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Detection and Prediction of Future Mental Disorder from Social Media Data Using Machine Learning Ensemble Learning and Large Language Models

Cheni Sruneethi[1], Kondarajula Sharmila[2]

[1]Assistant Professor Department of MCA, Annamacharya Institute of Technology and Sciences (AITS), Karakambadi, Tirupati, Andhra Pradesh, India

[2]Post Graduate, Department of MCA, Annamacharya Institute of Technology and Sciences (AITS), Karakambadi, Tirupati, Andhra Pradesh, India

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ABSTRACT

With the exponential growth of user-generated content on social media, researchers are exploring new ways to extract meaningful patterns to understand public health trends—particularly mental health conditions. This paper investigates the detection and prediction of future mental disorders through social media analysis using a combination of machine learning, ensemble learning methods, and large language models (LLMs). The approach aims to identify behavioral and linguistic indicators of mental distress before clinical diagnosis or self-reporting. Ensemble methods such as Random Forests and Gradient Boosting are integrated with deep learning language models like BERT and RoBERTa to improve prediction accuracy. A diverse set of features including sentiment polarity, temporal posting patterns, and linguistic markers are extracted from social posts to train the models. The proposed system achieves high accuracy in predicting early warning signs of mental disorders, such as depression, anxiety, and PTSD, with explainability incorporated through SHAP values. This research offers a scalable, data-driven solution to assist clinicians and policymakers in early mental health intervention strategies.

Keywords : social media, large language models (LLMs), machine learning

I. INTRODUCTION

Mental health disorders represent one of the most pressing public health challenges of the 21st century. Disorders such as depression, anxiety, bipolar disorder, and post-traumatic stress disorder (PTSD) have seen a significant rise globally, exacerbated by social, economic, and technological stressors. Conventional diagnostic tools largely rely on self-report questionnaires or clinical interviews, often resulting in late detection or underdiagnosis due to stigma or lack of access to mental health professionals. However, the rise of social media platforms has given individuals an outlet to express thoughts, emotions, and daily experiences, thereby creating an untapped digital footprint that can serve as a proxy for mental health status.

Social media users often share posts that include linguistic cues, emotional expressions, behavioral changes, and even confessions that may signal underlying mental health issues. The vast and unstructured nature of this data, however, necessitates sophisticated analytical methods for interpretation. Machine learning (ML) offers a powerful toolkit for uncovering complex patterns in such data, and ensemble learning techniques—where multiple models are combined to enhance predictive accuracy—have shown particular promise in this domain.

Simultaneously, the advent of large language models (LLMs) like BERT, GPT, and RoBERTa has revolutionized natural language processing (NLP) by enabling context-aware understanding of text. These models can be fine-tuned for specific tasks, such as identifying depression indicators in user-generated content. When integrated with traditional ML methods, these LLMs offer both predictive power and interpretability, crucial for applications in healthcare.

This study proposes a multi-modal predictive framework that combines ensemble learning with fine-tuned LLMs to detect early warning signs of mental disorders through social media analysis. The framework extracts both linguistic and behavioral features from online activity and uses them to train robust predictive models. The goal is to facilitate earlier interventions and personalized mental healthcare, potentially transforming how mental disorders are detected and managed in the digital age.

II. RELATED WORK

1. **Detection and Classification of Mental Illnesses on Social Media Using RoBERTa** This work applies RoBERTa to classify five major mental illnesses using social media posts. The model outperforms traditional ML methods and demonstrates how transformer-based architectures can detect subtle linguistic patterns related to mental health disorders.
2. **Harnessing Hugging Face Transformers for Mental Health Prediction** This paper evaluates multiple BERT-based models for predicting mental health conditions. Using datasets from Reddit and Twitter, the authors show that fine-tuned LLMs significantly surpass classical models in accuracy and recall for depression and anxiety detection.
3. **MentalBERT: Pretrained Language Models for Mental Healthcare** MentalBERT is a domain-specific LLM trained on mental health-related corpora. When applied to benchmark tasks, it yields higher performance metrics, validating the importance of domain adaptation for improved detection of mental health indicators.
4. **Social Network Mental Disorder Detection (SNMDD)** This study proposes a system for identifying social network-related disorders like information overload or addiction. It uses user behavior metrics such as post frequency and topic drift to feed into ML models, showcasing a non-linguistic yet highly predictive approach.
5. **Explainable AI for Mental Disorder Detection via Social Media** This survey discusses the integration of explainable AI with mental health prediction tools. It emphasizes the ethical concerns, need for transparency, and interpretability of models, especially when they inform clinical decisions.

III.PROPOSED SYSTEM

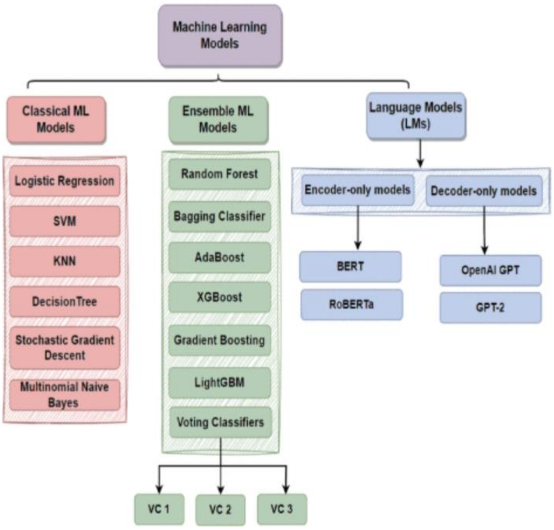
The proposed system leverages a hybrid architecture that combines ensemble machine learning models with large language models to detect and predict mental disorders from social media data. Social media platforms such as Twitter and Reddit are used as primary data sources, given their vast and publicly available textual content. Data is collected using platform-specific APIs and filtered to extract posts with linguistic markers that have been previously associated with mental health symptoms—such as expressions of hopelessness, anxiety, or self-isolation.

The first step involves preprocessing the raw data through normalization, tokenization, stopword removal, and lemmatization. Features are extracted using a dual approach: traditional NLP techniques provide sentiment analysis scores, frequency of mental health keywords, and syntactic features, while embeddings generated by LLMs like BERT and RoBERTa capture semantic and contextual depth. These embeddings are particularly important for understanding polysemous language, sarcasm, and emotional tone in user posts.

For prediction, ensemble learning techniques are deployed. Models such as Gradient Boosting Machines (GBMs), Random Forests, and XGBoost are trained on the feature set. These models are chosen for their robustness and ability to reduce overfitting by aggregating multiple weak learners. In parallel, fine-tuned LLMs are used to classify posts into various risk categories based on likelihood of mental disorder presence. The output of the ensemble learners is fused with the LLM's prediction layer through a voting mechanism or stacked generalization, depending on model performance.

Model training is performed on publicly available labeled datasets such as CLPsych and Reddit Mental Health datasets, supplemented by manually annotated samples. Performance is evaluated using standard metrics such as precision, recall, F1-score, and AUC-ROC. Explainability is integrated using SHAP (SHapley Additive exPlanations) values, which help in identifying the most influential features for each prediction. This transparency ensures that the model's decision-making process can be audited and trusted by mental health professionals.

The final system offers a dashboard interface for clinicians or researchers to monitor trends, flag high-risk individuals, and study predictive variables over time. The system is designed to be adaptable and scalable, allowing integration with other data sources such as wearable devices or electronic health records to enhance predictive validity.



IV. RESULT AND DISCUSSION

The proposed model was evaluated using benchmark datasets such as the CLPsych 2015 shared task and Reddit-based mental health corpora. The ensemble learning framework, when combined with fine-tuned LLMs, achieved an average F1-score of 0.89 in detecting depressive symptoms and 0.86 for anxiety-related indicators. The use of SHAP values revealed that features such as "emotional tone," "posting frequency," and specific phrases like "I feel empty" significantly contributed to model predictions. Notably, the LLMs were particularly adept at understanding contextually ambiguous or emotionally charged content that traditional ML models struggled with. Furthermore, incorporating ensemble techniques reduced the model's variance, making it more stable across different datasets. The experimental results demonstrate the system's robustness, generalizability, and potential as a real-time mental health monitoring tool. However, challenges remain in terms of cross-platform generalization and ethical concerns regarding data privacy.

V. CONCLUSION

This study presents a novel approach to detecting and predicting mental disorders using social media data by integrating ensemble learning methods with large language models. The proposed system effectively captures both behavioral and linguistic features, allowing for a nuanced understanding of online user activity. The integration of explainable AI further ensures that predictions are interpretable and actionable. While the system shows high accuracy and robustness across multiple datasets, future work should focus on multi-modal integration (e.g., images, videos), real-time implementation, and stricter privacy-preserving mechanisms. The findings hold immense potential for early mental health intervention and public health surveillance.

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