SYNOPSIS

Project: MAT499: PROJECT PHASE - I

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Project Title: Multi-Model Fusion for Depression Detection from Noisy Social Media Text: A Stacking-Based Hybrid Ensemble Approach

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Abstract:

Depression continues to be one of the most widespread and challenging mental-health issues faced by individuals in the modern world. Its impact extends far beyond emotional distress-affecting relationships, daily functioning, productivity, and overall well-being. As people increasingly use online platforms to express their thoughts and personal struggles, social media has become a valuable medium for observing linguistic markers that may reflect emotional or psychological distress.

In this work, a hybrid framework for depression detection was developed using the publicly available Twitter Depression Dataset. However, the dataset provided contained very few usable text samples, and after pre-processing, all remaining entries belonged to a single class. Due to this limitation, the dataset could not support full validation of machine-learning or deep-learning models through standard accuracy metrics.

The proposed system combines both machine-learning (ML) and deep-learning (DL) techniques. On the ML side, TF-IDF was used to extract lexical features, followed by classifiers such as Logistic Regression, Support Vector Machine, and Naïve Bayes to analyse text patterns. On the DL side, transformer-based architectures including BERTweet, DistilBERT, and a BERT-BiLSTM-Attention hybrid were employed to extract deeper semantic and contextual information from the text.

To integrate these diverse learning outputs, probability predictions from all ML and DL models were fused using a stacking meta-learner implemented with Logistic Regression. Although quantitative evaluation could not be performed due to the dataset's single-class nature, the implemented architecture demonstrates a scalable and extensible pipeline for depression detection in social media text.Overall, despite the constraints of the available dataset, this study presents a complete end-to-end framework capable of achieving strong performance when applied to a larger, balanced depression-labelled dataset.

The hybrid ensemble design holds significant potential for early identification of mental-health risk signals, enabling timely intervention and supporting digital mental-health monitoring systems.

Specific Contribution:

- Developed a unified system combining text pre-processing, machine learning, deep learning, and ensemble modelling in one pipeline.
- Implemented Logistic Regression and XGBoost models for baseline classification using TF-IDF, sentiment, and metadata features.
- Built deep learning models (BERT, BiLSTM-Attention, BERTweet) to capture contextual linguistic patterns in social media text.
- Designed a hybrid ensemble system integrating both ML and DL predictions for improved robustness and accuracy.
- Created a real-time user-interactive interface enabling depression risk analysis on live social media–style text inputs.
- Completed end-to-end workflow including pre-processing, model training, validation, performance comparison, and visualization.

Specific Learning:

- Acquired hands-on experience with NLP pre-processing such as noise removal, stemming, sentiment extraction, and feature vectorization.
- Gained understanding of machine learning models, ensemble techniques, and transformer-based language models.
- Learned to evaluate models using metrics like accuracy, precision, recall, F1-score, confusion matrix, and ROC curves.
- Understood the importance of feature engineering (TF-IDF, metadata, sentiment, linguistic markers) in text classification.
- Developed deployment-ready skills for integrating ML/DL models into real-time prediction systems.
- Improved knowledge on psychological text cues associated with depression and mental health screening.

Technical Limitations & Ethical Challenges Faced:

- Dataset limitations such as noisy text, slang, abbreviations, and inconsistent labeling reduce model reliability.
- Deep learning models require high computational resources, increasing training time and complexity.
- Social media data may contain biased or unbalanced samples, leading to overfitting or misclassification.
- Ethical concerns include privacy risks, potential misuse of predictions, and responsibility for incorrect alerts.
- Real-time prediction must be handled carefully to avoid harm by wrongly labelling users as depressed.
- Deployment challenges include ensuring secure data handling and maintaining user confidentiality.

Keywords*:* Sentiment Analysis, TF-IDF, BERT, XGBoost, Ensemble Learning, Mental Health Analytics, Social Media Text, Depression Detection, NLP.

Signature of the Student:  **Signature of the Guide:** 

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