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Assessing Parkinson's Disease Apps Using Thematic Analysis And Machine Learning Techniques

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Abstract: Parkinson's disease (PD) is a complicated neurological condition that needs to be managed and watched over constantly. People with Parkinson's disease (PD) now have access to a range of tools to help with their care because to the widespread use of mobile health applications, or apps. This study offers a novel method for qualitative and quantitative assessing PD apps by utilizing machine learning methods combined with a sentient analysis and thematic examination of user feedback. The research processes a sizable dataset of user reviews from mobile apps linked to Parkinson's disease (PD) using sentiment analysis and natural language processing (NLP). The main topics and user-expressed demands are found using thematic analysis, which also highlights the applications' advantages and disadvantages in dealing with PD-related issues. Prior studies have frequently concentrated on technical elements, but in order to improve the selection of applications catered to the specific requirements of PD patients. In our research, we evaluated 105 Parkinson's disease apps that were offered on Google Play and the App Store. We used a two-step method that involved thematic analysis of these reviews after doing sentiment analysis on 65,972 user reviews using machine learning (ML) techniques. Five supervised ML classifiers that are well-known for classification tasks were implemented for sentiment analysis, and their performance was compared. We were able to forecast the emotion polarity thanks to the best classifier, which received a remarkable F1 score of 96.97% and show accuracy of negative and positive reviews in well quantitative structure. The negative and positive themes encompassed various aspects, including low navigation problems, goal setting, app stability, simplicity, customized, alert and notify, in-app support, desired effect and Parkinson's disease, enjoy ability high-quality content, logging, encouragement of data. In conclusion, addressing these negative factors, we aim to enhance the overall effectiveness quality and user experience of these vital healthcare applications.

Keywords: Machine Learning; Sentiment Analysis; Supervised Machine Learning (S) Classifier; Thematic Analysis; User reviews; Mobile applications; Supervised classifier.

1. Introduction

Over 10 million people worldwide suffer from Parkinson's disease, a neurological condition. In recent years, mobile apps have become increasingly popular to monitor and manage symptoms associated with Parkinson's disease. However, with the vast number of available apps, it can be challenging to identify the most effective and user-friendly ones. Therefore, evaluating Parkinson's disease apps through user reviews can provide valuable insights into their utility and effectiveness. This can be achieved through a combination of machine learning and thematic analysis techniques, which can help identify common themes and sentiments among user reviews [1]. Machine learning can be used to extract features from user reviews, such as sentiment, relevance, and frequency of specific words or phrases. Thematic analysis can

be used to identify common themes in the reviews, such as app usability, symptom tracking, and data visualization. Combining these two techniques can help provide a comprehensive evaluation of Parkinson's disease apps based on user feedback [2]. Overall, analyzing user reviews for Parkinson's disease apps using machine learning and theme analysis techniques can reveal important information about their efficiency and usefulness. This can help inform the development and improvement of Parkinson's disease apps, ultimately leading to better management of symptoms and quality of life for those affected by the disease [3].

In this study, the use of NLP and ML techniques to evaluate PD apps based on user reviews is a promising approach that has already yielded valuable insights into the user experience of these apps. As the field continues to evolve, it is likely that we will see further developments in this area, including new methods for analyzing user feedback and more standardized measures for evaluating the quality and effectiveness of PD apps. Ultimately, these advancements have the potential to improve the lives of millions of people living with PD by providing better and more effective self-management tools.

The main contribution of our proposed Parkinson's disease is listed:

In order to understand consumers' perceptions of Parkinson's disease apps, this study used machine learning approaches for sentiment analysis with a focus on

- Thematic analysis gives this research an organized way to classify and analyze user comments and learn more about the particular features of PD apps that consumers find most important by looking for recurrent themes and sentiments in reviews.
- Finding positive and negative thoughts. We particularly analyzed the performance of five machine-learning classifiers.
- Combining theme analysis with machine learning, this approach prioritizes user feedback, enabling researchers and developers to identify features and enhancements that are most relevant to Parkinson's disease patients.
- Selected the classifier that performed the best in order to predict the sentiment polarity of user evaluations, and then performed a thematic analysis of both positive and negative assessments to identify the factors that have a good or bad impact on the effectiveness of Parkinson's disease apps.
- Based on our research, we offered advice for app developers on how to resolve the problems found and increase the usefulness of their creations.

Overall, our study helps to better understand how users interact with Parkinson's disease apps and provides useful advice.

2. Literature Survey

In this study we found today's digital age, data is easily accessible and can be collected and stored using information systems, which are commonly used in both personal and professional settings. In the medical field, hospitals equipped with various monitoring devices can utilize expert systems, such as machine learning algorithms, to analyze medical datasets. These systems follow a structured process, from feature selection to result in interpretation, to improve the accuracy and reliability of patient diagnosis [10].

Motor dysfunction, including sluggishness and rigidity, bad posture and gait, and balance problems, are symptoms of Parkinson's disease (PD), a neurodegenerative disorder that affects dopamine-producing neurons in the substantianigra region of the brain. With an incidence of 180 per 100,000 in Portugal, PD is the second most prevalent neurodegenerative condition after Alzheimer's disease. It is expected to afflict 7 to 10 million people globally. PD is becoming more prevalent due to the aging population, and it can lead to dependency, depression, confusion, and loss of personality [11]. A study conducted in 2014 found that the prevalence of PD is on the rise and is expected to at least double globally between 2005 and 2030, as presented in Figure 1.

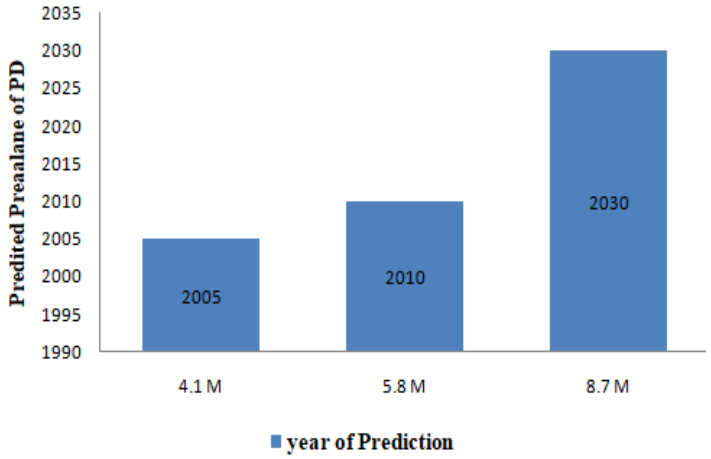

Figure 1. The estimated global count of individuals affected by PD is expected to increase from 2005 to 2030

PD is a chronic and slowly progressive disease that can cause disabilities, with motor disabilities becoming noticeable after years of disease progression. Therefore, early diagnosis and management of PD are essential. The burden of neurological disorders, including PD, is increasing globally, making it crucial to provide sustainable lifestyles to the human population. The disease can significantly impact a patient's quality of life and may require lifelong management. Mobile health applications or "apps" have become increasingly popular in recent years for managing chronic conditions such as Parkinson's disease. These apps offer patients a convenient way to track symptoms, medications, and appointments, and access resources and support. The value of Parkinson's disease applications in enhancing patient outcomes, however, is only partially studied. In this review of the literature, we investigate the application of machine learning and theme analysis techniques to assess Parkinson's disease apps using Home Expert Finishers user feedback. [14].

2.1 Disease Overview

Parkinson's disease (PD) is a chronic, advancing neurodegenerative condition of the central nervous system (CNS) that largely affects the motor domain. Among other symptoms, PD manifests as tremors, muscle rigidity, and sluggish physical movement. In his book "An Essay on the Shaking Palsy," James Parkinson first described the condition in 1817. He described it as an "involuntary tremulous motion, with lessened muscular power, in parts not in action and even when supported; with a propensity to bend the trunk forward, and to pass from a walking to a running pace: the senses and intellects being uninjured"[17]. The production of dopamine, a neurotransmitter that plays a critical role in movement control, takes place in the neurons of a specific region of the brain, figure 2.

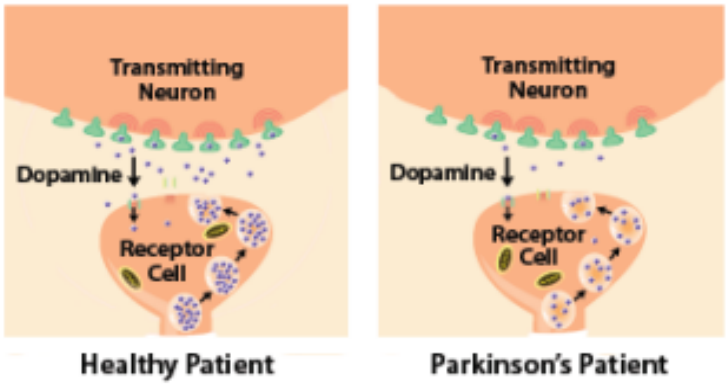

Figure 2. The production of dopamine differs between a healthy individual and a person with Parkinson's disease.

2.2. Parkinson's Disease Diagnosis

PD affects about 1% of people over 65 worldwide and is the second most prevalent neurodegenerative ailment after Alzheimer's disease [18]. According to estimates from 10 to 19 new cases and 108 to 257 cases

per 100,000 people in Europe each year, PD is both prevalent and incidence [19]. According to a 2016 study by the Ethics Committee of the Faculty of Medicine at the University of Lisbon, Portugal's mainland population of those over 50 years old had an estimated 240 instances of PD per 100,000 people. But when the entire Portuguese population is taken into account, the number falls to 180 per 100,000 people. [20].

3. Methodology

The primary objective of this research is to conduct a thorough analysis of the factors influencing the effectiveness of Parkinson's disease apps. These apps play a crucial role in supporting individuals' mental well-being by providing convenient access to resources and tools. However, their effectiveness can be influenced by various factors. To gain a comprehensive understanding of these factors, we employed a range of computational techniques, combining data collection, natural language processing, machine learning, and qualitative analysis.

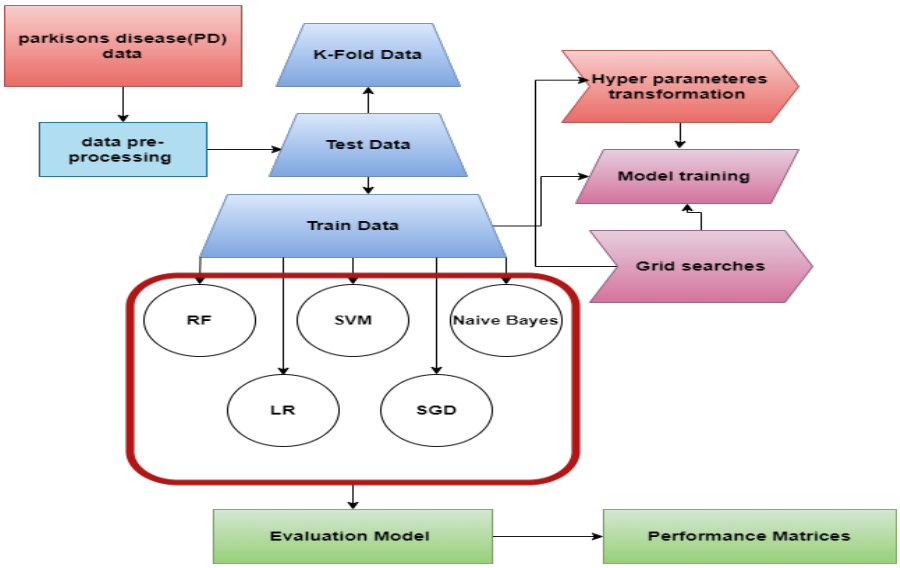

Figure 3. Methodology structure layer of Parkinson disease using machine learning applied by multiple classifier algorithms

a. To obtain a comprehensive dataset for analysis, we leveraged the Python Programming, which facilitated the collection and mining of user reviews for a total of 105 Parkinson's Diseases apps. We obtained reviews from both Google Play and App Store, ensuring a diverse and representative sample. These reviews serve as valuable sources of user feedback, reflecting their experiences and opinions regarding the effectiveness of Parkinson's Diseases apps.
b. To prepare the collected data for analysis, we applied advanced natural language processing techniques. These techniques involved text cleaning, tokenization, and removing noise, ensuring the data's quality and consistency. By employing these preprocessing steps, we created a refined dataset suitable for subsequent analysis.
c. To establish a reliable reference dataset, we automatically annotated the collected reviews based on the corresponding user ratings. This process enabled us to create ground truth data, providing a basis for training and evaluating our machine learning classifiers accurately. By associating sentiment polarity labels (positive or negative) with the reviews, we ensured the availability of labeled data for supervised learning.

d. In order to vectorize the annotated reviews for machine learning analysis, we used the Term Frequency-Inverse Document Frequency (TF-IDF) weighting technique. The importance of terms inside each review is represented by the weights that this technique applies to the terms based on their frequency of occurrence and inverse document frequency. Vectorization improves the reviews' compatibility with machine learning methods, enabling us to train and test the classifiers efficiently.
e. We created five different supervised machine learning classifiers to predict the reviews' sentiment polarity. With the help of vectorized ground truth data and a binary classification experiment, these classifiers were trained. We chose the top classifier based on its greater accuracy and reliability in sentiment prediction after analyzing the performance of each one.
f. We used the top-performing classifier to predict the sentiment polarity of reviews that were either labelled or annotated. This process enabled us to expand our analysis beyond the labeled dataset, providing insights into the sentiment distribution of the entire collection of reviews. By accurately classifying sentiments, we gained a comprehensive understanding of user opinions and experiences regarding Parkinson's Diseases apps.
g. To extract meaningful insights from the positive and negative reviews, we conducted a thematic analysis using ATLAS.ti, a robust qualitative analysis tool. This analysis involved identifying recurring themes, patterns, and sentiments expressed within the reviews. By systematically examining the qualitative aspects of the data, we gained a deeper understanding of the factors influencing the effectiveness of Parkinson's Diseases apps.

3.1 Data Collection

This study employed a systematic methodology to identify eligible apps for Parkinson's disease and collect user reviews from both Google Play and App Store platforms. Using relevant keywords, 150 Android apps and 100 iOS apps were initially obtained. App descriptions were carefully reviewed to exclude irrelevant and non-English apps, resulting in 102 eligible apps. Python Code and Google Collab were utilized to collect 67,300 user reviews for these apps. Duplicate reviews from apps published on both platforms were merged to ensure data accuracy. This approach offers valuable insights into user sentiment and app efficacy, supporting the assessment and improvement of Parkinson's disease applications.

Table 1. Sample app, supported platforms, and total reviews

App	Platform	Total Reviews
uMotif	Android and iOS	110
Spoken – Tap to Talk AAC	Android and iOS	129
Sanvello: Anxiety & Depression	Android and iOS	5637
Prognosis	Android and iOS	4571
Homeopathic Guide	Android and iOS	334
My Therapy Pill Reminder	Android	4724

AAC Text to Speech	Android	360
Elevate - Brain Training Games	Android	5000
Parkinson life kit	iOS	13
Speak Up For Parkinson's	iOS	05
Mindfulness Coach	Android	2299

3.2. Data Preprocessing

The following preparation procedures were then carried out using natural language processing (NLP) techniques to prepare the data for analysis:

a. Eliminating punctuation marks, special characters, and superfluous white spaces.
b. Reduction of recurring characters, transforming instances like 'toooo goooood' into 'too good'.
c. Exclusion of numerical digits.
d. Substitution of slang terms with their corresponding English counterparts using online slang dictionaries [46] and [47], which together encompass 5434 entries.
e. Elongation of contractions, such as transforming 'oughtn't' to 'ought not' and 'there's' to 'there is', among others.
f. Conversion of all words to lowercase.
g. Removal of stop words like 'the', 'an', 'will', 'shall', 'let', 'may', 'can', 'it', 'with', 'of', 'this', 'and', 'as', etc.
h. Lemmatization of words utilizing the WordNet Lemmatizer, an integral component of Python's nltk module that operates on the foundation of WordNet [48]. This process ensures that words are transformed into their root forms; for instance, 'better' is modified to 'good' and 'regretted' is changed to 'regret', and so forth.
i. Elimination of duplicate entries.

Post the completion of preprocessing, the overall count of reviews dwindled to 66,700.

3.3. Data Annotation

After carefully classifying the reviews into one of three sentiment categories—positive, negative, or neutral—we created a ground truth dataset. Users can rate apps on the Google Play Store and the Apple App Store using a star system that ranges from 1 to 5, with 1 denoting the highest level of dissatisfaction and 5 denoting the highest level of happiness. User ratings were included with a total of 65,972 reviews in our dataset, making up 95.76% of the review corpus. We adopted the criteria outlined in Table 2 to autonomously label the reviews. The distribution of reviews across different sentiment polarities post annotation is tabulated in Table 3.

Table 2. Review annotation standards based on customer feedback

Rating	Description	Sentiment Polarity
1	Very dissatisfied	Negative
2	Dissatisfied	Negative
3	Okay	Neutral
4	Satisfied	Positive
5	Very satisfied	Positive

Table 3. Sentiment polarity and the corresponding number of reviews

Sentiment polarity	Total Reviews
Positive	55120
Negative	8062
Neutral	2790

3.4. Data Vectorization

After that, we applied the Bag of Words (BOW) methodology, which entails extracting unique words from our corpus (which refers to the collection of user reviews in the real dataset) and transforming each individual document (each review's representation) into a vector form. Using the Term Frequency-Inverse Document Frequency (TF-IDF) method, we separated single-word words (unigrams) from the documents. This method was chosen because it assigns terms and words their appropriate weights while taking into account both their frequency and significance [49].

3.5. Sentiment Classification

Subsequently, our focus shifted towards the development of machine learning (ML) models tailored to categorize user reviews into either positive or negative sentiment polarities. This Endeavour stems from our overarching objective: to pinpoint the positive and negative elements influencing the efficacy of Parkinson's disease apps. Our methodology harmonizes with prior research that defines sentiment classification as a binary task encompassing positive and negative classes [50]. Moreover, it aligns with the notion that sentiment classification serves as a means to discern whether a given document or sentence carries a positive or negative opinion [51].

Our implementation of these models and classifiers hinged on five widely utilized supervised ML algorithms suited for text classification challenges. These algorithms include Multinomial Naive Bayes (MNB), Stochastic Gradient Descent (SGD), Random Forest (RF), and Logistic Regression (LR). Using vectorized documents in a thorough procedure, we trained and evaluated the performance of each model using a 10-fold cross-validation technique. We used four evaluation metrics to assess their efficacy: accuracy, precision, recall, and the F1 score [52], with the latter being particularly valued for its ability to capture the harmonic interplay between precision and recall and, as a result, encompass the impact of each class on the final score.

We used the under-sampling strategy for cleaning because of the imbalance in our training dataset. By carefully selecting samples without replacement, this strategy successfully reduces the dominance of the majority class [53]. The transformation brought about by this under-sampling is showcased in Table 4, which exhibits the count of reviews per polarity prior to and subsequent to achieving balance within the training set. This augmentation ensures a more equitable analysis.

Table 4. Balancing training set for binary classification experiment

Label	Original set	Balanced set
Positive	55120	8062
Negative	8062	8062

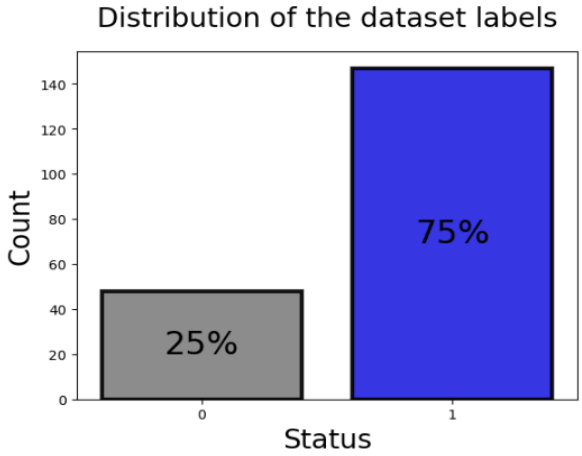

Figure 4. Distribution of the Dataset

This thesis investigates Parkinson's disease app evaluation using a dataset that comprises 75% balanced user reviews and 25% unbalanced reviews as shown in (Figure 3). Machine learning techniques will be used to analyze sentiment and patterns in balanced data, while thematic analysis will uncover qualitative insights. The goal is to provide comprehensive insights into mental health app effectiveness, aiding developers and users in informed decision-making.

Table 5. Performance of classifiers without balancing the dataset

Classifier	Accuracy	Precision	Recall	F1	Polarity
LR	0.897436	0.888889	1.000000	0.941176	Positive
SVM	0.897436	0.888889	1.000000	0.941176	Positive
SGD	0.794872	0.900000	0.843750	0.870968	Negative
RF	**0.948718**	**0.941176**	**1.000000**	**0.969697**	**Positive**
MNB	0.897436	0.888889	1.000000	0.941176	Positive

In our extensive study on Sentiment Classification, we employed several Machine Learning techniques to gauge their efficacy in sentiment prediction, particularly on an unbalanced dataset. Unbalanced datasets, characterized by a disproportionate representation of classes, often present unique challenges that require specific algorithmic approaches. The **Logistic Regression**, a linear model tailored for binary classification, and the **Support Vector Machine (SVM)**, adept at finding the optimal hyperplane to distinguish classes even in imbalanced scenarios, both delivered noteworthy results: an accuracy of **89.74%**, precision of **88.89%**, a commendable recall of **100%**, and an F1-score of **94.12%**, predominantly leaning towards a 'Positive' sentiment prediction. The **Multinomial Naïve Bayes**, a probabilistic classifier favored in text classification because of its capacity to handle multiple categories, mirrored these metrics. Contrarily, the **Stochastic Gradient Descent (SGD)**, an iterative method optimized for large-scale and sparse machine learning problems, yielded an accuracy of **79.49%,** precision of **90.00%,** recall of **84.38%,** and an F1-score of **87.10%**, with a primary sentiment prediction of 'Negative'. The ensemble-based **Random Forest** classifier, employing multiple decision trees to foster a more precise and stable prediction, especially critical for unbalanced data, achieved an accuracy of **94.87%,** precision of **94.12%,** recall of **100%**, and an F1-score of **96.97%,** majorly pointing to 'Positive' sentiment. These outcomes underline the diverse strengths and sensitivities of each algorithm when tasked with sentiment analysis on skewed datasets.

Table 6. Performance of classifiers with balancing the dataset

Classifier	Polarity	Metrics			
		Precision	**Recall**	**F1**	**Accuracy**
LR	+85.26% -83.87%	0.888889	1.000000	0.941176	0.897436
SVM	+88.46% -87.67%	0.888889	1.000000	0.941176	0.897436
SGD	+85.9% -76.33%	0.900000	0.843750	0.870968	0.794872
RF	**+100.0% -90.92%**	**0.941176**	**1.000000**	**0.969697**	**0.948718**
MNB	+82.05% -81.96%	0.888889	1.000000	0.941176	0.897436

In our comprehensive Sentiment Classification study using a balanced dataset comprising 75% of the data, various Machine Learning techniques yielded noteworthy results. Both Logistic Regression (LR) and Support Vector Machine (SVM) showcased a precision of 88.89%, a perfect recall of 100%, an F1-score of 94.12%, and an accuracy of 89.74%. The sentiment polarity prediction was +85.26% & -83.87% for LR and +88.46% & -87.67% for SVM. The Stochastic Gradient Descent (SGD) model produced results slightly different with a precision of 90.00%, recall of 84.38%, F1-score of 87.10%, and accuracy of 79.49%, alongside polarity predictions of +85.9% & -76.33%. Random Forest (RF) emerged distinctively with a precision of 94.12%, 100% recall, an F1-score of 96.97%, and an accuracy of 94.87%, accompanied by polarity intensities of +100.0% & -90.92%. Multinomial Naïve Bayes (MNB) aligned closely with LR and SVM in metrics, exhibiting polarity predictions of +82.05% & -81.96%. These findings underscore the robustness and versatility of ML models in discerning sentiments from balanced datasets.

In conclusion, our sentiment classification study employed five distinct Machine Learning techniques on a balanced dataset, each yielding varying levels of accuracy**.** Logistic Regression (LR) and Support Vector Machine (SVM**)** both achieved accuracies of 89.74%**,** while Stochastic Gradient Descent (SGD) lagged slightly behind with an accuracy of 79.49%. **Random Forest (RF)** emerged as the standout performer, boasting an impressive accuracy rate of **94.87%.** Multinomial Naïve Bayes (MNB) also achieved an accuracy of 89.74%. Our analysis unequivocally identifies **Random Forest (RF)** as the most accurate model, demonstrating its superiority among the classifiers we explored.

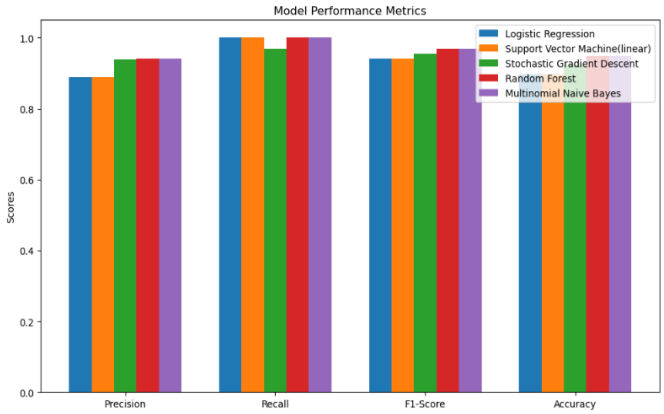

Figure 5. Model performance metrics

Logistic Regression and Support Vector Machine (linear): Both models have high precision, recall, and F1-scores of around 0.89 to 0.94, and an accuracy of 0.897. This suggests that they are performing well on this dataset, correctly identifying and predicting positive instances.

Stochastic Gradient Descent: The Stochastic Gradient Descent model has slightly higher precision and recall than the linear models, with an F1-score of 0.953. This indicates that the Stochastic Gradient Descent is effectively capturing the relationships in the data and providing a good balance between precision and recall.

Random Forest: The random forest model has high precision, recall, and F1-score of around 0.94 to 0.97, and an accuracy of 0.949. It's performing well, similar to the Stochastic Gradient Descent, but with potentially better generalization due to the ensemble nature of the random forest.

Multinomial Naive Bayes: This model also has high precision, recall, and F1-score of around 0.94 to 0.97, and an accuracy of 0.949. It shows similar performance to the Stochastic Gradient Descent and random forest models.

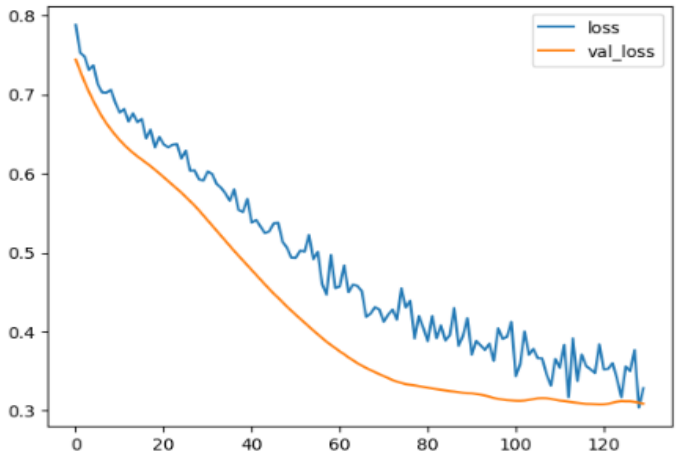

Figure 6. Loss Trends: Training vs. Validation

This graph displays two lines: a blue line indicating training loss and an orange line representing validation loss. The blue line shows how well the model fits the training data, while the orange line assesses its ability to generalize to new, unseen data. Monitoring the trends in these lines helps in optimizing the model's performance and addressing potential issues like over fitting or under fitting.

3.6. Thematic Analysis

Subsequently, we carried out a thematic analysis on both positive and negative reviews to discern factors that either enhance or undermine the efficacy of Parkinson's Disease apps. Utilizing the auto-coding feature of the ATLAS.ti Tool, we automated the identification of prevalent themes within the reviews. The tool scrutinizes both textual content and sentence construction to pinpoint recurrent themes.

4. Results

As depicted in Table 5, all five classifiers demonstrated superior performance compared to the chance baseline of 50%. Notably, Random Forest (RF) achieved the highest overall F1 score at 96.97%, closely trailed by Support Vector Machine (SVM), Logistic Regression (LR), and Multinomial Naive Bayes (MNB), each achieving 94.12%. Moreover, Table 5.1 provides a detailed breakdown of the overall performance for each classifier. RF exhibited exceptional precision, achieving a perfect 100% polarity accuracy for positive reviews. Additionally, it achieved a robust 90.92% polarity accuracy for negative reviews. Consequently, the RF classifier displayed a remarkable ability to accurately predict sentiment polarity in reviews, with an impressively low error rate.

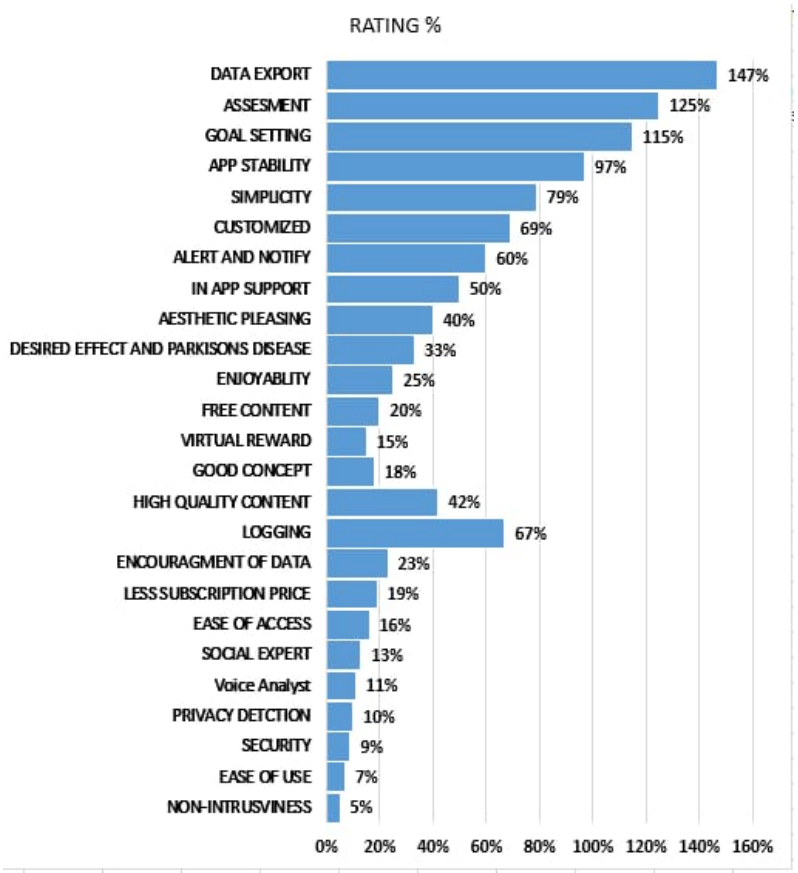

Figure 7. Positive user ratings are broken down into topic categories (y-axis) and the matching number of linked themes (x-axis)

4.1 Sentiment Prediction

Subsequently, we utilized the top-performing ML classifier, namely RF, to categorize the 12,100 unlabeled reviews. The outcome of this classification process revealed that 8,643 reviews were designated as positive, while 3,457 reviews were categorized as negative.

4.2 Positive and Negative Themes

Then, using both the ground truth dataset (see Table 3) and the newly classified dataset (using the SGD classifier), we carried out a thematic analysis of both positive and negative evaluations. We examined 8,062 negative evaluations and **55,120** positive ones in all. Employing **ATLAS.ti,** we initially identified **5,720** distinct themes within the positive reviews and **1,761** unique themes within the negative reviews. To streamline the analysis, we further consolidated closely related themes and removed generic or inconsequential ones. Consequently, we distilled 25 theme categories from the positive reviews (refer to Figure 7) and 21 theme categories from the negative reviews (refer to Figure 8). Henceforth, these categories will be referred to as "positive themes" and "negative themes" in the subsequent sections of this paper.

The positive themes are presented in Table 7 in the Appendix section together with their descriptions and representative sample reviews. The positive themes are data export, assessment, goal setting, app stability, simplicity, customized, alert and notify, in-app support, aesthetic pleasing, desired effect and Parkinson's disease, enjoy ability, free content, virtual reward, good concept, high-quality content, logging, encouragement of data, less subscription price, ease of access, social expert, voice analyst, privacy detection, security, ease of use, non-intrusiveness.

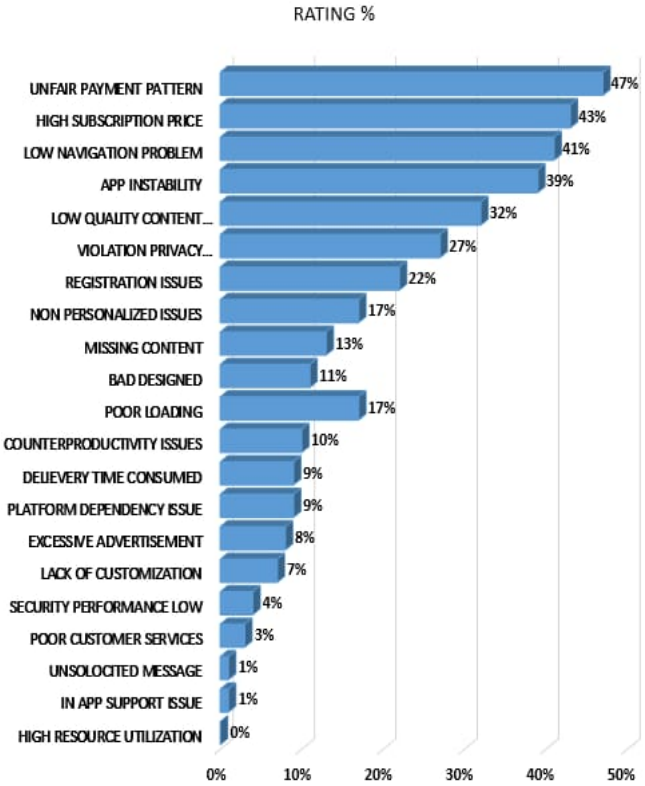

Figure 8. Theme categories (y-axis) and the corresponding number of related themes (x-axis) for negative user reviews**.**

In contrast, Table 8 in the Appendix section lists the negative themes along with a summary and relevant sample reviews. The negative themes are the following: low navigation problems, poor loading, user interface, app instability, registration issues, high resource utilization, platform dependency issues, lack of customization, violation of privacy information, unsolicited messages, excessive advertisement, security performance low, high subscription price, unfair payment pattern, low-quality content update, missing content, counter productivity issues, non-personalized issues, poor customer services, delivery time consumed, in-app support issue. Chapter 5 delves into an in-depth examination of the negative themes, exploring their implications. Subsequently, design guidelines are proposed for mitigating these negative aspects, drawing from the lessons learned from the positive factors.

5. Discussion

In this research study, we conducted an evaluation of Parkinson's disease apps by analyzing user reviews to gauge their effectiveness. Our empirical analysis revealed a predominant trend of positive reviews, indicating that the majority of users find these apps valuable and supportive in managing Parkinson's disease. Nonetheless, our investigation also unveiled issues that act as deterrents to user engagement, some of which carry significant health-related concerns. Through a thorough thematic analysis, as detailed in Tables 7 and 8 in the Appendix section, we identified various themes representing factors that impact Parkinson's disease apps both positively and negatively. In this section, we delve into a comprehensive examination of the negative factors and subsequently provide design recommendations informed by the positive aspects.

Factors Affecting the Effectiveness of Parkinson Disease Apps Negatively

In Table 6, the 21 negative themes (or factors) are subdivided into five distinct categories: usability issues, content-related concerns, privacy and safety matters, cost-related considerations, and issues related to customer support.

5.1 Usability Issues

Usability refers to an app's ability to effectively, efficiently, and satisfactorily enable specific users to accomplish their goals or tasks within a defined context of use [54]. A variety of interface and platform-

related variables have been identified by our research as having an impact on the usability of apps for Parkinson's disease and preventing users from successfully performing their duties.

a. Navigation Problems: The choice of controls and navigational elements within an app can have a big impact on how user-friendly it is [55, [56]. Simply put, individuals with diminished cognitive capabilities may struggle to discern which controls, like menus or buttons, will lead them to their intended destination. According to the results of our study, users had trouble navigating the app to reach the features or locations they wanted because of things like missing or unresponsive navigation options, inaccurate redirection, or a lack of shortcuts. Here are a few comments made by users who faced these difficulties.

Table 7. Themes with Negative Associations and Their Respective Categories

Negative Themes	Category
Low Navigation Problem	
Poor Loading	
User Interface (Bad Design)	
App Instability	**Usability Issues**
Registration issues	
High Resource Utilization	
Platform Dependency Issue	
Lack of Customization	
Violation Privacy Information	
Unsolicited Message	**Security Issues**
Excessive Advertisement	
Security Performance Low	
High Subscription Price	
Unfair payment pattern	**Payment Issues**
Low-Quality Content Update	
Missing Content	
Counter productivity issues	**Content Issues**
Non-personalized issues	
Poor Customer Services	**Customer Support Issues**
Delivery Time Consumed	
In-App Support Issue	

b. Poor Loading: Users have raised concerns regarding the delayed responsiveness experienced while using the app. Specifically, they expressed frustration over prolonged loading times and intermittent interface freezing or unresponsiveness when navigating through features or engaging in intended

activities, such as viewing meditation videos or playing in-app games. The requirement to download software dependencies or stream material from the internet, as well as restrictions imposed by insufficient phone resources, such as low internal memory, may cause these challenges, as seen in the comments below.

"New version loads really slow and requires internet for most applications. Liked the previous version better. New version gets hung up on the opening logo and takes over a minute before you can access any program. It used to be a simple mood & health tracker with relaxation exercises. They've added more programs, but it's worthless if you can't access them. (Their response below didn't address my initial complaint of it loading slow so I've expanded my review to be more specific." [R29425]

c. User Interface Design (Bad Design): Research underscores the importance of visual aesthetics in usability. An app's UI design plays a vital role in user perception. When an app lacks an appealing layout, or a cohesive color scheme, or suffers from graphics and text rendering problems, it may be perceived as unattractive and less usable. Users who find the UI unappealing are more likely to seek alternatives (as shown in the sample comment below).

"User interface needs improvement especially when typing your thoughts and the page is stuck." [IOS-R1906]

d. App Instability: Core functionality is a cornerstone of app usability. Users rely on apps to perform essential tasks effectively. However, when an app experiences functionality issues, such as non-working features or unexpected behavior, it diminishes its usefulness and may discourage users from continued engagement (as shown in the sample comment below).

"Having issues with most of the app features. The sleep time don't record properly, originally bought this watch to monitor my sleep patterns? When you can set heart rate, blood pressure and other features it doesn't show on the home page even after restarting, re setting and removing that feature and then adding it back. Over all needs to be looked into." [R764]

e. Registration Issues: The registration and login process should be straightforward for users. Complicated registration forms, convoluted password recovery procedures, or unclear instructions can create barriers for users. If these problems persist, users may opt to avoid the app altogether (as shown in the sample comment below).

"Requires registration before you even know if you would be interested. I'm not going to sign up for something prior to knowing if I like it, and I don't have Face book." [R4289]

f. High Resource Utilization: Efficient resource management is essential for app performance. Apps that drain a device's battery quickly or consume excessive system resources can negatively impact the user experience and may lead users to seek alternatives (as shown in the sample comment below).

g. Platform Dependency Issue: Developers commonly design apps to function on both Android and iOS platforms [66]. However, the challenge of fragmentation, which can occur within the same platform and across platforms, significantly impacts app stability [67]. This worry results from the requirement to support several platform iterations and handle particular user interface, user experience, interaction method, device specification, and development tool features. Because developers find it difficult to satisfy all dependencies, certain apps have trouble rendering correctly or functioning correctly on particular devices or platforms, as shown in the comments below.

"Not working on android phone. Doesn't Even open." [R142]

h. Lack of Customization: According to research, personalization is crucial for giving users a sense of agency and self-determination [68, [69], which affects their long-term engagement with an app. In other words, users' motivation eventually wanes, leading to the end of app usage, if they are unable to customize or alter the app's layout or functionality to suit their interests and tastes. Users have voiced

annoyance about their inability to change elements like the narrator's voice (for example, switching from male to female) or customize their virtual character or avatar, as shown by the sample comments that are supplied below.

"Wasn't easy enough or customizable" [R10349]

5.2 Security Issues

Regarding the gathering and use of private and health-related data, there is an alarming lack of transparency in the world of Parkinson's disease apps. Moreover, there is an observed tendency to prioritize marketing efforts aimed at revenue generation over promoting the well-being of users. These ethical issues have developed as a result of the general lack of uniform and explicit ethical & security requirements for Parkinson's Disease apps [57], [58]. As a result, according to research findings, user privacy, confidentiality, and general safety cannot be ensured in the context of apps for Parkinson's disease [59].

a. Violation of Privacy information: Transparent permissions and privacy practices are essential for user trust. Apps that request excessive permissions or lack clear privacy policies may raise red flags for users concerned about their data security. Addressing these concerns is crucial for building user confidence (as shown in the sample comment below).

"Only way to use is to give up all privacy. All information about you will be public." [IOS-R1171]

b. Unsolicited Messages: Clear and helpful error messages are vital for user guidance. When users encounter issues within the app and receive vague or uninformative error messages, it can lead to confusion and frustration (as shown in the sample comment below).

"When I try to open it, it gives an error message that it unexpectedly closed...." [R30668]

c. Excessive Advertisement: In my recent experience with several healthcare apps, I've observed a prevalent issue of excessive advertisements. The sheer volume of ads within these apps often disrupts the user experience, hindering access to crucial health-related resources. Given the importance of these apps in managing medical conditions, the overwhelming presence of ads can diminish their credibility and usability (as shown in the sample comment below).

"App looks okay but the amount of advertisements and vendors taking private information is insane. This is a MEDICAL app." [R25426]

d. Security Performance Low: In my evaluation of several apps, I've noticed a concerning issue related to security performance. It's apparent that some of these applications may not be adequately safeguarding user data and privacy. This is especially troubling as these apps deal with sensitive medical information, making them potential targets for security breaches (as shown in the sample comment below).

"No authentication, privacy policy page doesn't exist, just an email scraper that gives you ONLY 500 words before asking for an absolutely insane monthly cost. Not worth it at all. Probably sells your info. I put a fake email and it didn't bounce. Don't waste your time! [R1578]

5.3 Payment Issues

Most people, according to studies, choose free Parkinson's Disease apps [62]. Additionally, it can be difficult for makers of direct-to-consumer apps for Parkinson's disease to build up and keep a large enough user base over time, both in the short and long term. Our research's findings illustrate how these issues are caused by the pricey subscription fees and billing schedules connected with expensive apps.

a. High Subscription Price: Paid apps provide exclusive content or features to potential subscribers who are willing to invest in the associated fees. However, a significant portion of users either find these fees unaffordable or are hesitant to pay, often perceiving the costs as disproportionately high relative to the value offered by the apps, as illustrated in the provided sample comments below.

"I like this app, but with so many choices out there with much more content, this app is overpriced. Also, please add a lifetime purchase option as I will not do subscriptions. \nIf the price is fair, I'll buy." [IOS-R29]

b. Unfair payment pattern: Users have voiced their displeasure with the payment methods utilized by several premium applications, finding them to be either unaffordable or unworkable. Users have specifically criticized (i) annual payment plans that don't allow for full ownership, (ii) monthly subscription fees for all app content rather than the choice to pay for individual content packs, and (iii) the lack of one-time subscription options that would provide lifetime access. Here are a few examples of comments that highlight these issues:

"Great Design Yet Misleading must mention its Paid right after trial! To use trial also would be nice to mention must use play subscription during trial so Auto Billing $39p/y can take over automatically after trial!!" [R18843]

5.4 Content issues

Recent research indicates a deficiency in the quality of content within the majority of Parkinson's Disease apps [60]- [61]. More specifically, these apps often fall short in comprehensively addressing the specific domain of interest, such as bipolar disorder, depression, and anxiety, among others, concerning the dissemination of information and the incorporation of evidence-based preventive and treatment guidelines for self-management. Our own investigation aligns with these findings, as users of Parkinson's Disease apps have expressed dissatisfaction with several aspects of content quality. These concerns encompass issues such as Poorly Crafted Content, a Lack of professionalism, the presence of Unproductive measures, limited content offerings, missing content, and Non-personalized content.

a. Low-Quality Content Update: Users have voiced their discontent with regards to off-topic, rudimentary, and impractical content, as evidenced by the sample comments provided below. Furthermore, certain content fails to account for the capabilities of the intended audience, resulting in its ineffectiveness. These concerns underscore the deficiency of evidence-based interventions and clinically validated treatment techniques within the majority of Parkinson's Disease apps [70] which, in turn, may have detrimental effects on patients' well-being [71]. Here are a few examples of user comments illustrating these issues.

"Crashes, bugs, sound going on and off. I thought the extra content was great and happily subscribed but now I can barely use it because the app is such a buggy mess." [R24247]

b. Missing Content: Users of applications for Parkinson's disease have expressed worries about the lack of critical components or information necessary for their self-management and motivational efforts. As seen in the sample comment supplied below, one example is the absence of analytics that make use of usage or behavioral data, such as information on mood tracking, to provide useful insights regarding their health state and development over time. Users have also pointed out the lack of other crucial information or functionality, like the inability to eliminate "intrusive" aspects and the inability to track mood on an hourly basis as opposed to merely daily.

"Why are those soothing music tracks missing?" [R24703]

c. Counter productivity issues: Users turn to Parkinson's Disease apps with the hope of finding relief from their Parkinson's Disease-related challenges. Regrettably, our research findings have unveiled instances where users reported experiencing worsening conditions after utilizing certain apps, as evident in the provided sample comments. These experiences underscore growing concerns surrounding the content quality of Parkinson's Disease apps and emphasize the pressing need for clinical validation and adherence to evidence-based best practices or guidelines before these apps are made available to the public.

"Freezes too much and is getting too expensive. I loved the content in it but it gets frustrating with it freezing consistently! :-(" [R22583]

d. Non-personalized content: Studies have demonstrated that Parkinson's Disease apps that fail to personalize the user experience tend to be less effective [63]. Our own research findings align with this, as users have expressed dissatisfaction with certain apps that offer generic content, rendering it

unsuitable and unhelpful for addressing their specific condition, as illustrated in the sample comment below.

"There is only one voice (a female) and she is neither soothing or relaxing. Worse than the poor voice is the amateurish scripts she reads. I also found the background sounds distracting and the facility to turn them off within the app doesn't work. Now, the app interface is slick and the additional modules plenty but that's all window dressing when the content is so poor." [R23905]

5.5 Customer Support Issues

Users have expressed their unhappiness at receiving inadequate or nonexistent help when using these apps. It's important to remember that research has shown that inadequate support might prevent technology, particularly mobile apps, from being used [64], [65].

a. Poor Customer Services: In the realm of Parkinson's Disease apps, users frequently cited concerns related to response time and availability of customer support. These applications are often used to manage a time-sensitive and highly critical condition, and delays in response can contribute to heightened anxiety for users. A lagging support system can hinder effective disease management, making the application less reliable as a medical tool (as shown in the sample comment below).

"The app has SEVERE latency issues, and does not serve its purpose at all. I emailed the developers a couple weeks ago, and have still not received a response. Don't waste your money on this". [R1646]

b. Delivery Time Consumed: In Parkinson's Disease apps, delays in service delivery pose a significant issue for users managing a time-sensitive condition. Extended load times and sluggish updates add to user stress, undermining the app's reliability as a medical tool (as evidenced by user testimonials in the study).

"I can't believe this reflex active has a place in well-known shops its shocking the watches are well under par even for the price range they sell at so many faults battery issues, firmware issues, no updates to try to even solves issues reflex active is not bothered in listening to customers I've had my watch nearly a year so I've had my personal experience with it I have the series 5 version, no back-light timer so auto black screen after 4 seconds, no brightness adjust list goes on and on shocking."[R766]

c. In-App Support Issues: Users noted a lack of diversified channels for communication, including the absence of email, phone support, and live chat options. When dealing with a medical condition as severe as Parkinson's Disease, having multiple avenues for assistance can make a significant difference. As shown by the example comment provided below, some programs lack crucial self-help tools like frequently asked questions (FAQs), interactive tutorials, and user manuals.

"Same problem as everyone else app doesn't work/connect. Refund for the watch please! Also, what type of reputable company has a Gmail email address for their customer support? What a joke!" [R950]

5.6 Resolving The Negative Factors: Design Recommendations

To tackle the aforementioned negative factors, we present the following design guidelines drawn from the 25 positive themes outlined in Table 7 (refer to the Appendix section). These themes represent the key elements that enhance the effectiveness of Parkinson's disease apps.

5.6.1 Creating User-Friendly Parkinson's disease Apps

Ensuring usability is paramount for promoting the widespread use of Parkinson's disease apps, as supported by research [72] - [73]. Consequently, in order to craft Parkinson's disease apps that are user-friendly, developers should take into account the following recommendations derived from our research findings:

a. Simplicity: Simplicity and ease of use should be prioritized in the user interface design [74].

b. Ease of use: Efforts should be made to minimize the learning curve and the cognitive load required for app usage. The interface should offer intuitiveness, meaning that interaction elements like icons, graphics, menus, and buttons should be both recognizable and unambiguous to users [75].

c. Aesthetic pleasing: The user interface should possess visual appeal and maintain consistency in terms of color schemes, fonts, layouts, graphics, and animations. Studies indicate that an aesthetically pleasing interface has the ability to engage users' motivation and interest, creating an immersive interaction experience [76].
d. App Stability: The app should be devoid of glitches and instances of crashing. This can be accomplished through testing across diverse screen sizes, device models, and mobile platforms.
e. Customized: The app interface should offer customization options to align with user preferences. Users value the ability to exert control over the appearance of the interface including options like altering colors, themes, background images, layouts, and more.
f. Ease of Access: Locating app features should be a straightforward process. This can be accomplished through the adoption of a linear task flow, utilizing clearly labeled and a restricted number of navigation elements (such as buttons or icons), and ensuring the presence of an easily accessible home screen [79].
g. Good Concept: To realize the inherent potential of Parkinson's Disease apps, it is recommended to maintain a focus on the core concept of centralized healthcare management.

5.6.2 Optimizing App Content for User Health and Quality

The main goal of apps for Parkinson's disease is to offer therapeutic interventions that help users' psychological wellbeing be improved. Based on the results of our study, developers should consider the following suggestions when creating the content for their apps:

a. High-quality content: Research has underscored the effectiveness of evidence-based content as a valuable complement to medical care [80]. Furthermore, the active involvement of Parkinson's disease professionals in content creation emerges as a critical factor in boosting user engagement and attaining desired outcomes [81].
b. Free content: A significant majority of individuals install Parkinson's disease apps primarily due to the availability of free content. Furthermore, many users prefer to interact with content before committing to a purchase decision, reflecting the principle that "free always wins" [72].

5.6.3 Incorporating Features to Facilitate User Task Completion

The following features or functionalities should be incorporated by app developers based on the findings of our research:

Logging: To make it easier to track emotions, everyday activities, and other things.

a. Goal Setting: Motivate users by enabling them to make commitments through the definition of goals [82].
b. Social expert: Enable users to engage with both peers and healthcare professionals, facilitating the exchange of experiences and insights.
c. Alert and notify: Valuable for prompting users to adhere to medication schedules, complete therapy sessions, or receive recommendations for essential content that can enhance their well-being.
d. Virtual reward: Offering rewards in the form of badges, coins, trophies, stickers, and similar incentives has been shown to serve as a potent motivator for users [83]. These rewards can lead to heightened satisfaction and bolster self-efficacy, instilling confidence in users to achieve their present and future objectives [82].
e. Assessment: Users who use the app can monitor their progress in controlling their health condition by using pre- and post-intervention tests or quizzes. Additionally, these evaluations can help guide content selections that are specific to the user's stage of treatment or recovery.

App Developers Should Provide Affordable Subscription Options and Ensure Transparent Billing Practices. It's important for developers to strike a balance between making money and helping people with

Parkinson's disease recover. Research has indicated that a significant portion of smartphone users willing to use mobile devices for health monitoring falls under the age of 30, primarily comprising young adults. Additionally, it is important to keep in mind that a sizable portion of people with Parkinson's disease issues fall into this category [85]. Many of these young adults may be students or recent entrants into the workforce, facing financial constraints that make high-cost subscriptions unaffordable. Hence, it is imperative for app developers to design subscription plans that are flexible, cost-effective, and considerate of everyone's needs, particularly young adults and those facing financial challenges. These plans may also include necessary fee waivers to ensure accessibility for a broader user base.

5.6.4 Ensuring Data Privacy and Security: A Developer's *Responsibility*

Safeguarding data, along with ensuring transparency in its transmission and utilization, stands as a paramount concern for users of Parkinson's disease apps, given the sensitive nature of these health-related issues. To establish and maintain users' trust, app developers must adopt an approach of openness and clarity concerning various data-related aspects. This includes delineating what data departs from users' mobile devices, the manner in which data is stored (whether through encryption, anonymization or in its plain form), who holds access privileges to the data, details regarding any data sales and recipients, as well as outlining measures in place to uphold the confidentiality of personally identifiable information [84].

5.6.5 Apps Should Not Unnecessarily Interfere with Users' Daily Life or Primary Tasks

Users gravitate towards apps that offer support without causing unnecessary intrusions into their routines. In essence, technology like Parkinson's disease apps should seamlessly integrate into users' everyday lives, rather than disrupt them [86]. As a result, developers must to refrain from actions that irritate users, such as in-app marketing (ads), numerous push alerts or reminders, or background operations that quickly exhaust vital phone resources like the battery, internal memory, and mobile data.

5.6.6 Ensuring Effective In-App and External Support for Users' Successful Task Completion: A Developer's Responsibility

Users of apps for Parkinson's disease display a range of support needs, depending on the severity of their diseases and how well-versed they are in mobile technologies. For instance, some users may need to speak directly with healthcare professionals to address health-related difficulties, while others may need help from developers to fix technological problems. Competent users may use their background knowledge or the in-app tutorials and FAQs to solve specific problems. Developers ought to provide a variety of user assistance mechanisms as a result. These consist of an in-app contact form, an easily understandable tutorial and support function, an instant messaging option that allows users to communicate with medical specialists or customer service representatives.

6. Conclusion & Future Work

In our study, we employed a machine learning (ML) approach for sentiment analysis to gain insights into user opinions concerning Parkinson's disease apps. Our primary objective was to discern both positive and negative sentiments. Five machine learning classifiers were compared, and the one that performed the best had an amazing F1-score of 96.97%. The integration of machine learning and theme analysis in the assessment of user reviews of Parkinson's disease applications is a potent method that aids in the continuous improvement of these digital resources. It closes the communication gap between end users and app developers, which eventually leads to better applications that benefit Parkinson's disease patients. This approach highlights the quality and significance of data-driven techniques in improving patient-cantered care and digital health solutions, demonstrating the promise of these approaches in the healthcare industry. The sentiment polarity of user reviews was then predicted using this classifier. In order to identify the elements impacting the effectiveness of Parkinson's disease apps, both positively and negatively, we also performed a thematic analysis of both positive and negative evaluations. In the future, we want to

apply our methodology to apps in several sectors to assess their advantages and disadvantages. We then intend to provide design recommendations that researchers and app developers might incorporate to raise the general calibre and efficiency of their apps.

***Appendix**

Table 8. Positive Themes, Descriptions, and Sample User Reviews

Theme	Description	Sample User Reviews
Data Export	Seamless data export enhances the app's utility in Parkinson's care.	"Useful and low-key, especially like how easy it is to export data." [R9512]
Assessment	Conducts precise evaluations for user progress.	"Exceptional cognitive health support! This app combines accurate assessments with the essential advice to seek specialized assistance." [R78] "The step-by-step training and assessments reduces any anxiety in using this app." [R7608] "Wonderful app for practicing critical evaluation skills. It allows you to become a medical detective by testing your assessment, diagnostic lab, and medication knowledge"[IOS-R549]
Goal Setting	Simplified process for defining achievable objectives.	"Fully functional and free. Great for a newbie. I like the goal setting, education, and the little tree that grows." [R8841] "Enjoying it so far, like 5 apps in one for meditation, goal setting, journaling, basically everything you need to slowly start to feel better." [R26592]
App Stability	Ensures consistent, glitch-free user experience.	"It's definitely fun. A very stable app with excellent graphics and presentation. Does it help train your brain? Well, I don't know yet. I will let you know." [R6687] "Does exactly what you need it to do. Helpful, stable, and no crashes." [R7957]
Alert and notify	Sends timely and relevant notifications.	"I'm enjoying this app so far, there are new challenges and it prompts/notifies when you need to complete your daily training, which I like." [R4262] "Perfect for Med tracking. I love that it has alarm reminders, notifications, and its simple. I just check that I took my meds."[R9711]

Good Concept	Founded on a well-thought-out idea.	"A Smart concept and a pretty design, thanks. Very helpful for those who study English as well." [R3052] "Great app, cool concept, decent execution with a simple interface. I definitely "liked" it." [R3644] "Great app, simple UI, and excellent concept!" [R4572]
Logging	Streamlined entry and record-keeping system.	"Nice app. Just learning about mindfulness meditation. Great job with teaching in the training section and I like logging practice sessions. I find the goals section helpful too." [R7266] "This is great for people who have to take meds multiple times a day. I used to just set alarms but the logging features are quite useful for self-monitoring. The interface is clean and not split across any more menus than necessary, which I really appreciate." [R13318]
Voice Analyst	Includes features for voice modulation analysis.	"This is a very helpful app, especially for looking at frequencies, etc. I've used it in the course of some voice therapy and it has been a key tool." [IOS-R6] "Excellent I would like to hear some relaxing sounds without the guided voice. I haven't explored the app that well, but if there's an option, let me know. I like the chat, you can compare and share problems with similar users. I also like the negative thoughts changing tool, Is kind of confusing at first, but very effective, thanks!" [R30195]
Privacy Detection	Actively identifies and protects user privacy.	"Thanks, five stars for clarified privacy policy, and it is accessible inside the app and needs no browser to read it." [R13694] "THIS. Peace of mind, there is no email sign up or login, no ads and no having to agree to some privacy agreement. The app itself doesn't even care about giving it a rating. If I was truly being mindful, perhaps I shouldn't give it a rating." [R7842]

Security	Implements rigorous measures to safeguard user data.	"this app is great for many reasons. one being you can set goals on there to stay focus. second, you can have your own private self-awareness journal on there that can help you get your ideas out. lastly, no one has access to your data. it's secured.'," [IOS-R2144] "This app makes me feel so safe and secure. I love how I can write down my thoughts and how there's so many features. I can meditate, there's relaxing music, there's groups you can use to talk to others that are going through the same thing as you, you can post motivational quotes or other stuff, and you have inspirational stuff when you first open the app." [R26644]

Table 9. Negative Themes, Descriptions, and Sample User Reviews

Themes	Description	Sample User Reviews
App Instability	Notable for frequent crashes and disruptions in user experience.	"Having issues with most of the app features. The sleep time don't record properly, originally bought this watch to monitor my sleep patterns. when you can set heart rate, blood pressure and other features it doesn't show on the home page even after restarting, re setting and removing that feature and then adding it back. Over all needs to be looked into." [R764] "I purchased this app cause for $15 I was expecting a easy to use pace training app. In reality, this app has very minimal functionality beyond highlighting words at a certain pace. The exercise is helpful but certainly not worth $15" [IOS-R44]
Platform Dependency Issue	Tied closely to specific platforms, limiting accessibility.	"Have emailed you and not heard anything. I get constant crashes e.g. more than 15-20 a day and interfering with my other apps. So annoyed as all I want to do is help out. I will try and email you again as you ask but I actually emailed to the email address you give NOT via anything else like on here." [R46] "More bugs then anything as it's constantly nagging to turn on features that aren't supported on my phone, plus it can't check for firmware updates for the watch because of a network error." [R1025]
Lack of Customization	Lacks flexibility in adapting to individual user preferences	"half the mentioned features aren't there. everything is based on presets, most of which can't be customized. there is no way to enter a note to explain a symptom or the degree of the symptom. instead of Yes/No for symptoms it should be degrees: mild/general/severe. there should be a way to track inactivity: nap, reading, tv. it's certainly not "comprehensive". the feedback and help screens don't work: they get stuck on Loading... after submitting. so, I've posted here." [R12117]

		"the notification settings are terrible. it ignores "Do Not Disturb" settings on the phone. i understand that for those that critically need their meds, that this is important, but at least have flexibility for those that don't want to be woken up for non-urgent pills. i even turned it to "silent follow up notifications" and it still loudly notified me. really annoying. going to uninstall if not fixed soon. at least give us the ability to customize notifications. Frequency of follow ups etc..."[R12193]
High Resource Utilization	Strains device resources, causing performance issues.	"To much battery pulling not happy" [R491] "Xperia Z3 compact: used 39% of battery in 24 hours. Not good. The quality of your worthwhile study is being undermined by the quality of your app. I have uninstalled the app." [R47]
Registration Issue	Hinders user on boarding and access to app functions.	"Requires registration before you even know if you would be interested. I'm not going to sign up for something prior to knowing if I like it, and I don't have Facebook." [R4289] "The registration screen is blank ????" [IOS-R34]
Low Navigation Problem	Navigational challenges impede ease of use	"strange navigation. too much publicity" [R14504] "Needs better navigation. The sitting meditation has separate instructions, which means you get relaxed and then have to stop, open your eyes and start the timer. Poor design. I have to use a separate timer to make this work. I listen to the instructions after already starting a separate timer so that I can do the time period of meditation that I want to do without having to stop and open the app again to start the timer which is separate from the instructions. The app needs to be revamped." [R7352]
Violation of Privacy Information	Raises concerns about data security and privacy.	"Only way to use is to give up all privacy. All information about you will be public." [IOS-R1171] "yes. it's really nice app but having a dangerous Fault. This app sends Location info to CrashlyticsInc in Cambridge. If your device has any strong or well protected security software, then must it will give you the signal about the Privacy Risk. So How can we trust on this App? (Especially if you are using Norton Internet Security in your device, then it will show you the warning by picture of CrashlyticsInc in Cambridge in a World Map." [R193]
Unsolicited Message	Users receive unwanted	"I can't even open my account. It accepts my email and password and then tries to confirm with an emailed code, which it does not send, then I just get there's

	and intrusive messages	been an error message. Also, it opens when my phone restarts and does it all again. I was excited for this app, but I'm only frustrated now." [R27720] "When I try to open it, it gives an error message that it unexpectedly closed...." [R30668]
Delivery Time Consumed	Delays in Parkinson's apps erode trust and impede care.	I can't believe this reflex active has a place in well-known shops its shocking the watches are well under par even for the price range they sell at so many faults battery issues, firmware issues, no updates to try to even solves issues reflex active is not bothered in listening to customers iv had my watch nearly a year so iv had my personal experience with it I have the series 5 version, no back-light timer so auto black screen after 4 seconds, no brightness adjust list goes on and on shocking. [R766]

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