Research Article: Contemporary Issues in Behavioral and Social Sciences

Machine Learning Approaches for Automated Mental Disorder Classification based on Social Media Textual Data

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Abstract

The application of machine learning models to mental health-related text data offers a novel approach to discern patterns and trends, aiding in the identification of subgroups and personalized treatment options. This research explores the classification of mental disorders based on text data extracted from subreddits focused on mental health. The dataset consists of 10,000 rows of text collected from four subreddits: 'BPD', 'bipolar', 'depression', and 'Anxiety', along with a combined category 'others' encompassing 'mentalillness' and 'schizophrenia'. To enable the application of machine learning models, various text preprocessing techniques were applied, including the removal of URLs, punctuation marks, and stopwords, as well as the transformation of raw text documents into a matrix of TF-IDF features. These preprocessing steps were performed on both the titles and text contents of the posts. Three machine learning models, namely Multinomial Naive Bayes, Multi-layer Perceptron, and LightGBM, were employed for the classification task. The models were trained and evaluated separately on both the post titles and the text content. The accuracy of each model was assessed to measure their performance. The results indicate that the Multinomial Naive Bayes model achieved an accuracy of 0.706 when classifying based on titles, while the accuracy increased to 0.73 when classifying based on the text content. The Multi-layer Perceptron model yielded an accuracy of 0.68 for title classification and 0.714 for text content classification. Notably, the LightGBM model exhibited superior performance, achieving an accuracy of 0.724 when using titles for classification, and an even higher accuracy of 0.77 when employing the text content. This research demonstrates the efficacy of machine learning models in classifying mental disorders using text data extracted from social media. These findings contribute to the ongoing exploration of using social media data for mental health analysis and may aid in developing automated tools for early detection and support for individuals facing mental health challenges.

Keywords: *Machine learning, Mental disorders, Text data, Reddit, NLP, BPD, Bipolar*

Introduction

The advent of machine learning models has transformed the landscape of mental health by providing robust instruments to analyze and comprehend textual information [1]. These models can be trained to process vast amounts of textual information, such as online forums, social media posts, or clinical notes, and extract valuable insights that can aid in mental health research, diagnosis, and treatment. By employing techniques like natural language processing (NLP) and sentiment analysis, machine learning models can uncover patterns, sentiments, and themes within mental health-related text data [2], [3].

One significant application of machine learning models in mental health is the identification of individuals at risk of mental health disorders. By analyzing text data from sources like social

media posts or online support forums, these models can detect signs of distress, emotional instability, or other indicators of mental health conditions. This information can help mental health professionals and researchers identify high-risk individuals who may require immediate intervention or support [4]. Moreover, machine learning models can also aid in early detection by flagging subtle linguistic cues or changes in language patterns that might indicate the onset of mental health issues.

Machine learning models can also contribute to improving mental health treatment and therapy by analyzing text data from therapy sessions or self-reporting tools. These models can be trained to identify language patterns or specific keywords that correlate with treatment outcomes or the effectiveness of different therapeutic approaches. By leveraging this information, mental health practitioners can gain insights into the factors that contribute to successful therapy outcomes and tailor treatment plans accordingly [5], [6]. Machine learning models can also assist in monitoring patient progress by analyzing changes in language use over time, enabling therapists to intervene when necessary and adjust treatment strategies.

Furthermore, machine learning models can help reduce the stigma associated with mental health by providing automated and objective analysis of text data. This approach allows individuals to express their thoughts and feelings more openly, as they may feel less judged by a machine than by a human. It also enables researchers to conduct large-scale studies on mental health-related text data, allowing for a broader understanding of mental health issues across different demographics, cultures, and languages.

During the COVID-19 pandemic, both mental and physical health faced unprecedented challenges. The prolonged periods of isolation, fear, and uncertainty took a toll on people's mental well-being. Many individuals experienced heightened levels of anxiety, depression, and stress as they grappled with the fear of contracting the virus and the myriad of socio-economic consequences. The pandemic disrupted routines, limited social interactions, and increased screen time, leading to an exacerbation of mental health issues. Moreover, healthcare systems were strained, making it difficult for some individuals to access necessary mental health support. However, the pandemic also spurred innovations in telemedicine and digital mental health resources, allowing many to seek therapy and counseling remotely, which proved beneficial to some. As the pandemic receded, efforts to address the long-term mental health impact continued, emphasizing the importance of resilience-building and community support.

Regarding physical health, the pandemic exposed the vulnerabilities of individuals with pre-existing health conditions and highlighted the significance of maintaining a healthy lifestyle [7], [8]. The necessity of social distancing and lockdown measures led to reduced physical activity for many, contributing to sedentary lifestyles and potential weight gain. Additionally, postponement or avoidance of routine medical check-ups and treatments due to the fear of exposure to the virus created new challenges in managing chronic conditions. However, the pandemic also encouraged a surge in health-conscious behavior, with more people focusing on home workouts, outdoor activities, and healthier eating habits. After the pandemic, there was a renewed emphasis on preventive healthcare and the importance of maintaining a robust immune system.

Mental illness is a broad term that encompasses a wide range of conditions affecting a person's thoughts, emotions, behavior, and overall mental well-being. It includes disorders such as mood

disorders, anxiety disorders, psychotic disorders, personality disorders, and eating disorders, among others. Each specific mental illness has its own unique symptoms, causes, and treatment approaches.

Borderline Personality Disorder (BPD) is a complex psychiatric condition characterized by a pervasive pattern of instability in mood, interpersonal relationships, self-image, and behavior. Individuals with BPD often experience intense and rapid mood swings, ranging from euphoria to profound sadness or anger, which can be triggered by perceived abandonment or rejection. These mood fluctuations, coupled with a profound fear of abandonment, can lead to impulsive and self-destructive behaviors, such as self-harm or suicidal ideation. BPD is also associated with difficulties in interpersonal relationships, as individuals with this disorder often struggle with maintaining stable and healthy connections due to their fear of rejection and tendency to perceive others as either entirely good or entirely bad.

Bipolar Disorder, on the other hand, is a chronic mental illness characterized by recurring episodes of manic and depressive states [9]. Manic episodes are marked by an elevated mood, increased energy levels, impulsivity, and a heightened sense of self-importance. Depressive episodes, on the other hand, are characterized by feelings of extreme sadness, loss of interest or pleasure in activities, changes in appetite and sleep patterns, and a sense of worthlessness or guilt. The transition between these two states can be sudden or gradual and can significantly disrupt an individual's daily functioning and overall quality of life. Bipolar Disorder is believed to be caused by a combination of genetic, neurobiological, and environmental factors, and effective treatment often involves a combination of medication and therapy to manage symptoms and stabilize mood swings.

Both Borderline Personality Disorder (BPD) and Bipolar Disorder are psychiatric conditions that can significantly affect an individual's mental well-being and daily functioning [10], [11]. While they exhibit certain similarities, it is important to recognize their distinctive features and diagnostic criteria.

One key similarity between BPD and Bipolar Disorder is mood instability. In BPD, individuals often experience intense and rapid shifts in mood, ranging from extreme highs to lows, often triggered by interpersonal stressors or perceived abandonment. On the other hand, individuals with Bipolar Disorder also experience mood swings, but these are characterized by distinct episodes of mania and depression. Manic episodes in Bipolar Disorder involve elevated mood, increased energy, impulsive behavior, and an inflated sense of self, while depressive episodes manifest as profound sadness, loss of interest, and feelings of worthlessness.

Another common feature shared by BPD and Bipolar Disorder is impulsivity. Both disorders are associated with impulsive behaviors, such as reckless spending, substance abuse, or engaging in risky sexual activities. However, in BPD, impulsivity is often driven by a fear of abandonment and a desperate attempt to avoid perceived rejection, whereas in Bipolar Disorder, impulsivity can arise during manic episodes when judgment and impulse control are compromised.

Despite these shared characteristics, there are distinct differences between BPD and Bipolar Disorder. BPD primarily affects an individual's sense of self and relationships, leading to an unstable self-image, identity disturbance, and intense fear of abandonment. Interpersonal difficulties are a hallmark feature of BPD, with individuals often exhibiting black-and-white

thinking, idealizing and devaluing others, and experiencing turbulent relationships. In contrast, Bipolar Disorder primarily revolves around mood dysregulation, with episodes of mania and depression having a more profound impact on a person's emotional state.

Depression, Anxiety, Mental Illness, and Schizophrenia are all significant mental health conditions that can have a profound impact on individuals' lives. While they may share some common symptoms and affect emotional well-being, they are distinct disorders with their own characteristic features and diagnostic criteria [12], [13].

Depression is a mood disorder characterized by persistent feelings of sadness, loss of interest or pleasure in activities, changes in appetite and sleep patterns, decreased energy, feelings of worthlessness or guilt, and difficulty concentrating or making decisions. It can be a debilitating condition that affects various aspects of a person's life, including their relationships, work, and overall quality of life.

Anxiety disorders, on the other hand, encompass a range of conditions characterized by excessive and persistent worry, fear, or anxiety that significantly interferes with daily functioning. These disorders can include generalized anxiety disorder, panic disorder, social anxiety disorder, and specific phobias. Symptoms may include restlessness, irritability, muscle tension, racing thoughts, and avoidance behaviors.

Schizophrenia is a chronic and severe mental disorder characterized by distorted thinking, hallucinations, delusions, disorganized speech and behavior, and impaired social functioning. It is often accompanied by significant difficulties in distinguishing between what is real and what is not. Individuals with schizophrenia may experience disruptions in their perception, thoughts, emotions, and behavior, making it challenging to maintain relationships, work, or engage in daily activities.

Social media platforms provide a vast amount of textual data that individuals voluntarily share, offering a unique opportunity to extract valuable insights about their mental well-being [14], [15]. By leveraging machine learning techniques, researchers and practitioners aim to develop automated systems that can accurately classify mental disorders based on users' social media posts.

Data preprocessing

The dataset used in this study consists of 10,000 rows of text data obtained from four subreddits related to mental disorders: BPD, bipolar, depression, and anxiety. In addition to these specific subreddits, the data also includes posts from subreddits related to mental illness and schizophrenia. This diverse range of subreddits provides a comprehensive collection of text data that reflects the experiences and discussions within various mental health communities on Reddit.

To facilitate the classification task, the subreddits were categorized into three main groups: BPD, bipolar, and others. The "others" category encompassed subreddits related to depression, anxiety, mental illness, and schizophrenia. This categorization allowed for a simplified and manageable classification task, where the focus was primarily on distinguishing between the specific disorders of BPD and bipolar, while also considering the broader category of other mental disorders.

In order to prepare the text data for the application of machine learning models, several preprocessing steps were performed. Firstly, URLs were removed from the text to eliminate any web links that could potentially interfere with the analysis. Punctuation marks were also removed to focus solely on the textual content and avoid the influence of punctuation on the classification process. Stopwords, which are commonly occurring words with little semantic meaning (e.g., "the," "and," "is"), were removed to reduce noise and improve the quality of the features. Finally, the raw text documents were transformed into a matrix of TF-IDF (Term Frequency-Inverse Document Frequency) features, which quantifies the importance of each word in the documents based on its frequency and rarity across the entire corpus.

Table 1. Subreddits

Category	Count
BPD	3534
Anxiety	2464
Depression	2323
Bipolar	711
Mental Illness	685
Schizophrenia	283

It is worth noting that these preprocessing steps were applied to both the titles and the text contents of the posts. By considering both components of the posts, the study takes into account the potential insights and discriminatory power that may arise from the combination of concise titles and more extensive text content. This comprehensive approach aims to capture the most relevant information for accurate classification and to leverage the potential contributions from both the title and the body of the posts.

Table 2. A randomly selected subset of 15 titles and bodies

	title	Text contents (snippet)	Created UTC	Over 18	subreddit
95287	Small Victory	Hey all!\n\nI just wanted to post about my lit…	1.62E+09	FALSE	BPD
36036	I'm trying so hard to gain control of my illne...	I was diagnosed with BPD at 16, about a year a...	1.66E+09	FALSE	BPD
493352	How to manage	I've struggled with anxiety for a few years no...	1.64E+09	FALSE	Anxiety
346285	how to get rid of lethargy	I used to be depressed for many months within ...	1.66E+09	FALSE	depression
436982	I Walk Alone	Im a loner by choice. Everything i touch dies,...	1.67E+09	FALSE	depression
382246	looking for help at the bottom of the barrel	Hi, new to reddit but I'm not sure where else ...	1.65E+09	FALSE	depression
73240	Has anyone else given up on socializing/having...	Basically I have given up on trying to make or...	1.61E+09	FALSE	BPD
255631	(TW/CW) I relapsed. Five years of hard work fo...	[removed]	1.67E+09	TRUE	bipolar
356432	I have no energy.	I have no energy to do anything not even play ...	1.66E+09	FALSE	depression

136761	I'm not a solid person	In movies about time travel, often while situa...	1.59E+09	FALSE	BPD
79859	*mentions of alcohol* Anyone else have this pr...	When I drink I can't tell I'm drunk. I can be ...	1.61E+09	FALSE	BPD
346207	self harm free	IM ALMOST 10 DAYS SELF HARM FREE i hope i can ...	1.66E+09	FALSE	depression
636100	I don't know anymore CW: mentions of s****de	[removed]	1.66E+09	FALSE	schizophrenia
115260	help	Recently got into a relationship and it's been...	1.58E+09	FALSE	BPD
661428	I've been diagnosed with BPD, bipolar 1, ADHD,...	Said to my counselor, "I think I might be auti...	1.65E+09	FALSE	mentalillness

Methods

We applied Multinomial Naive Bayes, Multi-layer Perceptron, and LightGBM for the classification tasks. Multinomial Naive Bayes is a probabilistic classification algorithm commonly used in natural language processing tasks, particularly for text categorization and sentiment analysis. It is based on the principle of Bayes' theorem with the assumption of independence between features. In the case of multinomial Naive Bayes, the features are treated as discrete count variables, often representing the frequency of words or terms in a document [16]. The algorithm calculates the probabilities of each class based on the occurrence of these features and assigns the most probable class to a given input.

The multi-layer perceptron (MLP) is a fundamental neural network architecture used for supervised learning tasks, such as classification and regression [17]. It consists of multiple layers of interconnected artificial neurons called perceptrons. Each perceptron applies a non-linear activation function to the weighted sum of its inputs and passes the output to the next layer. The MLP is designed to learn complex non-linear relationships between input features and target outputs. Through a process called backpropagation, the network adjusts the weights and biases of its connections during training to minimize the difference between predicted and actual outputs, optimizing the network's performance.

LightGBM is a gradient boosting framework that excels in handling large-scale datasets and achieving fast training speeds [18], [19]. It is based on the gradient boosting machine learning technique, which combines weak prediction models, typically decision trees, into a strong ensemble model. LightGBM introduces novel features such as the Gradient-based One-Side Sampling (GOSS) and Exclusive Feature Bundling (EFB) to improve training efficiency and prediction accuracy. GOSS focuses on optimizing the boosting process by efficiently selecting data instances for building trees. EFB bundles exclusive features together, reducing memory usage and enhancing the speed of training. LightGBM has gained popularity due to its ability to handle large datasets with high dimensionality and achieve competitive performance in various machine learning tasks.

Figure 1. Wordclouds

Wordcloud biopolar and PBD in text

Wordcloud biopolar and PBD in title

Table 2. Most frequent words in each subreddit

Most frequent words in title by BPD	bpd', 'feel', '’', 'like', 'get', 'fp', 'anyon', 'help', 'im', 'dae', 'peopl', 'relationship', 'need', 'want', 'friend', 'els', 'someon', 'know', 'think', 'dont', 'advic', 'make', 'love', 'hate', 'person
Most frequent words in title by 'bipolar'	bipolar', 'feel', 'anyon', 'episod', 'manic', 'get', 'depress', 'im', 'med', 'help', 'go', 'like', 'mania', 'els', 'take', 'know', 'need', 'lithium', 'time', 'work', 'start', 'experi', 'medic', 'make
Most frequent words in title by other disorders	anxieti', '’', 'feel', 'depress', 'im', 'help', 'get', 'like', 'anyon', 'need', 'want', 'life', 'go', 'dont', 'know', 'think', 'peopl', 'make', 'day', 'els', 'friend', 'anxiou', 'thought', 'cant', 'attack
Most frequent words within the text by BPD	feel', 'like', 'im', 'want', 'know', 'get', 'time', 'dont', 'go', 'bpd', 'realli', 'thing', 'think', 'peopl', 'even', 'make', 'tri', 'friend', 'one', 'would', 'love', 'day', 'year', 'talk'

Most frequent words within the text by 'bipolar'	feel', 'like', 'im', 'get', 'know', 'go', 'bipolar', 'want', 'time', 'realli', 'depress', 'day', 'start', 'thing', 'take', 'year', 'think', 'peopl', 'remov', 'tri', 'even', 'help', 'med', 'work
Most frequent words within the text by other disorders	feel', 'like', 'im', 'get', 'know', 'want', 'go', 'anxieti', 'time', 'dont', 'even', 'realli', 'think', 'thing', 'day', 'life', 'make', 'year', 'peopl', 'tri', 'one', 'help', 'would', 'friend'

Results

The results of the classification by title show that the Multinomial Naive Bayes model achieved an accuracy of 0.706, as shown in table 3. This means that when solely considering the titles of the posts from the mental disorder-related subreddits, the model was able to correctly classify them into their respective categories with an accuracy of approximately 70.6%. The Multinomial Naive Bayes algorithm is a probabilistic classifier commonly used for text classification tasks. It assumes that the features (in this case, the words in the titles) are conditionally independent given the class. Despite this assumption, the model performed relatively well, indicating that the titles alone contain valuable information for distinguishing between different mental disorders.

Table 3. Machine learning model results

Classification by Title	Accuracy (Title)	Classification by Text Content	Accuracy (Text Content)
Multinomial Naive Bayes	0.706	Multinomial Naive Bayes	0.73
Multi-layer Perceptron	0.68	Multi-layer Perceptron	0.714
LightGBM	0.724	LightGBM	0.77

When the classification was performed based on the text content of the posts, the Multinomial Naive Bayes model achieved a higher accuracy of 0.73. By considering the complete text content of the posts, including the body of the posts and not just the titles, the model improved its classification accuracy. This suggests that the additional information contained within the text content provides more discriminative features for accurately categorizing the posts into their respective mental disorder categories. The increase in accuracy from 0.706 to 0.73 demonstrates the importance of utilizing the full textual information available when classifying mental disorder-related posts.

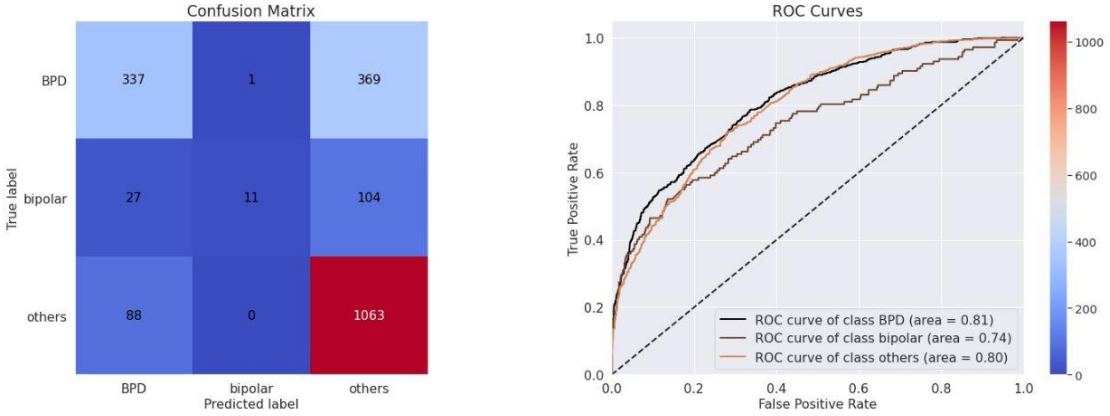
The Multi-layer Perceptron model, a type of artificial neural network, achieved an accuracy of 0.68 for classification by title and an accuracy of 0.714 for classification by text content. These results indicate that the Multi-layer Perceptron model performed slightly worse than the Multinomial Naive Bayes model in both cases. The lower accuracies might be attributed to the complexity of the neural network architecture and the availability of a limited amount of data for training. Despite this, the model still achieved reasonable accuracies, suggesting that it has the potential to learn meaningful patterns from the textual data. Fine-tuning the architecture

and increasing the size of the training data could potentially lead to improved performance of the Multi-layer Perceptron model.

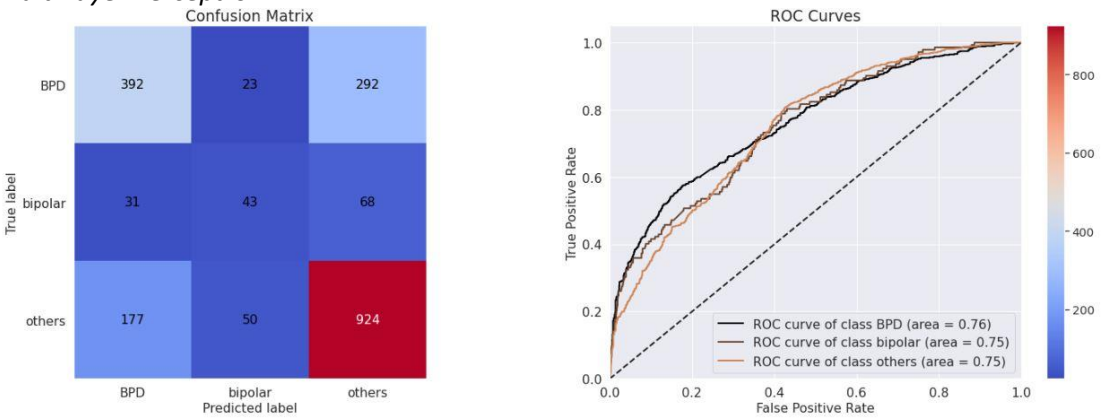
In contrast, the LightGBM model outperformed both the Multinomial Naive Bayes and Multi-layer Perceptron models. It achieved an accuracy of 0.724 for classification by title and an even higher accuracy of 0.77 for classification by text content. LightGBM is a gradient boosting framework known for its efficiency and accuracy in handling large-scale datasets. The superior performance of the LightGBM model suggests that its boosting algorithm effectively leveraged the features present in the textual data to accurately classify the mental disorder-related posts. The higher accuracy achieved by the LightGBM model compared to the other models highlights its potential for more precise identification and categorization of mental disorders based on textual information.

Figure 2. Confusion matrices and ROC curves for titles

Multinomial Naive Bayes



Multi-layer Perceptron



LightGBM

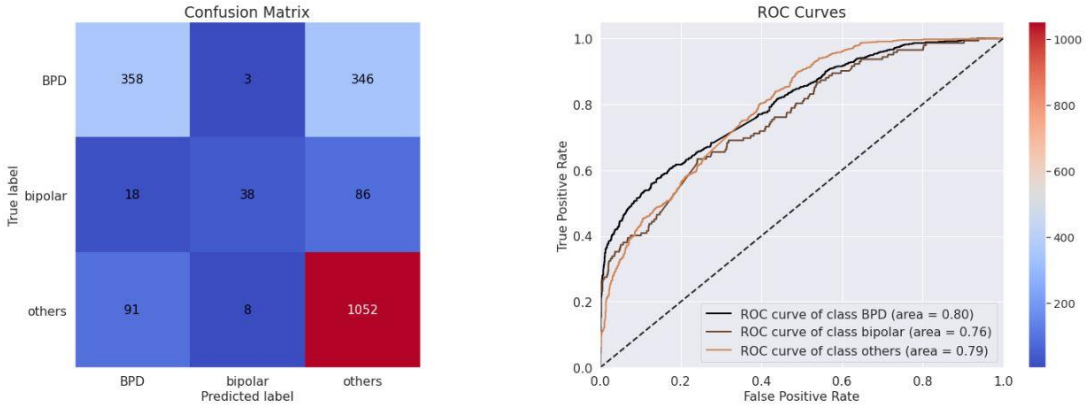
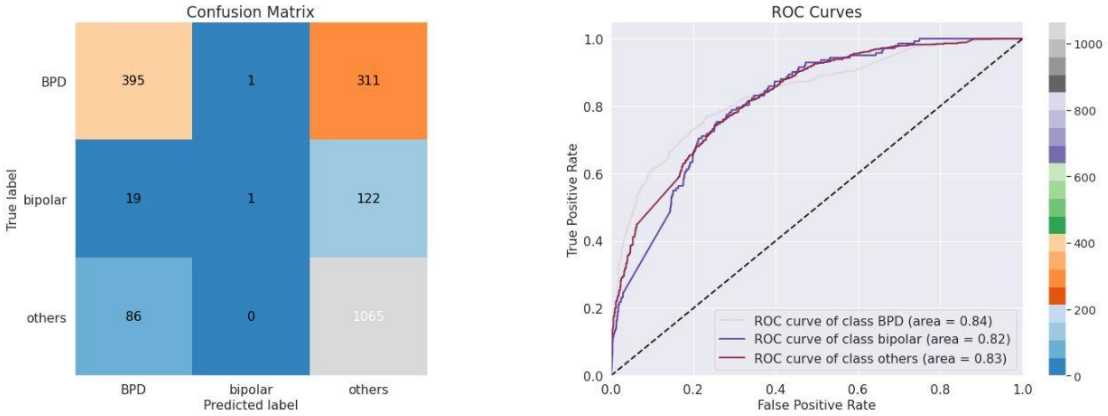
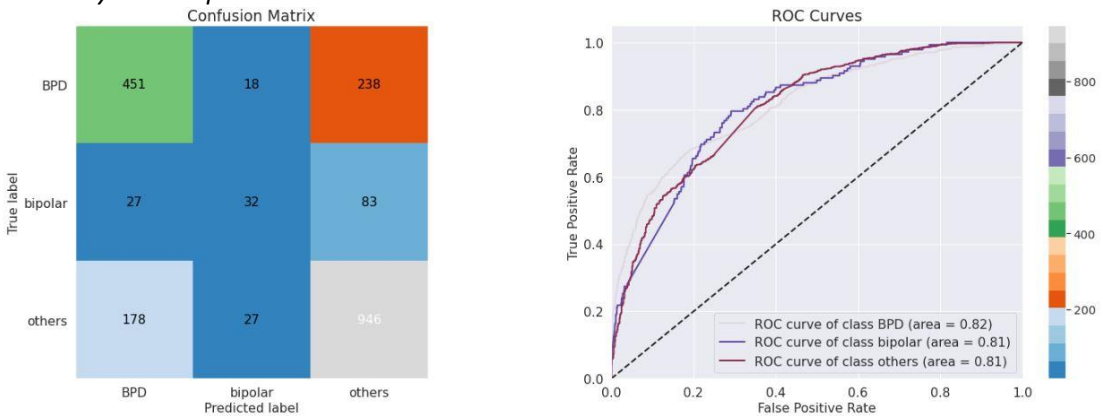


Figure 3. Confusion matrices and ROC curves for texts bodies

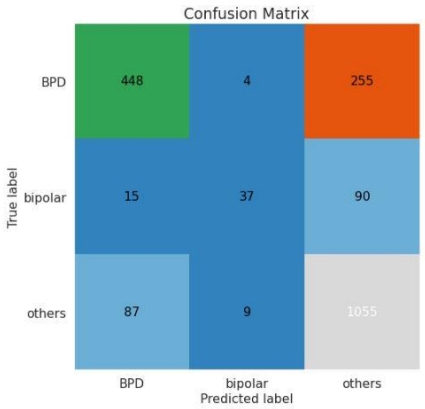
Multinomial Naive Bayes

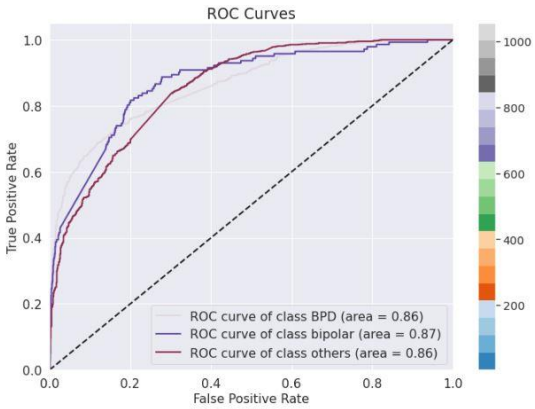


Multi-layer Perceptron



LightGBM





The most frequent words in the titles by individuals with BPD (Borderline Personality Disorder) include 'bpd', 'feel', 'like', 'get', 'fp', 'anyon', 'help', 'im', 'dae', 'peopl', and 'relationship'. These words reflect the emotional experiences and interpersonal challenges often associated with BPD. The prevalence of terms such as 'help', 'im', and 'peopl' suggests a desire for support and understanding from others in the community. The prominence of words like 'relationship' indicates that individuals with BPD may seek guidance and advice regarding their interpersonal connections.

In the titles of posts related to bipolar disorder, the most frequent words include 'bipolar', 'feel', 'anyon', 'episod', 'manic', 'get', 'depress', 'im', 'med', and 'help'. These words highlight the fluctuating mood states, episodes of mania and depression, and the need for medication and support that are commonly associated with bipolar disorder. The use of terms like 'episod', 'manic', and 'depress' suggests that individuals with bipolar disorder often seek information or share their experiences related to these specific states. The recurrence of words such as 'help', 'med', and 'im' reflects the need for assistance and management strategies within the bipolar community.

For the other mental disorders, such as depression, anxiety, mental illness, and schizophrenia, the most frequent words in the titles include 'anxieti', 'feel', 'depress', 'im', 'help', 'get', 'like', 'anyon', and 'need'. These words indicate common themes shared among individuals with these disorders, including feelings of anxiety and depression, the need for help and support, and the desire to connect with others who may understand their experiences. The use of terms like 'life', 'day', 'peopl', and 'friend' suggests broader concerns about daily functioning, relationships, and the impact of mental illness on one's social life.

When examining the most frequent words within the text content of the posts, the patterns are similar across the three categories. The words 'feel', 'like', 'im', 'get', 'know', and 'want' consistently appear as the most frequent words in the texts of individuals with BPD, bipolar disorder, and other mental disorders. These words reflect the subjective experiences and emotional states of individuals with mental disorders. Additionally, terms like 'time', 'think', 'peopl', and 'make' suggest the cognitive and social dimensions of living with mental health challenges.

Conclusion

This research demonstrates the effectiveness of machine learning models in accurately classifying mental disorder-related subreddits based on textual data. By applying Multinomial Naive Bayes, Multi-layer Perceptron, and LightGBM models to a dataset comprising posts from BPD, bipolar, depression, and anxiety subreddits, the study achieved promising results. The preprocessing of the data involved removing URLs, punctuation marks, and stopwords, enabling the transformation of textual data into TF-IDF features. This numerical representation facilitated the application of machine learning algorithms for classification purposes.

Among the models tested, the LightGBM model exhibited the highest accuracy. LightGBM outperformed both Multinomial Naive Bayes and Multi-layer Perceptron models. These results suggest the potential of LightGBM as a reliable tool for accurately categorizing mental disorder-related subreddits.

The findings of this research have significant implications for the development of automated tools to detect and support individuals with mental disorders in online communities. By effectively classifying subreddits based on textual data, these tools could provide valuable resources and assistance to those in need. However, it is important to note that further research is necessary to explore alternative models, feature engineering techniques, and diverse data sources to improve classification performance.

The ability to classify subreddits effectively enables the creation of automated systems that can identify and flag posts related to mental disorders. This has the potential to significantly improve the accessibility of mental health support in online communities. By promptly identifying individuals who may be experiencing mental health challenges, these tools can provide relevant resources, such as helpline numbers, self-help guides, or links to professional mental health services. Moreover, they can facilitate the establishment of supportive online communities where individuals can connect with others who share similar experiences, fostering a sense of belonging and reducing feelings of isolation.

Utilizing social media textual data for mental disorder classification poses several challenges, one of which is the inherent noise and ambiguity present in social media texts. Social media platforms are known for their casual and informal nature, leading to the presence of various linguistic elements that can hinder the accuracy of classification models.

One challenge is the prevalence of spelling errors in social media posts. Users often prioritize speed and convenience over accuracy when typing on social media platforms, leading to frequent typographical errors. These errors can introduce noise into the data and potentially misrepresent the intended meaning of the text, making it challenging for classification models to accurately interpret and classify mental health-related content.

Abbreviations and acronyms are also common in social media texts, as users often aim to communicate their thoughts within the character limitations imposed by these platforms. However, deciphering the meaning of abbreviations can be difficult, especially if they are specific to a particular community or group. This can result in misinterpretations and misclassifications when attempting to analyze and classify mental health-related content.

The informal and colloquial nature of social media also gives rise to the use of slang and unconventional language. Slang terms and expressions can be highly context-dependent and

subject to change over time, making it challenging for classification models to accurately interpret and classify the content. Additionally, sarcasm and irony are frequently employed in social media communication, and their detection and interpretation can be complex tasks for machine learning models.

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