

Predictive Analytics in Mental Health Leveraging LLM Embeddings and Machine Learning Models for Social Media Analysis


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ABSTRACT

The prevalence of stress-related disorders has increased significantly in recent years, necessitating scalable methods to identify affected individuals. This paper proposes a novel approach utilizing large language models (LLMs), with a focus on OpenAI's generative pre-trained transformer (GPT-3) embeddings and machine learning (ML) algorithms to classify social media posts as indicative or not of stress disorders. The aim is to create a preliminary screening tool leveraging online textual data. GPT-3 embeddings transformed posts into vector representations capturing semantic meaning and linguistic nuances. Various models, including support vector machines, random forests, XGBoost, KNN, and neural networks, were trained on a dataset of >10,000 labeled social media posts. The top model, a support vector machine, achieved 83% accuracy in classifying posts displaying signs of stress.

KEYWORDS

Generative Pre-Trained Transformer (GPT-3), Large Language Models (LLM), Machine Learning (ML), Mental Health, Social Media Analysis, Stress Disorder Identification, System Analysis and Design

MENTAL HEALTH AND MACHINE LEARNING MODELS: SOCIAL MEDIA ANALYSIS

Mental health describes a person's emotional, psychological, and social well-being, encompassing their overall mental and emotional state. It is a dynamic and complex aspect of human health that influences how individuals think, behave, feel, act, and relate to others or objects (World Health Organization [WHO], 2022). In the last decades, mental health illnesses have become widely

DOI: 10.4018/IJWSR.338222

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prevalent. The World Health Organization (WHO) underscores the increasing prevalence of health disorders globally (AlSobeh et al., 2019a), with estimates suggesting that over a billion individuals are affected by a range of mental health conditions (Organizacao Pan-Americana da Saude [OPAS], 2022). From a technology aspect, social media platforms such as Facebook, Instagram, and others have become increasingly popular for individuals to express their thoughts, emotions, and daily experiences. Users often share personal stories, express their frustrations, and seek support from their online communities. This wealth of textual data provides an opportunity to monitor, analyze, and estimate individuals' mental well-being at scale (Chafery, 2024). This escalating trend underscores the imperative for robust, scalable detection and intervention mechanisms. Social media often serves as a digital diary or outlet where users share their innermost feelings, thoughts, and experiences. These expressions can range from joy at personal achievements to stress, anxiety, and other mental health concerns. The language and tone used in these posts reveal significant insights into the user's emotional state and mental well-being. For instance, frequent posts about feelings of sadness, hopelessness, or anxiety could be indicative of underlying mental health issues such as depression or anxiety disorders. Changes in the frequency, content, and nature of social media posts can signal shifts in a person's mental state. A sudden increase in posting, especially if the content is erratic or distressing, or a sudden decrease or absence of activity, can be telling. Analyzing these patterns over time can provide clues about fluctuations in mental health, potentially signaling the onset of a mental health condition or changes in an existing condition. Social media allows users to connect with others, seek support, and engage in communities. How individuals interact with others online, the type of content they share, and the communities they engage with can offer insights into their mental state. Seeking support or discussing mental health challenges in online communities could indicate a need for help or an attempt to cope with personal issues. The advancement in natural language processing (NLP) and ML enables the analysis of vast amounts of unstructured social media data to identify patterns and indicators of mental health conditions. LLMs, like those used in this study, can analyze text data for semantic meaning, emotional tone, and other linguistic markers that are often associated with mental health states.

In the contemporary digital landscape, social media platforms have emerged as pivotal spaces for self-expression and social interaction. Platforms such as Facebook, Instagram, and Twitter serve as conduits for individuals to articulate their thoughts, emotions, and daily experiences. This digital discourse offers an expansive, yet underutilized, dataset that mirrors the collective mental health psyche of its users. The extraction and analysis of this textual data presents an unprecedented opportunity for large-scale mental health monitoring and analysis (Mahlous & Okkali, 2022; Ul Haq et al., 2020).

The field of NLP has seen transformative advancements with the introduction of LLMs such as OpenAI's GPT-3 and GPT-4 (Bubeck et al., 2023). These models represent a new era of NLP, where pre-trained models have begun to take precedence over traditional NLP tasks. OpenAI's models, particularly GPT-4, are notable examples in this domain. They have demonstrated remarkable versatility across various fields including programming and mathematics. These LLMs possess the capability to generate vector-based representations from textual data, effectively capturing sentiment and semantic meanings.

LLMs, like OpenAI's GPT-3, generate vector representations of text known as embeddings. These embeddings encode the semantic meaning and relationships within language in a high-dimensional space. In this research project, we focused on harnessing the potential of GPT-3 embeddings to discern stress-related disorders from social media content. GPT-3, with its advanced embeddings, capable of capturing a spectrum of semantic meanings and linguistic nuances, is posited as a foundational tool for developing an automated classification model. This model aims to categorically identify social media posts as indicative or nonindicative of stress disorders, thereby serving as an innovative screening mechanism for early identification and intervention in mental health issues.

Here we explore the integration of GPT-3 embeddings with sophisticated ML algorithms, including support vector machines (SVM) and random forests, to construct and refine predictive

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