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Research Article

Early Prediction of Depression by using Text and Deep Learning

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ABSTRACT

Introduction: In today's modern era, with the advancement of the world in various social media platforms, it has been greatly observed that the mental health problems of people have increased drastically. A person who looks happy can be suffering from severe mental health problems. Many people suffer from various mental health problems due to workload and social media influence as well as daily challenges, which often lead them towards significant harmful decisions. The increase in mental health diseases, like depression, bipolar disorder, and anxiety, makes the need for an in-depth analysis of an examination in this field.

Objectives: This paper surveys the comparative analysis of the current state of mental health research and the variety of inventions brought to date. It examines the usage of text analysis techniques in the text appearing on social media sites to get a better understanding of the emotions along with the challenges that confront the individual.

Methods: In this, various techniques using which the researchers can trace the modes of expression of mental health issues eventually detect early stages of distress and monitor the impact. This paper reviews the current applications of text analysis in mental health research, challenges in preprocessing unstructured data, and the importance of balancing machine-based analysis with human understanding.

Results: It briefly provides a survey of the importance of analysis using text in the mental health field and how it can benefit improved understanding and care in the said discipline. The findings highlight the importance of integrating these technologies into the current mental health practices to enhance emotional support and self-regulation.

Conclusions: The novelty of the research lies in its in-depth analysis of smart tools specifically designed for monitoring mental health using text, providing insights into the real-world challenges and benefits of using such technologies in everyday settings, beyond what has been explored in earlier studies.

Keywords: Mental Health, Text Analysis, Sentiment Analysis, Machine Learning (ML), Natural Language Processing (NLP), Deep Learning (DL).

INTRODUCTION

In the present digital generation, the fast-paced development of social networks increases the risk factors of mental disorders because people have a lot of emotional stress and social pressure. This stresses the need for quick and efficient ways of controlling and managing mental health disorders. One possible way to meet this demand is diagnosing an individual's mental state prior to its clinical manifestation via analysis of the text produced by him/her since certain emotions and mental states can be reflected in that text.

Sentiment analysis is a major subfield of NLP dealing with emotions & attitudes expressed in the subject's verbal or written speech. Researchers can assess the emotional behavior of social network users by employing NLP methods such as sentiment analysis and emotion classification [1, 2]. Nevertheless, even though NLP techniques carry a lot of

useful information, they are not always enough, especially when it comes to the prediction of several mental disorders at their early stages. Most of the techniques used earlier do not help in identifying the language variables, especially the signs and symptoms in the language that could be for the development of any mental disorders.

In order to improve constant accuracy and advance early prediction capabilities, it is also possible to make use of ML techniques in conjunction with NLP. Machine learning [3-7], neural networks [8-14], and, in particular, deep learning [15-18] are very efficient in learning to detect and recognize complicated structures and understand language components that are related to mental illness. By combining various techniques of machine learning (ML) and deep learning (DL) [19, 20], research on behavioral health predictive analytics attains a greater rate of accuracy [18]. Apart from that, clustering [4, 5] techniques can be used to group people with the same emotional and verbal behaviors, thus providing focused attention to offering mental healthcare.

The present research gives significance to the sphere of mental health in the context of online user engagements, which is becoming even more significant, especially with the rise of social media networks. The intention is also to fill the gaps in the research that already exists and improve the techniques of sentiment analysis with respect to the subtle recognition of the mental health in the text. The study also proposes new techniques for emotional detection using AI. Also, it explores existing paradigms and offers—within the scope of this study and beyond—viable options for tackling mental health problems in future studies.

The paper contains seven comprehensive sections. Section 1 provides an overview of the goals of the study and the relevance of mental health in the age of digital interactions. Section 2 gives an insight into the technologies employed and the problems constraining the processes of identifying mental health aspects. Section 3 summarizes the studies conducted in a certain field and mentions what has been done and what problems still need to be solved. Section 4 describes the approach adopted by the authors of this paper, which incorporates the use of ML and NLP techniques to enhance the performance of the sentiment analysis. Section 5 describes the results of the various experiments designed to demonstrate the potency of the techniques discussed above. Section 6 draws the main conclusions of the given research and provides some guidelines for further work in the respective area. The issue of AI and its significance with respect to mental health studies, as well as how this sphere deserves further investigation, is discussed. Section 7 gives the references of all the papers taken for review.

This section gives a basic overview of various components and technologies used while addressing the issues and challenges in the current technologies.

OVERVIEW

2.1 Basic Details

This section provides an outline of the key elements that are involved in carrying out a sentiment analysis in relation to mental health. It describes the various techniques used for sentiment analysis, which can be further used for mental health, such as depression detection, suicidal ideation, and several others. These are the basic foundations upon which the more sophisticated solutions will be based, as will be discussed in the subsequent sections.

2.2 Natural Language Processing (NLP)

Sentiments, emotions, or opinions conveyed within text data are identified and extracted with the help of NLP [21]. NLP provides an analysis of the structured expression of language and emotions and proves to be valuable in the evaluation of mental health. With access to vast text datasets, a person's emotional status can be understood and would go a long way in assessments regarding mental health. NLP breaks up the complex language into elements that are understandable so that algorithms can check not only the sentiment about the post but also, in most cases, if it was made under a feeling of stress, anxiety, or happiness. Thus, it is a key approach for text analysis.

2.3 Machine Learning:

Machine learning can be considered a very broad application of sentiment analysis. Text data is split into predefined categories like negative, positive, and neutral. Labeled data is used to train algorithms in detecting text data and its associated category of sentiment. The most commonly followed methods by algorithms in machine learning are SVM, decision trees, and logistic regression. They learn from the labeled data and classify the new unseen data on the basis of learned patterns by the model. Support vector machines are strong at binary classification tasks. Thus, they are most preferably used when there are a lot of features of the data.

Decision trees are very simple but powerful for some tasks of text in the case that the data splits into different branches based on feature values. Sentiment classification in general uses logistic regression, as it is a much more simplistic yet robust model. Taken together, these approaches in ML offer a systematic basis for undertaking sentiment analysis: breaking down and classifying complex text data into patterns that inform even wider analytic goals.

2.4 Deep Learning

Deep learning with the help of neural networks can pick up on complex language patterns. Among the deep learning methods, LSTM and BERT have been distinctive in considering word order and the context of a sentence. LSTM models have structures called memory cells that help remember what happened in the longer sequence and, hence, are best for understanding the flow and subtleties of language.

BERT works by reading text in two ways, both backward and forward, and catches the full context of every word in a sentence. This helps the bidirectional deep learning models to make precise captures of subtle cues relating to emotions and understanding of context. Deep learning-based LSTM and BERT empower the model to manipulate difficult linguistic structures with high accuracy and have uplifted sentiment analysis to a state where models can derive nuanced emotions embedded into words.

2.5 Convolutional Neural Networks

Another feature of text-based sentiment analysis is the use of CNNs [19][20][21], which are very important in cases where text data are represented in the form of word embeddings or n-grams. CNNs tend to have a strength in local pattern recognition, hence capturing the exact word order arrangement that will indicate the presence of the sentiment. They do not use recurrent networks, wherein they apply their convolutional layers to scan text inputs as small parts focusing on neighboring words or phrases. This approach is more likely to identify the structures within a sentence and, therefore, makes it easier to identify specific words that convey the sentiment.

CNN can easily realize subtle language patterns in the form of regular words or phrases. CNNs can also handle large text datasets with minimal increase in computational cost since they can process high-dimensional inputs. This has made them useful for a lot of applications in sentiment analysis where the application of the algorithm must be very quick yet highly accurate.

Altogether, these bases of NLP, machine learning, deep learning, and CNNs form a great backbone for sentiment analysis, from basic classification to very rich emotional understanding, thus giving them a comprehensive toolkit to check and interpret text data across several contexts. This approach multidimensionally enables researchers to build more accurate and robust models that enhance grasp of language and sentiment within the text.

LITERATURE SURVEY

3.1 Methodology for systematic literature review

Identified all the keywords required to perform article searches in the context of the survey. After that, searches were done in several electronic databases, such as Google Scholar, ACM, IEEE, ScienceDirect, and Springer, which made it possible to find relevant articles. The results were then filtered by years and keywords, where the selected texts were sorted into review articles and research papers.

Analyzed the sentences and gathered information from the Word documents to explore the content more thoroughly. By keeping separate files for our notes and other information, we were able to maintain order and keep track of the work done. Also, the use of Copilot, Gemini, helped us better understand the central issues of the articles. Each article was also searched for some keywords in order to facilitate more exploration. The whole process is depicted in Figure 1.

3.2 Findings of the present study

Lexicons are word or phrase lists that reflect the values of sentiment and are thus used in the interpretation of emotions or opinions that may be found in the text. Kostadin Mishevm, Ana Gjorgjevikj, and their team very well made use of lexicons combined with transformers [22] to increase accuracy in sentiment analysis. These models, such as BERT, GPT, and other transformer models, go beyond lexicons by learning the context within a text and therefore enhance the organization and meaning of the content.

In mental health research, text mining [1,2] has been helpful in the identification of emotional cues like stress or anxiety, primarily from social media platforms. Haruna Isah and other researchers [23] used these sequences of words and sophisticated natural language processing designs to use these sequences to predict mental health trends, and they successfully applied it by using it in analyzing Facebook data for sentiment signals.

Ordinal regression is a suitable statistical method for ordered categories that indicate an increasing level of severity but no exact interval between them. Shihab Elbagir and Jing Yang [23] adopted this method to enhance their sentiment analysis accuracy. Meanwhile, clustering [24, 25] is an unsupervised learning technique applied to classify objects into clusters of similar objects to obtain patterns. For example, Hima Suresh, Shreya Ahuja, and Gaurav Dubey [25] used clustering methods to classify sentence polarities and obtained sentiment in their work. Homogeneous ensemble classifiers [26] are an effective alternative for improving model performance as they aggregate several models of the same type, such as decision trees, to decrease overfitting and improve accuracy. These methods, such as bagging and boosting, improve model robustness.

Models like BERT are useful for contextual analysis tasks because they can view the entire context of words in sentences. Researchers such as Tianyi Wang and Ke Lu [27] have used BERT to achieve higher accuracy than simpler models like Naive Bayes, which, despite its simplicity, remains effective for basic text classification tasks. Sandy Kurniawan et al. [28] used, Other than using these models individually, many researchers have used hybrid approaches to combine machine learning (ML) and deep learning (DL) techniques to achieve better results in sentiment analysis. Yogesh Chandra and Antoreep Jana [18] used hybrid approaches and combined the models to gain better results.

Deep learning (DL) is the most significant ML technique in which it uses multi-layered neural networks to enable the model to process raw data like images, text, or audio on more complex tasks. Mehmet Umut Salur and Ilhan Aydin [17] took hybrid deep learning (DL) models to enhance the accuracy, while Hasibe Busra Dogru et al. [16] considered the Doc2Vec model for enhancing the accuracy of text representation.

There are several studies on how the LSTM should be combined with dense layers for emotion recognition. A study by Dr. C. S. N. Murthy et al. [29] was highly successful, with an accuracy score of 99% against 10 epochs using only LSTM [21]. Convolutional neural networks [8-14] have also appeared well-suited for the task, as they provide the ability to create convolutional filter layers capable of extracting complicated features in the image. This structure of CNN ensures the efficient detection of the feature, ranging from edges to complex textures, because these can be used with images of any complexity and yet would recognize them. Yue Feng [12] added more head mechanisms to CNN models to take accuracy further. Jin Wang [8] combined CNN with LSTM in modeling a better model.

Zabit Hameed and Begonya Garcia-Zapirain [30] reported how BiLSTM performs quite well even at a high epoch count of 100. Guixian Xu et al. [31] also attained significant accuracy using BiLSTM with the ReLU activation function over 200 epochs. These models show the flexibility and effectiveness of advanced neural networks for sentiment analysis and text classification. It shows that approaches such as BERT, CNN-LSTM hybrids, and BiLSTM can yield substantial improvements in accuracy by leveraging context and feature complexity. Through these diverse approaches, several researchers have demonstrated how modifications of machine learning or deep learning methodologies, when tailored with extra layers or used in combination with existing models, can greatly enhance precision in tasks related to sentiment analysis. This existing literature has thus formed a starting base for further refining architectures based on the model complexity of issues in text mining and tasks in sentiment [35-40].

METHODOLOGY

4.1 Research Methodology

The research is in a structured and organized way that would enable us to achieve a full understanding of this topic. This ensured that every crucial area of this topic was covered. Various academic papers and articles were reviewed by using various reputed databases such as IEEE Xplore, Google Scholar, ScienceDirect, and many more.

After reviewing a range of papers from the year 2010 to 2024, segregating the articles based on their techniques that were used in the sentiment analysis field for mental health. Reviewing these papers, I obtained a mix of approaches such as those based on NLP techniques, machine-learning (ML) techniques, deep-learning (DL) techniques, and convolutional neural networks. At first, we explored NLP techniques, such as lexicons, transformers, and text-data

mining, which have allowed us to analyze text-based data efficiently and understand them. Further on, shifted the research toward machine-learning methods such as clustering, ordinal regression, homogeneous ensemble classifiers, and much more.

To enhance the accuracy, further explore advanced methods such as deep learning to get more sophisticated solutions. These research papers offered useful insights into a range of approaches, such as LSTM, BiLSTM, and several others, which are effective in understanding and processing sequential data. These techniques helped us to achieve a high level of accuracy for text sentiment analysis. Also, too focused on convolutional neural networks (CNNs) to get insights into text-based analysis at a granular level. Various methods and algorithms in the field of neural networks were studied to get a deeper level of accuracy and efficiency. To consider nearly 15 papers that have been published in the range of 2019-2024 to focus on ensemble learning methods for text analysis and to make project even more robust.

Further reading across several interdisciplinary papers meant to give deeper insights into the field of mental health. To enhance research by using several different methodologies so that it could get broader insights regarding contextual understanding. This will help us ensure that the study was good enough to meet our objectives of research. For such case, this would lead us towards gaining clarity about the survey as well as its thoroughness.

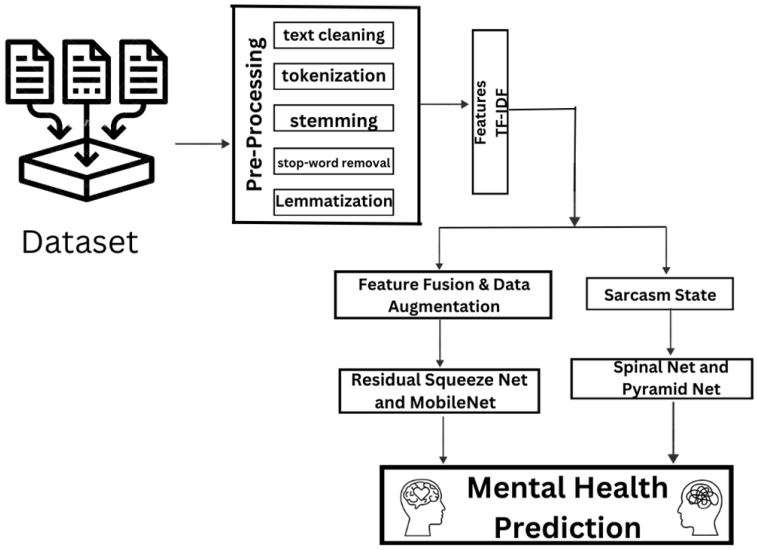

Figure 1. Proposed Mental health prediction model for Text dataset

4.2 Analysis of papers across subdomains

As depicted in Figure 1, the paper is divided into four major subdomains to adequately cover all aspects of sentiment analysis in mental health, with special focus on

identifying depression symptoms, suicidal ideation, and other relevant issues. In total, 35 research papers were surveyed that will help us understand the best text-based sentiment analysis techniques applicable in this area. Figure 2 depicts this division of research focus.

Figure 2 shows that 18% of the papers read dealt with sentiment analysis through NLP techniques. NLP gave us all the necessary tools for processing and interpreting text that could capture and understand emotional cues within mental health data. The studies also mention the use of machine learning techniques along with various other algorithms in roughly 25% of research papers considered for analysis. It did involve some core concepts of ML to enable the emotions of text data to be categorized & hence can be quite handy in a mental health-based application.

The rest of 27% of research focused on deep learning methods. It is through these methods that could improve the precision of the model. Deep learning comes after machine learning and gives more sophisticated techniques to catch complex patterns of language that may yield even more precise results for the task of sentiment analysis. Subsequent to that, 18% of the reviewed paper dealt with convolutional neural networks, which looked in more depth at data with this level of granularity. Such exploration on CNNs helped us to look inside detailed features within the text and pattern sets in relation to mental health conditions.

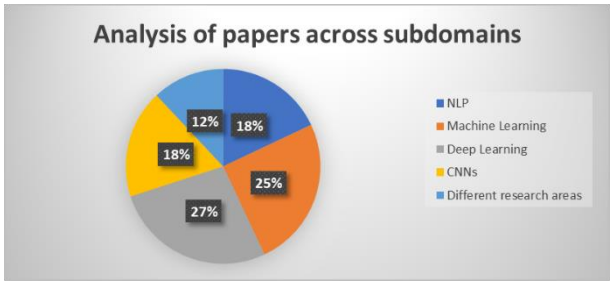

Figure 2. Analysis of paper across subdomains

The other 12% of the research papers tackled more areas of relevance beyond the four major categories above. Such studies offered more general perspectives, giving insights that supplemented that is main concern and

enriching the research with interdisciplinary views. Such a spread over different techniques enabled us to approach the topic of mental health sentiment analysis from a variety of angles in ensuring a comprehensive understanding of the field.

RESULTS AND DISCUSSIONS

This paper reviews numerous machine learning (ML) and deep learning (DL) techniques related to text classification & sentiment analysis and tests their ability under different configurations.

By using the LSTM [29][32,33] model, a maximum accuracy of 99.56% was achieved at 10 training epochs; this shows the capability of the model to catch the sequential information inside text data. The Bidirectional LSTM (BiLSTM) [30,31] model, which applies bidirectional text processing, reported a precision of 91.54%. Although lower than the one LSTM achieved, the bi-directional structure in BiLSTM provides better contextual information in some cases.

Ordinal regression [23] resulted in an accuracy of 91.81%; that is, it is one of the most accurate models considered in this research work. Therefore, one may assume the appropriateness of an ordinal regression method when used on tasks for which the ordinal relations exist among the text classes or categories. In turn, the average accuracy of a flat classification and the hierarchical classification by Naive Bayes [28,34] was equal to 75% and 77%, respectively. It had better precision in text.

mining using bigrams as features. The SVM algorithm proved to be more accurate in using unigrams as a feature set than Naive Bayes. This clears the efficacy of SVM in using simpler feature representations.

Using n-gram models provided a total accuracy of 90% and a multi-class sentiment classification of around 70%. With the fine-tuned model BERT [35], the overall accuracy was about 75%. Methods that make use of lexicons and transformers [1] were able to give the highest MCC score of 89%. Feature ensemble methods [26, 35] resulted in 81% precision that proved higher than the baseline, with dependency analysis producing a result of 71% precision.

Table 1. Models and their accuracy

Models	Accuracy
LSTM	99.56%
BiLSTM	90%
Naïve Bayes	75% - 77%
n- gram Models	90 %
BERT	75%
Lexicons & Transformaers	89%
Feature Ensemble Methods	80%
CNN	85% - 90%
Deep Learning Models	90%
Doc2Vec Model	94%
Hybrid Model of ML & DL	88%
Clustering Methods	76%

Convolutional neural networks [8-14] produced an accuracy range of 85–90% in sentiment analysis. In summary, deep learning models [15-17] yielded an accuracy of approximately 90%. The accuracy of the doc2vec model [16] was

recorded at 94%, demonstrating the ability of this model to grasp semantic relationships. Accuracy for traditional machine learning methods [4-7] averaged around 88%. Hybrid models and both machine learning and deep learning [18] had an accuracy that ranged from 81% to 90%. The clustering [24, 25] methods had moderate accuracy at about 76%. These results underscore the variability among models and point toward a path for higher performance by using hybrid and feature-specific design approaches.

CONCLUSION

This study assesses sentiment analysis in the field of mental health, using data from text through various techniques. Unlike previous work, this piece of writing does not base its discussion on mere findings but attempts to discuss its utility in practical applications. This paper finally tries to figure out how technology can aid in identifying mentally ill patients. Some of the common kinds include those suffering from depression, anxiety disorders, or even tendencies to be suicidal. Thus, the outcome of the research will be the focus on how the social media detection system could become popular and aid in an early diagnosis and prevention of such crises.

The research and analysis presented in this survey clearly show how much progress has been made in creating models for sentiment analysis. Such progress holds great potential in finding signs of mental health issues in people, especially in the early stages. Such a system can provide early warnings that someone might be having problems by detecting subtle emotional cues in online messages and posts. This article reviews approaches from the past that have been applied in this field while bringing out opportunities for improvement; it shows how the aspect of sentiment analysis may be able to continue to grow and become more effective in the future. This field has a huge scope for innovation and customization; there is much more to see in the future.

FUTURESCOPE

Future work can be done on getting more accurate models that might be able to detect a large range of mental health conditions and developing methods that will be adaptable to new languages and cultural contexts. One area of future work is that these systems should be even more accessible and integrated into diverse platforms ranging from social networking sites to mental health-oriented applications. Furthermore, the real-time sentiment analysis may also be developed where real-time detection with corresponding reactions may be done so that urgent cases get immediate attention. This can be done, for instance, when someone posts suicidal thoughts in some corner of the globe.

Therefore, this research work presents how the applications of sentiment analysis advance in relation to mental health and also the opportunities before it. Improvement and extension of such technologies can definitely make impacts toward mental health awareness and early intervention. As it continues to develop, saving lives and enhancing the mental well-being of human beings can only increase.

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