MeFit: Depression Detection Using Smart Watch

Akash Biswas-2020200005 *Dept. of Electronics and Telecommunication Engineering Sardar Patel Institute of Technology Mumbai, India*

Riya Goenka-2020200017 *Dept. of Electronics and Telecommunication Engineering Sardar Patel Institute of Technology Mumbai, India*

Keerti Didwania-2020200011 *Dept. of Electronics and Telecommunication Engineering Sardar Patel Institute of Technology Mumbai, India*

Abstract—This project centers on the creation of an integrated system leveraging smartwatch technology and a web application to detect and monitor depression. The primary goal is to offer individuals a proactive and accessible means of identifying potential signs of depression through continuous smartwatch monitoring. The web application serves as a central platform for data analysis, providing users with insightful feedback and personalized recommendations for mental well-being. By combining wearable technology and web-based analytics, this initiative strives to enhance early detection, monitoring, and management of depression, fostering a more informed and supportive approach to mental health. Furthermore, the integrated system introduces a paradigm shift by not only focusing on early detection but also actively engaging users in their mental health journey. The platform encourages a collaborative approach, allowing individuals to set personalized goals and receive tailored recommendations for interventions based on their unique data patterns. This two- tiered strategy, encompassing both early detection and proactive management, aims to create a comprehensive mental health solution that goes beyond identification, fostering a society that is better equipped to support and prioritize the mental well-being of its individuals.

Index Terms—Depression Detection, Machine learning, Flutter, Random Forest Algorithm

I. INTRODUCTION

The increasing prevalence of lifestyle diseases, driven by aging, stress, and epidemics, emphasizes the need for advanced mental health solutions. In the United States, mental health conditions affect approximately 8% of adolescents annually, highlighting a significant public health challenge [1]. Digital technologies, particularly mobile and wearable devices, show promise in addressing mental health issues such as anxiety, stress, and insomnia [4]. Wrist-worn devices, due to their proximity to the body and continuous use, enable effective real-time monitoring and personalized interventions to pro- mote well-being [6].

Despite the growing adoption of mobile health applications, limited research exists on user perspectives and features of smartwatch-based mental health apps [7]. This study bridges this gap by evaluating existing commercial wrist-worn devices and analyzing their impact on mental health management. The research aims to uncover benefits and limitations, offering insights for designing next-generation wearable technologies that ensure user engagement and continuous data collection.

Applications in this domain typically perform two key roles: enhancing user awareness of behaviors or emotional states and delivering tailored interventions, such as encouraging physical activity or improving sleep [6]. Real-time feedback empowers users to take preventive actions, potentially mitigating mental health deterioration [8].

This project focuses on early detection of depressive symptoms through smartwatch-based HRV analysis and an intuitive web interface. The research hypothesizes that low-frequency HRV will increase, and high-frequency HRV will decrease during stress, with distinct patterns observed in healthcare professionals compared to the general population [3]. By developing physiological algorithms and user-centric solutions, this work seeks to enhance mental health care accessibility and promote timely interventions.

II. MOTIVATION

The driving force behind this project lies in a strong commitment to transform mental health care by addressing the critical need for early detection and intervention in depression. Timely and tailored care is essential for effective mental health management, and our solution capitalizes on the capabilities of smartwatch technology combined with an intuitive web platform. Smartwatches facilitate continuous monitoring of users' physical and emotional states, offering valuable, objective insights into mental health metrics. These insights empower users to track and comprehend their mental health patterns over time, fostering a deeper understanding of their well-being [6], [7].

The accompanying web application serves as a central- ized platform for accessing resources, receiving personalized feedback, and engaging in proactive self-care practices. By normalizing mental health monitoring as a routine part of daily life, this project seeks to reduce stigma and enhance the accessibility of mental health management tools. Integrating such monitoring into widely used technology makes seeking help and support easier, while encouraging open discussions about mental health challenges [8]. Furthermore, the design prioritizes inclusivity, ensuring users across all age groups and technical expertise levels can benefit from the system's features.

III. LITERATURE REVIEW

This study investigates methodologies in the domain of depression prediction systems, focusing on their advantages and limitations to contextualize the proposed solution. By

addressing gaps and inefficiencies in existing technologies, this work introduces an innovative approach aimed at advancing wearable-based mental health monitoring. An exploratory review analyzed user feedback on discussion forums regarding smartwatch applications for mental health. These apps are primarily categorized into two groups: those focused on data collection, such as ecological momentary assessments (EMA) for mood tracking, and those providing interventions like guided meditation sessions [4] [8]. Commonly discussed mental health challenges included depression, anxiety, and bipolar disorder.

Applications for Raising Self-Awareness:
Users valued the ability of smartwatch apps to monitor personal metrics, such as mood and physical activity. For example, applications like Centered were appreciated for tracking meditation time, mood patterns, and daily steps [4].

Applications for Promoting Intervention:
Intervention-focused features, such as meditation or calming playlists, were considered effective in reducing anxiety and negative thoughts. Examples include user experiences with the Headspace app or utilizing smartwatches with earbuds for audiobooks or podcasts [4], [6].

Features Available:
Popular features included medication tracking, mood monitoring, and visual reminders. For instance, apps like Stigma and WebMD were highlighted for their capabilities in long-term mood tracking and medication reminders, respectively [9], [10].

Motivations and Interest:
Overall, users showed strong enthusiasm for smartwatch applications, expressing interest in exploring additional features and applications to better manage mental health [8], [9]. This analysis underscores the potential of wearable technology in mental health management, while identifying areas where improvements can enhance user experiences and outcomes.

IV. OBJECTIVES

1. Advanced Risk Assessment and Early Intervention: The project aims to develop a depression detection system utilizing smartwatch technology and a web application. By incorporating machine learning algorithms, the system will identify subtle deviations in physiological and behavioral data for early intervention, providing timely support in addressing depressive symptoms [6], [7].

2. Personalized Mental Well-being Recommendations: Beyond detection, the system will offer tailored recommendations, such as mindfulness exercises and stress management techniques. This personalized approach ensures mental health interventions align with individual needs, promoting a user-centric care model [4], [9].

3. DSM-Aligned Self-Assessment for Insights: Integrating DSM-based self-assessment tools enhances diagnostic accuracy, providing users with actionable insights into their mental health. This fosters informed discussions with healthcare professionals, aligning with established diagnostic criteria [8], [10].

4. User-Friendly Web App Interface: A core objective is to create an intuitive web application interface for seamless user interaction. Clear visualizations and an engaging design will empower individuals to monitor their mental health metrics and maintain consistent engagement with the system [7], [9].

5. Continuous Monitoring Through Smartwatches: Leveraging the continuous data collection capabilities of smartwatches, the system will monitor key indicators such as heart rate variability (HRV), sleep patterns, and activity levels, enabling real-time insights for holistic mental health management [6], [8].

6. Integration of Educational Resources and Collaborative Partnerships: The system aspires to integrate educational resources and collaborate with mental health professionals to provide users with comprehensive support. This holistic platform aims to address both detection and education, fostering proactive mental health management [9], [10].

V. METHODOLOGY

The Depression Detection System (DDS) is designed to identify individuals at risk for depression or other mental health conditions. The system utilizes technology, including machine learning algorithms, natural language processing, and computational methods, to analyze various data sources and detect patterns indicative of depressive symptoms [1] [2]. The key components of the proposed system are outlined below:
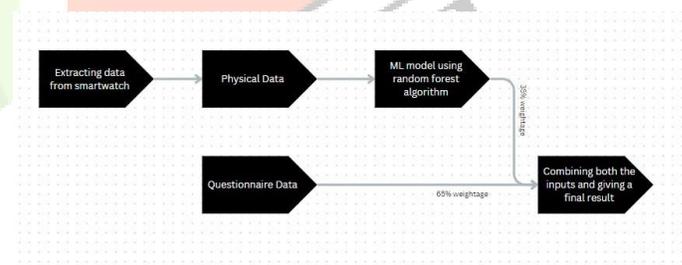

Fig. 1. Block Diagram.

A. Dataset Collection

The Depression Detection System collects data from two primary sources:

1) Smartwatch Data: Metrics such as daily step count, heart rate, and sleep duration are gathered. These metrics provide insights into users' physiological well-being and daily activities [3], [4].
2) Psychological Questionnaire: A quiz based on the *Diagnostic and Statistical Manual of Mental Disorders*

(DSM) gathers subjective data about the user's psychological state. By aligning with DSM standards, the questionnaire ensures relevance and accuracy in capturing psychological dimensions [5], [6].

B. Train the model and predict status

Real-time monitoring of physiological indicators via wearable devices enables early detection and treatment of depressive symptoms. This study evaluated multiple machine learning algorithms:

- Random Forest: A robust ensemble learning method that combines predictions from multiple decision trees to enhance accuracy and prevent overfitting. Trained on 50,000 samples and validated on 10,000, the model achieved 98% accuracy in detecting depression by analyzing ac- tivity levels, with high precision, recall, and F1-scores [7], [8].
- Support Vector Machine (SVM): An algorithm that separates data by maximizing the margin between support vectors. While effective for complex data, it achieved only 63% accuracy, indicating limited suitability for this task [9].

Future work aims to deploy the Random Forest model for continuous monitoring and expand the dataset to improve generalization.

Fig. 2. Random Forest.   Fig. 3. Support Vector Machine.

Random Forest model was crafted using a dataset of 50,000 physical data samples, achieving an impressive 98% accuracy on a test set of 10,000 samples. The model, developed through strategic data partitioning, preprocessing, feature selection, and hyperparameter tuning, demonstrates proficiency in classifying physical data into low, medium, and high categories. The evaluation encompassed precision, recall, and F1-score metrics, with feature importance analysis shedding light on influential determinants. Future directions involve exploring deployment strategies, dataset augmentation for enhanced generalization, and the implementation of vigilant continuous monitoring. This research significantly advances effective physical data classification, offering a robust framework with broad real-world applications.

C. Final Result

By integrating data from both the smartwatch (35% weightage) and a psychological questionnaire (65% weightage), the

Fig. 4. Random Forest Model Analysis.

depression detection system aims to develop a comprehen- sive understanding of the user's physical and mental well- being. The smartwatch collects objective biometric data, such as heart rate variability, activity levels, and sleep patterns, providing real-time physiological indicators that could signal depression. On the other hand, the psychological questionnaire gathers subjective responses about the user's mood, thoughts, and emotional state. This dual-modal approach enhances the system's ability to detect potential signs of depression by considering both types of data. The biometric data offers a continuous, unbiased view of the user's physical state, while the psychological questionnaire captures the personal, experiential aspects of mental health that the smartwatch cannot measure. By combining these two sources of information, the system can create a more holistic and accurate assessment of the user's mental health, leading to more effective and timely interventions. This method not only increases the reliability of depression detection but also ensures that both the physical and psychological dimensions of well-being are addressed, providing a more robust framework for mental health management.

D. App building and data integration using Flutter

Utilizing the dynamic capabilities of Flutter, successfully developed a comprehensive mobile application designed to conduct quizzes and provide users with a holistic evaluation of their well-being. The app seamlessly integrates both subjective data from the quiz responses and objective data from the physical data model, delivering a unified and insightful final output, all within the Flutter framework.

The quiz feature, implemented with Flutter widgets, engages users with a user-friendly interface to answer psychological questions derived from established standards like the Diagnostic and Statistical Manual of Mental Disorders (DSM) [2]. Their responses are collected and processed within the app to provide a personalized psychological profile.

Simultaneously, the application leverages the power of Flutter to showcase the results derived from the Random Forest algorithm-based model analyzing physical data collected from smartwatches. This model, integrated directly into the app,

assesses metrics such as step count, heart rate, and sleep duration to gauge the user's physical well-being [3], [4].

The integration process, conducted entirely within the Flutter environment, combines the insights from the psychological quiz and the physical data model to generate a comprehensive final output. This output serves as a nuanced and holistic assessment of the user's mental and physical health status, providing valuable insights for self-awareness and potential intervention.

E. User-friendly interface

The user-friendly interface accessible through mobile applications represents a significant leap forward in the realm of healthcare technology. This innovative application serves as a beacon of progress in mental health by integrating cutting-edge technology to enhance both assessments and interventions. At its core, the application harnesses objective physical data and employs advanced predictive modeling techniques. This approach not only improves the accuracy of mental health assessments but also enables personalized interventions tailored to individual needs. By leveraging real-time data analysis and machine learning algorithms, the application empowers healthcare professionals to make informed decisions swiftly and effectively.

Moreover, the user interface is designed with accessibility and ease of use in mind, ensuring that patients can engage with the platform effortlessly. Features such as intuitive navigation, clear visualizations of data trends, and interactive tools for self-assessment contribute to a seamless user experience. In terms of impact, the application is poised to make a profound difference in patient well-being. By promoting early detection of mental health issues and delivering timely interventions, it aims to mitigate the onset of more severe conditions. Ultimately, this contributes to a healthier society by addressing mental health proactively and transforming the landscape of mental healthcare delivery. Overall, this innovative application not only represents technological advancement but also embodies a commitment to improving patient outcomes and fostering a more inclusive approach to mental health support.

VI. EXPERIMENTAL RESULTS

Developed a Mobile App with the help of Flutter and integrated the Random Forest Classifier to classify the physical data via the Flask API. To communicate and retrieve physical activity data specifically the heart rate from the smartwatch, flutter blue plus package was used. Eventually all the physical data like number of steps, stress level, sleep duration could be extracted from the user's smartwatch or smartphone.
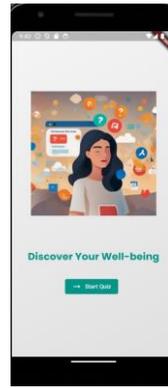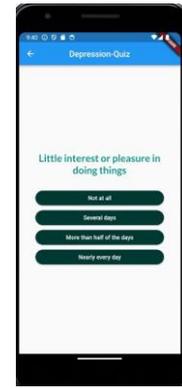

Fig. 5. Home Page   Fig. 6. Quiz based on PHQ 9

Fig. 7. After clicking on start quiz you are redirected to the PHQ-9 quiz which has 9 questions. The PHQ-9 is the depression module, which scores each of the 9 DSM-IV criteria as "0" (not at all) to "3" (nearly every day).
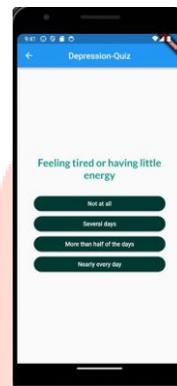

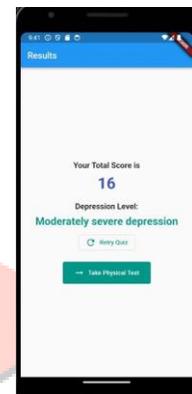Fig. 8. Quiz questions based on PHQ-9   Fig. 9. Result of the PHQ-9 Quiz

Fig. 10. The Result of the PHQ-9 quiz has been classified into 5 categories based on the total score of the quiz.
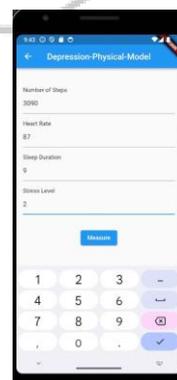

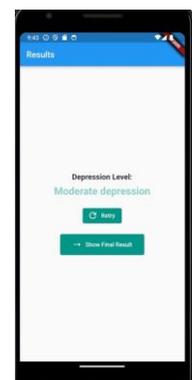Fig. 11. The Physical Data form.   Fig. 12. Result of the Physical data form.

Fig. 13. Based on the physical Data, we have classified depression into 4 categories with the help of the Random Forest Classifier.

Fig. 14. Combined Result- Quiz (65%) and Physical Data (35%).

VII. FUTURE SCOPE

The scope of this project is promising and extends across several dimensions. First and foremost, ongoing advancements in machine learning and data analytics could enhance the accuracy and predictive capabilities of the depression detection system. The integration of additional data sources, such as wearable devices with more advanced sensors, could provide richer insights into users' physical and mental states. Moreover, expanding the application's compatibility to emerging technologies and platforms, such as augmented reality or voice-based interfaces, could further enhance user discourse and solutions within the mental engagement and accessibility. Collaborations with healthcare providers and institutions for data sharing and research could contribute to a broader understanding of mental health trends. Additionally, the project's scalability allows for potential expansion into global markets, addressing diverse cultural nuances in mental health. As societal awareness of mental well-being continues to grow, the project stands poised to evolve with emerging technologies and contribute significantly to the ongoing health domain.

VIII. CONCLUSION

The culmination of this ambitious project, realized through the development of a sophisticated mental health assessment application using Flutter, marks a significant stride in the pursuit of holistic well-being. The integration of a meticulously designed psychological quiz, rooted in the standards of the Diagnostic and Statistical Manual of Mental Disorders (DSM), with a cutting-edge Random Forest algorithm-based model analyzing physical data from smartwatches, forms the backbone of a comprehensive health evaluation. The user-friendly interface crafted with Flutter effortlessly guides individuals through engaging quizzes, providing a seamless display of detailed physical health metrics, and orchestrating the amalgamation of diverse data streams. Flutter's efficiency and cross-platform capabilities have played an indispensable role in creating a cohesive and accessible user experience. As the application's real-time analysis and feedback mechanism empower users to glean valuable insights into their mental and physical well-being, it concurrently lays the groundwork for early intervention. Looking forward, the future horizon of this project holds promise for continued advancements, including the integration of emerging technologies, expanded data sources, and the potential for global scalability. In an era where mental health awareness takes center stage, this project stands as a robust testament to the transformative potential of technology in fostering a more profound and holistic understanding, as well as providing robust support for mental well-being.

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