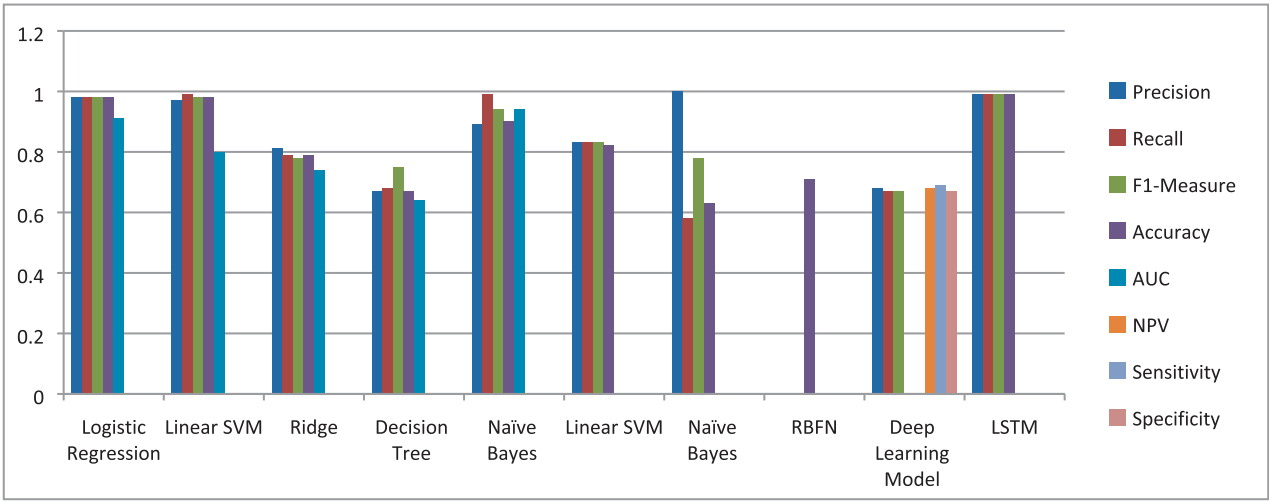

Fig. 2. Accuracy comparison chart.

take care of mental and emotional health. It has paved a way for data scientists to work towards depression with the help of artificial intelligence integrated with machine learning and deep learning. Combining Optical Character Reader (OCR) with AI leads to facial emotion recognition and can detect whether a person in an image or video is smiling or sleeping (eyes closed) and this can lead to early detection of depression and prevention of suicide. Deep learning models are trained using large sets of labelled data and neural network architectures which learn features directly from the data instead of manual feature extraction. The software has the combined application of Image Processing, Voice or speech recognition and AI. Emotional artificial intelligence has a strong role to play in medical and healthcare diagnosis. The following Table 1 provides the studies discussed above in a glance.

The performance accuracy comparison chart drawn on the basis of various studies mentioned in literature review is outlined in Table 2 below.

The above Table 2 has been represented in graphical form in Fig. 2.

3. Analysis

Unlike the mood swings caused by everyday activities, depression can be a major health issue, especially if it lasts for a long time and is moderate to severe. Fortunately, despite the fact that depression is a nonverbal illness, those who are suffering leave some indications. Because of the excessive use of social media, these indications can be obtained from texts posted on social media Platforms like twitter, Facebook, and Instagram, and then analysed to see discover if the writing style correlates to a depressive pattern. A set of benchmark studies related to depression detection are conveys various patterns to detect depression. In some of the significant studies related to NLP and sentiment analysis of tweets to detect depression it was found that Multinomial Naïve Bayes algorithm worked better than SVM in terms of accuracy and F1 score. Results were evaluated using confusion matrix and parameters like accuracy, precision and recall. Depression is detected through social networking sites like Facebook, twitter, etc. using various ML techniques. As per the analytical work done by [10] concludes that SVM significantly performs better as compared to other classifiers but it is also being observed that for features precision, recall and F-measure calculation decision tree performs better.

4. Conclusion

Depression is becoming an epidemic disease that affects people of all social classes, cultures, and countries on a frequent basis. Due to the inherent nature of solitude, finding those who seek for help because of mental condition but are unable to express their desire is difficult, and often goes overlooked even by those who are depressed. Since textual sentiment analysis is a non-invasive technique that can be constantly monitored and controlled, it can help diagnose the disease. This is a big support in the combat against depression since it allows us to distinguish times of happiness and melancholy without visiting a psychologist, allowing us to fight back quickly when needed. Depression is detected, analysed and prevented through twitter sentiment analysis (text-processing), facial expressions (image and video processing) and use of chatbots, emotional AI and combined inputs (text, audio,

image, video). Various artificial intelligence and machine learning techniques like Naïve-Bayes, LSTM – RNN, Logistic Regression, Linear Support Vector, PCA, KNN Classification, etc. are being used to recognize emotions and hence to detect depression. Efficiency and performance of various algorithms like SVM, Multinomial Naïve-Bayes are analysed to see which works better to detect emotions and hence depression through tweets. Interactive technology-driven AI-based solutions are also discussed. For example, Chatbot detects depression and responds back with a joke or song to lighten the mood of the user. Such kind of emotional AI and ML-Based solutions can prove to be beneficial in detecting, analysing and preventing depression and also provide a cure to it. In future, these approaches can be integrated into a vast system to clinically categorize patients suffering from depression on the basis of discovering their emotional profiles. To conclude, depression, mood and emotion can be detected through text, images, videos, speech, gestures, etc. through different AI and ML techniques for each of them.

CRediT authorship contribution statement

Manju Lata Joshi: Conceptualization, Methodology, Formal analysis, Supervision. **Nehal Kanoongo:** Visualization, Investigation.

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] A. Savadi, C.V. Patil, Face Based Automatic Human Emotion Recognition, IJCSNS Int. J. Computer Sci. Network Security 14 (7) (2014) 79–81.
[2] M. Nadeem, Identifying depression on Twitter. arXiv preprint arXiv:1607.07384, 2016.
[3] S. Oak, Depression Detection and Analysis, in: 2017 AAAI Spring Symposium Series, 2017 March.
[4] A Mercy Rani, R. Durgadevi, Image Processing Techniques To Recognize Facial Emotions, Int. J. Eng. Adv. Technol. (IJEAT) 6 (6) (2017).
[5] M. Deshpande, V. Rao, Depression detection using emotion artificial intelligence, in: 2017 international conference on intelligent sustainable systems (iciss), 2017, pp. 858-862.
[6] M.M. Aldarwish, H. Farooq, Ahmad Predicting depression levels using social media posts, in: 2017 IEEE 13th international Symposium on Autonomous decentralized system (ISADS), 2017, pp. 277-280.
[7] D.S. Thosar, Varsha Gothe, P. Bhorkade, V. Sanap, Review on Mood Detection using Image Processing and Chatbot using Artificial Intelligence, Life 5(03) (2018).
[8] A. Biradar, S.G. Totad, Detecting depression in social media posts using machine learning, International Conference on Recent Trends in Image Processing and Pattern Recognition, Springer, Singapore, 2018, pp. 716–725.
[9] M. Gavde, Comparative Study on Mood Detection Techniques, Int. J. Res. Appl. Sci. Eng. Technol. 6 (2018) 1456–1457, https://doi.org/10.22214/ijraset.2018.4245.
[10] Md R. Islam, A.K. Muhammad, A. Ahmed, A. Raihan M. Kamal, H. Wang, A. Ulhaq, Depression detection from social network data using machine learning techniques, Health Inform. Sci. Syst. 6(1) (2018) 1-12.
[11] Md R. Islam, A. Raihan M. Kamal, N. Sultana, R. Islam, Mohammad A. Moni, Detecting depression using k-nearest neighbours (knn) classification technique, in: 2018 International Conference on Computer, Communication, Chemical, Material and Electronic Engineering (IC4ME2), IEEE, 2018, pp. 1-4.
[12] H. Kumar, A. Latha, Depression detection with sentiment analysis of tweets, International Research Journal of Engineering and Technology (IRJET), 06 (05) e-ISSN: 2395-0056 p-ISSN: 2395-0072; (2019, May).
[13] D. Ramalingam, V. Sharma, P. Zar, Study of depression analysis using machine learning techniques, Int. J. Innov. Technol. Explor. Eng. 8(7C2) (2019) 187-191.
[14] E. Victor, M.A. Zahra, A.R. Sewart, R. Christian, Detecting depression using a framework combining deep multimodal neural networks with a purpose-built automated evaluation, Psychol. Assess. 31 (8) (2019) 1019.
[15] T.M. Fonseka, Venkat Bhat, S.H. Kennedy, The utility of artificial intelligence in suicide risk prediction and the management of suicidal behaviors, Aust. N. Z. J. Psychiatry 53 (10) (2019) 954–964.
[16] S.N. Shephali, A.V. Patil, G.S. Patil, S.P. Patil, B.D. Jitkar, AI Therapist Using Natural Language Processing, International Journal of Research in Engineering, Science and Management (IJRESM), 3(2) (2020, February).
[17] N. Rajaraman, A. P. R, Bhuja. G Depression Detection of Tweets and A Comparative Test. In International Research Journal of Engineering and Technology (IRJET) 09 (03) (2020, March) ISSN: 2278-0181.
[18] B. Zohuri, S. Zadeh, The Utility of Artificial Intelligence for Mood Analysis, Depression Detection, and Suicide Risk Management, J. Health Sci. 8 (2020) 67–73.
[19] H.S. AlSagri, M. Ykhlef, Machine learning-based approach for depression detection in twitter using content and activity features, IEICE Trans. Inf. Syst. 103 (8) (2020) 1825–1832.
[20] N.P. Shetty, B. Muniyal, A. Anand, S. Kumar, S. Prabhu, Predicting depression using deep learning and ensemble algorithms on raw twitter data, Int. J. Electr. Computer Eng. 10 (4) (2020) 3751.