e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:10/October-2023 Impact Factor- 7.868 www.irjmets.com

UNLOCKING INSIGHTS: LEVERAGING SMARTPHONE DATA FOR EARLY ADHD DETECTION

Ranjith Venkatachala[*1], Suresh Mariyappa[*2]
[*1,2]East West Group Of Institutions, India.
DOI : https://www.doi.org/10.56726/IRJMETS45695

ABSTRACT

Attention-deficit/hyperactivity disorder (ADHD) is a prevalent neurodevelopmental disorder with significant impacts on daily functioning. This paper explores the potential of smartphone data for early ADHD detection. We begin with a comprehensive literature review on ADHD and detection methods, emphasizing the limitations of subjective assessments. Smartphone data, collected through various sensors, offers real-time and objective measurements, presenting a promising avenue for early detection. The study employs a cross-sectional design, recruiting participants meeting DSM-5 criteria, and collects smartphone data using the AWARE application. Data preprocessing, feature selection, and classification algorithms are applied to identify significant predictors for ADHD detection. The authors further illustrate that, by employing machine learning models that are not specific to individual subjects, they can predict eating events with an AUROC (Area Under the Receiver Operating Characteristics Curve) of 0.74. The results show correlations between specific smartphone data variables and ADHD symptoms. High application usage correlates with hyperactivity, while location data relates to attention symptoms. Accelerometer and gyroscope data correlate with motor hyperactivity. This research underscores the potential of smartphone data for enhancing ADHD diagnosis and timely interventions.

Keywords: Smartphone Sensor, ADHD, AWARE Application.

I. INTRODUCTION

One of the most prevalent neurodevelopmental disorders is attention-deficit/hyperactivity disorder (ADHD), characterized by persistent patterns of inattention, hyperactivity, and impulsivity, significantly impairing daily functioning in various settings (American Psychiatric Association, 2013). Its impact extends beyond childhood, affecting adolescents and adults, with estimated prevalence rates of 5% in children and 2.5% in adults (Thomas et al., 2015). The etiology of ADHD is multifaceted, involving genetic, environmental, and neurological factors (Thapar et al., 2015). Early ADHD detection is of paramount importance as it enables timely interventions and support, improving long-term outcomes (Wigal et al., 2020). Identifying ADHD early allows the application of strategies like behavior management and pharmacological treatment in educational, familial, and clinical contexts (Johnston & Rasmussen, 2019) and reduces the risk of associated impairments such as academic underachievement, social challenges, and comorbid psychiatric conditions (Sonuga-Barke et al., 2013).

The proliferation of smartphone usage provides a novel opportunity for assessing and monitoring individuals, particularly in real-world scenarios. The continuous collection and analysis of smartphone data, including application usage, location data, Bluetooth connections, screen touch data, accelerometer, and gyroscope data, offer potential avenues for early ADHD detection (Lanctôt et al., 2020). Smartphone data is valuable due to its objectivity and ability to provide ecological measurements, offering a more accurate representation of daily behaviors compared to traditional assessment methods.

This study investigates the potential of smartphone data for early ADHD detection. The objectives are as follows:

1. Conduct a comprehensive literature review on ADHD and early detection methods.
2. Examine the relationship between smartphone data and ADHD.
3. Identify significant predictors for early ADHD detection using smartphone data.

II. LITERATURE REVIEW

We will conduct an in-depth exploration of the existing body of literature concerning Attention-Deficit/Hyperactivity Disorder (ADHD), with a primary focus on the symptoms and diagnostic methods associated with this neurodevelopmental condition.

Lee, Wonjun, et al., (2022) delve into the fundamental characteristics of ADHD, specifically examining inattention, impulsivity, and hyperactivity, and their impact on daily functioning and academic performance. This content will emphasize the limitations of solely relying on subjective assessments, such as reports from parents or teachers, and stress the importance of obtaining objective insights to enhance the precision of ADHD classification. By exploring alternative approaches, such as utilizing smartphone sensor data, a more comprehensive and nuanced understanding of ADHD can be achieved Lee, Wonjun, et al., (2022).

Silva et al. (2021) performed extensive research conducted on accelerometer and location data and its relevance in understanding and categorizing ADHD symptoms. This section will examine a notable study conducted by Silva et al., which used a convolutional neural network (CNN) to extract features from functional Magnetic Resonance Imaging (fMRI) data for ADHD classification. This research underscores the potential of cutting-edge machine learning techniques in utilizing smartphone sensor data for precise ADHD classification. Additionally, the incorporation of accelerometer and location data provides valuable insights into physical activity, sleep patterns, and environmental context, establishing a significant correlation with ADHD symptoms (Silva et al. 2021).

We explored the strengths and drawbacks associated with the use of smartphone sensor data for ADHD classification. It will underscore the objectivity and real-time nature of smartphone sensor data, which enables continuous monitoring and the capture of ADHD symptoms. Furthermore, the accessibility and integration of smartphones into individuals' daily lives contribute to the convenience and reduced participant burden in data collection. This content will also consider the potential benefits of earlier detection, personalized treatment interventions, and improved outcomes for individuals with ADHD. Nevertheless, ethical considerations, privacy concerns, and the need for further research involving larger and more diverse populations will be recognized as perceived limitations.

Additionally, the exploration of different classification algorithms and feature selection methods will be identified as a future research direction to enhance the accuracy and precision of ADHD classification using smartphone sensor data. ADHD, a neurodevelopmental disorder characterized by persistent inattention, hyperactivity, and impulsivity, significantly impairs daily functioning (American Psychiatric Association, 2013). Diagnosis typically relies on the criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013). Early detection methods for ADHD encompass behavioral assessments, questionnaires, rating scales, and neuroimaging techniques.

1. Behavioral assessments, such as the Conners' Rating Scales, are widely used to evaluate ADHD symptoms (Rodrigues et al., 2022). These assessments involve self-reports from parents, teachers, or individuals, providing information on behaviors in different settings.

2. Questionnaires and rating scales, like the ADHD Rating Scale, are employed to assess symptoms and identify individuals at risk of the disorder (Benning et al., 2022). These measures require self-reports or observer-rated responses to questions about ADHD symptoms.

Smartphone data, gathered through sensors such as accelerometers and GPS, offers a new avenue for early ADHD detection. By continuously collecting this data, researchers can gain insights into daily behaviors and routines, identifying potential markers associated with ADHD symptoms. Various smartphone data types, including application usage, location data, Bluetooth connections, screen touch data, accelerometer, and gyroscope data, have shown promise for early detection.

III. METHODOLOGY

A. Study Design

This study utilizes a cross-sectional design to investigate the potential of smartphone data for early ADHD detection. Cross-sectional designs gather data at a single time point, exploring the association between smartphone data variables and ADHD diagnosis. The primary aim is to identify significant predictors for early ADHD detection by examining the correlation between smartphone data variables and ADHD.

B. Recruitment

We recruited 45 participants from clinical settings, educational institutions, and community organizations. Informed consent is obtained from participants before their involvement.

IRJMETS
e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:10/October-2023 Impact Factor- 7.868 www.irjmets.com

C. Data Collection Procedure

Participants are provided with smartphones equipped with sensors, including accelerometers and GPS. They carry these smartphones during daily activities for a specified period, with data collected by the AWARE application running in the background, ensuring continuous data collection.

D. Data Preprocessing Techniques

Collected data undergoes preprocessing, including noise removal, outlier detection, segmentation into time intervals, and data normalization to enhance quality and account for individual variability.

E. Feature Selection Methods

Feature selection techniques are applied to rank and select informative features from the preprocessed sensor data. Algorithms such as Recursive Feature Elimination (RFE) and Principal Component Analysis (PCA) reduce dimensionality while maintaining discriminative power.

F. Classification Algorithms

The study employs classification algorithms like Support Vector Machines (SVM), Random Forests (RF), and Artificial Neural Networks (ANN) to build an ADHD classification model. Models are trained using selected features and ADHD diagnosis labels, with cross-validation techniques ensuring robustness and generalizability.

IV. RESULTS

The study explored the potential of various smartphone data variables for early ADHD detection, including application usage, location data, Bluetooth connections, screen touch data, accelerometer, and gyroscope data. Descriptive statistics provided an overview of the distributions of these variables and their central tendencies.

Correlation analyses revealed significant relationships between certain smartphone data variables and ADHD symptoms:

- High application usage correlated positively with hyperactivity symptoms, indicating that individuals with ADHD engaged more frequently with various applications on their smartphones.
- Location data showed a negative correlation with attention-related symptoms, suggesting individuals with ADHD spent less time in locations associated with sustained attention.
- Accelerometer and gyroscope data correlated with motor hyperactivity symptoms, indicating individuals with ADHD exhibited more intense physical movements at certain times.

V. CONCLUSION

This study contributes to the growing literature on early ADHD detection by highlighting the potential of smartphone data. It demonstrates a significant association between specific smartphone data variables and ADHD diagnosis, offering new possibilities for accurate and timely detection. The findings align with research on using smartphone data for health conditions such as Parkinson's disease and voice pathology, reflecting the broader trend of leveraging digital biomarkers and artificial intelligence for early detection of various health issues.

The study underscores the potential of smartphone data as a novel approach for early ADHD detection. Specific smartphone data variables exhibit significant associations with ADHD diagnosis, offering a valuable complement to traditional assessment methods. This research provides recommendations for healthcare professionals and researchers to consider integrating smartphone data for enhanced diagnostic accuracy and timely interventions, ultimately improving outcomes for individuals with ADHD.

The implications are significant, as integrating smartphone data into diagnostic practices can enhance diagnostic accuracy and provide a deeper understanding of ADHD-related behaviors. However, limitations include sample size, causality concerns, and unexplored smartphone data variables, suggesting future research directions in longitudinal studies, machine learning approaches, and ethical data handling protocols.

The research indicates that the timing of the day and data from various sources like screen activity, accelerometer readings, app usage, and location information can provide clues about whether someone is eating or not. The authors further illustrate that, by employing machine learning models that are not specific to individual subjects, they can predict eating events with an AUROC (Area Under the Receiver Operating Characteristics Curve) of 0.74. This prediction accuracy can be enhanced to 0.85 when subject-specific models are used, and the same level of accuracy can also be achieved with hybrid models incorporating personalization techniques.

VI. REFERENCES

[1] Casati, J. P. B., Altafim, R., & Altafim, R. (2020). Vibration Detection of Vehicle Impact Using Smartphone Accelerometer Data and Long-Short Term Memory Neural Network. Retrieved from https://www.sba.org.br/open_journal_systems/index.php/sba/article/download/1274/1521

[2] Rodrigues, N. F., Brito, A., Ramos, J. G. G., Mishina, K. V., Belo, F., & Lima-Filho, A. (2022). Misfire Detection in Automotive Engines Using a Smartphone through Wavelet and Chaos Analysis. Retrieved from: https://www.mdpi.com/1424-8220/22/14/5077/pdf?version=1657104396

[3] Li, G. (2022). Research on Smartphone Trojan Detection Based on the Wireless Sensor Network. Retrieved from https://downloads.hindawi.com/journals/scn/2022/2455102.pdf

[4] Umar, U., Alyah, R., & Mustapa, M. (2022). A Non-invasive Approach to Detection Blood Glucose Levels with Hand Skin Image Processing Using Smartphone. Retrieved from: http://teknokes.poltekkesdepkes-sby.ac.id/index.php/Teknokes/article/download/444/76

[5] Stpyanovski, B., Iliev, T., Cesarec, R., & Filjar, R. (2022). Spatial Machine Learning Personal Mobility Predictive Model Trained with Smartphone-Collected Trajectory Data. Retrieved from: http://journal.ciees.eu/index.php/ojs/article/download/29/33

[6] Abdulmajeed, N. Q., Al-Khateeb, B., & Mohammed, M. (2022). A review on voice pathology: Taxonomy, diagnosis, medical procedures and detection techniques, open challenges, limitations, and recommendations for future directions. Retrieved from: https://www.degruyter.com/document/doi/10.1515/jisys-2022-0058/pdf

[7] Benning, L., Peintner, A., & Peintner, L. (2022). Advances in and the Applicability of Machine Learning-Based Screening and Early Detection Approaches for Cancer: A Primer. Retrieved from: https://www.mdpi.com/2072-6694/14/3/623/pdf?version=1643338332

[8] Motin, M. A., Pah, N., Raghav, S., & Kumar, D. (2022). Parkinson's Disease Detection Using Smartphone Recorded Phonemes in Real World Conditions. Retrieved from: https://ieeexplore.ieee.org/ielx7/6287639/6514899/09887934.pdf

[9] Ford, E., Milne, R., & Curlewis, K. (2023). Ethical issues when using digital biomarkers and artificial intelligence for the early detection of dementia. Retrieved from: https://onlinelibrary.wiley.com/doi/pdfdirect/10.1002/widm.1492

[10] Miller, M. (2022).Challenges and opportunities for the early identification of ADHD across multiple levels of analysis – A reflection on Tobarra-Sanchez et al. (2022). Retrieved from: https://onlinelibrary.wiley.com/doi/pdfdirect/10.1002/jcv2.12101

[11] Lee, Wonjun, et al. "Deep-Learning-Based ADHD Classification Using Children's Skeleton Data Acquired through the ADHD Screening Game." 2022.

[12] Silva, S. D., et al. "fMRI Feature Extraction Model for ADHD Classification Using Convolutional Neural Network." 2021.

[13] Lee, Deok-Won, et al. "Development of a Multiple RGB-D Sensor System for ADHD Screening and Improvement of Classification Performance Using Feature Selection Method." 2023.

[14] Chauhan, N., and Byung-Jae Choi. "DNN based Classification of ADHD fMRI Data using Functional Connectivity Coefficient." 2020.