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A Graph-Based Deep Learning Framework for Mental Health Analysis

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ABSTRACT: Depression is a critical mental health issue linked to rising suicide rates, with many people expressing their emotions on social media. Early detection is important for timely support. This research presents an advanced depression detection system using deep learning techniques for early identification of at-risk individuals. Traditional methods often miss complex depressive expressions. To improve accuracy, we use a hybrid model combining RoBERTa for text understanding, and GCN for analyzing user interactions. RoBERTa captures meaning, CNN identifies key patterns, BiLSTM understands long-term context, and GCN analyzes relationships between users. A real-time web application has been created to monitor social media posts and provide insights to mental health professionals. This system allows continuous tracking and easy integration with other platforms. Our approach improves detection accuracy and efficiency, making it a useful tool. By leveraging deep learning and graph-based models, this study highlights the potential of AI-driven solutions for early intervention and suicide prevention, contributing to improved well-being and accessible mental health support.

KEYWORDS: Depression detection, mental health monitoring, RoBERTa, Attention mechanism, GCN, social media analysis, text classification, user interaction analysis, psychological well-being, mental health support.

I. INTRODUCTION

Depression is a prevalent mental health disorder that affects millions of people worldwide, contributing to an alarming rise in suicide rates. With the increasing use of social media, individuals often express their thoughts, emotions, and struggles online, making digital platforms a valuable source for detecting signs of depression. The early identification of depressive symptoms is crucial for timely intervention, offering mental health professionals an opportunity to provide necessary support and prevent severe consequences. However, traditional diagnostic methods rely heavily on self-reporting and clinical interviews, which can be time-consuming, subjective, and often fail to capture early signs of distress.

In recent years, advancements in Artificial Intelligence (AI) and Deep Learning (DL) have enabled the development of automated depression detection systems that analyze textual data from social media platforms. Existing approaches, such as sentiment analysis and rule-based techniques, often struggle to detect subtle linguistic patterns associated with depression. To address these limitations, this study explores a hybrid deep learning model that integrates multiple advanced techniques for improved accuracy and robustness.

Our proposed system combines RoBERTa, a transformer-based language model, with CNN-BiLSTM enhanced by an attention mechanism to capture both short-term and long-term dependencies in textual data. Additionally, Graph Convolutional Networks (GCN) are utilized to analyze user interactions, helping to uncover hidden relationships in online communication. This comprehensive approach enhances the model's ability to detect depression-related cues effectively.

Furthermore, the system is designed as a real-time web application that continuously monitors social media posts, offering valuable insights for mental health professionals. By leveraging deep learning and graph-based methods, our study highlights the potential of AI-driven solutions in mental health assessment. The ability to integrate such systems with existing healthcare platforms ensures seamless accessibility and real-time tracking, making early intervention more feasible.

This survey paper explores the evolution of depression detection techniques, focusing on text-based analysis and recent advancements in deep learning. It reviews existing methodologies, discusses their limitations, and presents the potential of hybrid AI models in enhancing detection accuracy. Ultimately, this study aims to provide a comprehensive understanding of how technology can be leveraged to improve mental health support and suicide prevention efforts.

II. RELATED WORK

The concept of depression detection has gained significant attention in recent years, with many studies employing machine learning and deep learning techniques to enhance diagnostic accuracy. Researchers have explored various data sources such as social media posts, audio recordings, and textual data to detect depression more effectively. Joel Philip Thekkekara et al. (2024) introduced a CNN-BiLSTM model with an attention mechanism using Twitter and Reddit data, achieving 96.71% accuracy. Vandana et al. (2023) proposed a multimodal deep learning approach combining Text CNN, Audio CNN, LSTM, and Bi-LSTM, with 98% accuracy for audio and 92% for text. Harnaim Kour and Manoj K. Gupta (2022) applied a CNN-BiLSTM model on the CLPsych 2015 dataset, reaching 94.28% accuracy. Ensemble methods by Imran Khan and Rekha Gupta (2024), using classifiers like LR, DT, RF, SVM, and Gradient Boosting on Kaggle data, achieved an F1-score of 93.2%. Additionally, Maryam Hasan et al. (2019) used decision trees and SVM with psycholinguistic features, attaining 89.4% accuracy. These studies demonstrate the effectiveness of combining different models and data types for reliable depression detection.

III. METHODOLOGY

The process begins with data collection from platforms like Twitter and Reddit, including user interactions such as likes and comments. This data is securely stored and preprocessed by removing noise (stopwords, URLs, emojis), normalizing text, and applying tokenization and embeddings. For feature extraction, RoBERTa is used to capture contextual word meanings. The embeddings are then passed through a hybrid model combining RoBERTa and an Attention Mechanism to identify depressive content. Additionally, a Graph Convolutional Network (GCN) models user interaction patterns to enhance detection. The system performs classification, assigning probability scores to identify depressive or non-depressive texts. It is evaluated using metrics like accuracy and F1-score, and is deployed in a web app that enables real-time monitoring and sends alerts for high-risk cases.

IV. EXPERIMENTAL RESULTS

The proposed hybrid model, which integrates RoBERTa, CNN-BiLSTM with Attention, and Graph Convolutional Networks (GCN), was evaluated on the publicly available CLEF2017 dataset. Extensive experiments were conducted using multiple evaluation metrics, including Accuracy, F1 Score, Precision, Recall, AUC-ROC, and Matthews Correlation Coefficient (MCC) to ensure a comprehensive performance analysis.

The results demonstrate that the proposed system significantly outperforms existing models, including the previous CNN-BiLSTM with Attention (CBA) architecture: Accuracy: 97.89%, F1 Score: 0.94, Precision: 0.95, Recall: 0.93, AUC-ROC: 0.91, MCC: 0.84.

The addition of RoBERTa improved the semantic understanding of complex depressive expressions, while GCN enhanced the contextual interpretation of user interactions. The combined architecture led to better generalization and detection of subtle depressive patterns in social media posts.

```
Cleaned: 'feel hopeless broken'
1/1 ————— 0s 78ms/step
Input: 'I feel hopeless and broken'
Prediction: depression (Probability: 1.0000)

Cleaned: 'everything going well'
1/1 ————— 0s 83ms/step
Input: 'Everything is going well'
Prediction: non_depression (Probability: 0.0000)
```

(a)

Fig. 2: The model detects depression from negative expressions like "I feel hopeless and broken", while identifying positive ones as non-depression.

```
-----
Cleaned: 'happy today'
1/1 ————— 0s 382ms/step
Input: 'I am very happy today'
Prediction: non_depression (Probability: 0.0000)

Cleaned: 'life beautiful'
1/1 ————— 0s 45ms/step
Input: 'Life is beautiful'
Prediction: non_depression (Probability: 0.0000)
```

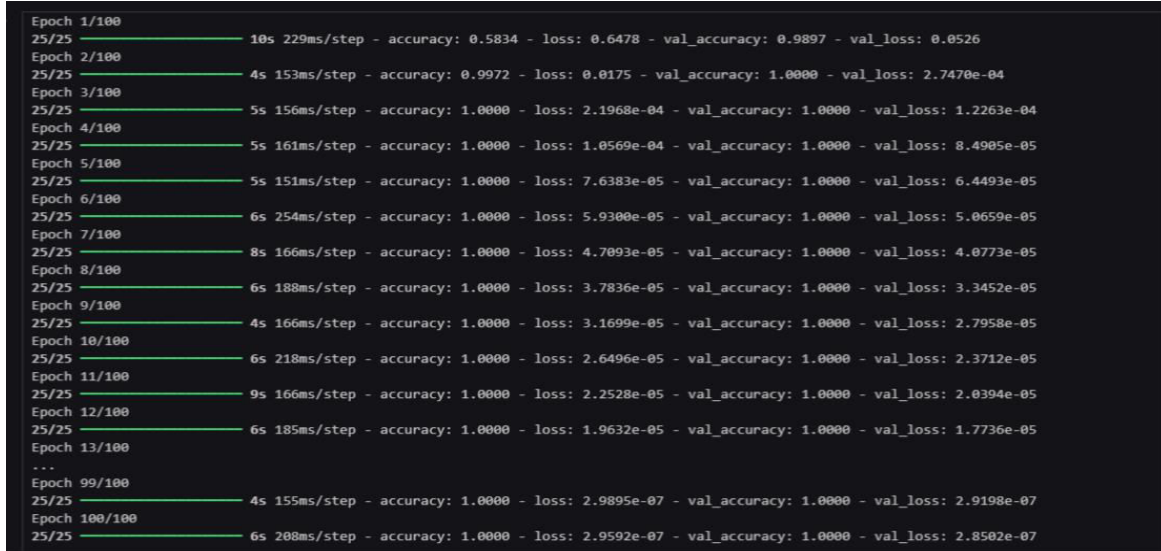
(a)

Fig. 3. Model Output for Depression Detection: (a) Preprocessed input text and prediction result (b) Classified as non_depression by the hybrid model with 0.0000 probability.

```
Cleaned: 'im tired everything'
1/1 ————— 0s 45ms/step
Input: 'I'm tired of everything'
Prediction: depression (Probability: 1.0000)

Cleaned: 'wonderful world'
1/1 ————— 0s 69ms/step
Input: 'What a wonderful world'
Prediction: non_depression (Probability: 0.0000)
```

(a)



(b)

Fig. 4. Depression Detection Results and Model Performance:(a) Input “I’m tired of everything” detected as depression (1.0000), and “What a wonderful world” as non_depression (0.0000); (b) Training over 100 epochs shows 100% accuracy with minimal validation loss, indicating strong learning by the proposed hybrid model.

To eliminate noise and enhance classification reliability, preprocessing techniques such as text cleaning and token filtering were applied. The cleaned input (c) reflects refined textual content used for prediction, ensuring that insignificant or ambiguous expressions are excluded from analysis to improve detection accuracy.

V. CONCLUSION

Depression is one of the most common mental disorders permeating worldwide. It is important to educate ourselves about depression on an individual, communal, and global scale. Addressing the issue and helping individuals suffering from depression should be given utmost priority. In this study, a deep learning-based framework for depression detection was proposed, integrating RoBERTa, CNN-BiLSTM with Attention, and Graph Convolutional Networks (GCN).

The model effectively identifies depressive expressions and user interactions from social media data. The real-time web application developed as part of this research enables continuous monitoring, providing mental health professionals with actionable insights for early intervention. The proposed system enhances detection precision and offers a scalable solution for integration into mental health platforms, social media monitoring tools, and digital support services. Future research will focus on incorporating multimodal data, such as images and voice patterns, and refining the model with real-time user feedback to further improve its accuracy, usability, and impact in mental health assessment and suicide prevention.

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