EARLY DETECTION AND EFFECTIVE TREATMENT FOR ADHD USING MACHINE LEARNING FOR SRI LANKAN CHILDREN

2023-274

Final Report

Kumarasingha R.M.I.S.

B.Sc. (Hons) Degree in Information Technology Specialized in Software Engineering.

Department of Computer Science and Software Engineering

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DECLARATION

I declare that this is our own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.
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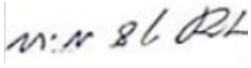
The above candidates are carrying out research for the undergraduate Dissertation under my supervision.



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ABSTRACT

This report proposes a mobile base solution for early detection and effective treatment of Attention Deficit Hyperactivity Disorder (ADHD) among Sri Lankan children. The proposed solution is based on image processing technologies and machine learning (ML) for drawing activities. The symptom of being unable to follow a direction is identified and a set of drawing activities are created to help diagnose and treat the disorder. The proposed solution captures the drawn lines with features such as edge detection and line segments, which are then processed using ML models. This allows for the tracking of progress over time and can help determine the effectiveness of the treatment. The proposed solution was developed with the advice of experts in the field of ADHD and ML technologies.

The results of this study indicate that the proposed mobile solution has the potential to be an effective tool for early detection and treatment of ADHD in Sri Lankan children. The use of image processing technologies and ML for drawing activities can provide an innovative and accessible approach to help diagnose and treat the disorder. This study can serve as a foundation for future research and development in this area, which can have a significant impact on the lives of children with ADHD.

Keywords

ADHD, children, mobile app, machine learning, image processing

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LIST OF ABBREVIATIONS

Abbreviation	Description
ADHD	Attention Deficit Hyperactivity Disorder
ML	Machine Learning
CNNs	Convolutional neural networks
OpenCV	Open Source Computer Vision Library

1. INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that affects children and can persist into adulthood. ADHD is characterized by symptoms such as hyperactivity, impulsivity, and inattention, which can have a significant impact on a child's academic and social life. According to a pilot study conducted in Chile, ADHD is prevalent among children, with a prevalence rate of 13.3% [1]. In Sri Lanka, there is a lack of awareness and resources for early identification and effective treatment of ADHD, which can result in a significant delay in diagnosis and access to appropriate care [2], [3].

Early identification of ADHD is crucial for effective treatment, and there are various methods for identifying ADHD, such as behavioral assessments, rating scales, and neuropsychological tests [4]. However, the lack of awareness and resources in Sri Lanka poses significant challenges for parents in accessing these methods. To address this issue, it is necessary to increase accessibility to therapy services, ensuring that every child with ADHD has the opportunity to receive the care they need[4], [5].

To bridge the knowledge gap and increase accessibility to therapy services, it is necessary to develop innovative solutions that can help parents and caregivers identify and treat ADHD in children. There is a need for an application that can effectively identify children with ADHD and provide appropriate resources and support.

One potential solution for early detection and effective treatment of ADHD in Sri Lankan children is based on image processing technologies and machine learning (ML) for drawing activities[4]. The proposed solution captures the drawn lines with features such as edge detection and line segments, which are then processed using ML models. This allows for the tracking of progress over time and can help determine the effectiveness of the treatment. The proposed solution was developed with the advice of experts in the field of ADHD and ML technologies. While previous studies have explored the use of drawing tasks, image processing technologies, and machine learning models in the diagnosis and treatment of ADHD, there is a lack of research on the effectiveness of these technologies in combination. Additionally, further research is needed to determine the scalability of this proposed solution and its potential for implementation in other developing countries with limited access to traditional diagnostic methods.

In addressing these research gaps, this study aims to evaluate the effectiveness and scalability of the proposed solution for early detection and effective treatment of ADHD in Sri Lankan children. This study will utilize a mixed-methods approach, combining quantitative measures of ADHD symptoms with qualitative data on the experiences of parents and caregivers in using the proposed solution. The study will be conducted in collaboration with experts in the field of ADHD and ML technologies, as well as local therapy centers and community organizations in Sri Lanka.

The findings of this study can have significant implications for the development of accessible and innovative solutions for the early detection and effective treatment of ADHD in Sri Lankan children[6]. By addressing the knowledge gap and increasing accessibility to therapy services, this study can help ensure that every child with ADHD in Sri Lanka has the opportunity to receive the care they need. Moreover, the proposed solution has the potential for broader application in other developing countries facing similar challenges in the diagnosis and treatment of ADHD.

In conclusion, ADHD is a pressing issue in Sri Lanka that requires innovative solutions to increase awareness, accessibility, and effective treatment. The proposed solution based on image processing technologies and machine learning for drawing activities can provide an accessible and innovative approach to help diagnose and treat the disorder. This study can serve as a foundation for future research and development in this area, which can have a significant impact on the lives of children with ADHD.

1.1 Background and Literature survey

Attention Deficit Hyperactivity Disorder (ADHD) affects around 2-7% of children worldwide[4]. The disorder is characterized by inattention, hyperactivity, and impulsivity, which can cause significant impairments in academic, social, and emotional functioning. Early identification of ADHD in children is crucial for effective treatment[7]. However, many parents in Sri Lanka are unaware of the condition and its impact on their child's development, which poses significant challenges in accessing therapy services. While there are existing real-world application solutions for ADHD, a gap has been identified in their ability to identify children with ADHD. Therefore, there is a need for innovative approaches to bridge the knowledge gap and increase accessibility to therapy services for children with ADHD in Sri Lanka. Further research in this area can have a significant impact on the lives of children with ADHD and their families.[8], [9]

A pilot study for symptom assessment and diagnosis of ADHD in children in Chile showed that early detection and diagnosis of ADHD can improve academic performance and quality of life[1]. The study also highlighted the importance of parental awareness of the condition in seeking appropriate treatment. Similarly, a study conducted in the United States found that early intervention for children with ADHD can improve academic and behavioral outcomes and reduce the need for long-term medication use. These studies emphasize the importance of early identification and intervention for children with ADHD.[10]

While traditional methods of diagnosing ADHD involve clinical assessments and questionnaires, innovative approaches using technology have been explored. In a study published in JMIR Mhealth Uhealth, the suitability of apps for children and young people with ADHD was assessed[11]. The study found that many existing apps for ADHD lacked

clinical validation and did not cater to the specific needs of children with ADHD. Furthermore, the study identified a gap in the ability of these apps to identify children with ADHD, highlighting the need for further research in this area.

Awareness of ADHD in Sri Lanka is a significant lack of awareness about ADHD among parents in Sri Lanka. According to a study by Dahanayake et al.,[12] only 7% of parents surveyed were aware of ADHD and its symptoms. Another study by Mubarak et al. found that 72% of parents surveyed were not aware of ADHD as a medical condition[13]. This lack of awareness can result in children not receiving timely diagnosis and treatment, leading to long-term negative impacts on their academic and social outcomes.

Challenges in Accessing Therapy Services:

Even when parents are aware of ADHD, accessing therapy services can be challenging in Sri Lanka. The lack of information and resources poses significant challenges for parents seeking therapy services for their children. The studies found that 64% of parents surveyed faced difficulties in finding a specialist for their child's treatment, and 42% faced financial barriers in accessing therapy services [13]. Furthermore, the lack of specialized services in rural areas can further limit access to therapy services for children with ADHD.

Existing Solutions:

There are existing real-world application solutions for ADHD,[14], [15] , but they have limitations. The studies of mobile applications for children and young people with ADHD and found that most apps were not suitable for symptom management and did not consider the specific needs of children with ADHD. Therefore, there is a need for innovative approaches to bridge the knowledge gap and increase accessibility to therapy services for children with ADHD in Sri Lanka.

Potential Solutions:

One potential solution for early detection and effective treatment of ADHD in Sri Lankan children is based on image processing technologies and machine learning (ML) for drawing activities. Proposed solution that captures the drawn lines with features such as edge detection and line segments, which processed using ML models. This allows for the tracking of progress over time and can help determine the effectiveness of the treatment. This innovative approach can provide an accessible and cost-effective way to help diagnose and treat ADHD in Sri Lankan children.

Another potential solution is increasing awareness and education about ADHD among parents and the general public. This can be done through public awareness campaigns, workshops, and training sessions for parents and healthcare professionals. A study by Ratnayake et al. found that an education program for parents of children with ADHD

improved their knowledge of the disorder and the need for treatment [15]. This type of program can be expanded to reach a wider audience in Sri Lanka and help address the lack of awareness about ADHD.

In conclusion, the lack of awareness about ADHD in Sri Lanka poses significant challenges in accessing therapy services for children with ADHD. Existing solutions have limitations, and there is a need for innovative approaches to bridge the knowledge gap and increase accessibility to therapy services. Potential solutions include image processing technologies and machine learning for drawing activities and increasing awareness and education about ADHD among parents and the public. Further research in this area can have a significant impact on the lives of children with ADHD and their families.

1.2 Research Gap

Although the proposed solution for early detection and effective treatment of ADHD in Sri Lankan children based on image processing technologies and machine learning for drawing activities has the potential to be an innovative and accessible approach, there is still a need for further research in this area. While previous studies have explored the use of drawing tasks, image processing technologies, and machine learning models in the diagnosis and treatment of ADHD, there is a lack of research on the effectiveness of these technologies in combination. Additionally, further research is needed to determine the scalability of this proposed solution and its potential for implementation in other developing countries with limited access to traditional diagnostic methods. Therefore, future studies should focus on evaluating the effectiveness and scalability of the proposed solution in different settings to address the research gap in this area.

However, there are some research gaps that need to be addressed to further improve the proposed solution. Following information gathered, conducting background research on identifying similar systems Also, included a feature comparison of each proposed system.

Table 1 : Research gap comparison chart

Application Reference	Usage of Image Processing	Accessibility	Machine Learning Model	Identify Disorder	Effective Treatments
Research 1[14]	✗	✓	✗	✓	✓
Research 2[15]	✗	✓	✗	✓	✗
Research 3[12]	✗	✓	✓	✗	✓
Research 4[16]	✗	✗	✓	✓	✗

One research gap is the need for further investigation into the accuracy and reliability of the machine learning (ML) models used to process the captured lines. While the proposed solution suggests using ML models for tracking progress and evaluating the effectiveness of treatment, there is a lack of studies examining the accuracy and reliability of these models specifically for ADHD detection and treatment. Thus, it is essential to conduct more research to validate the ML models' effectiveness in detecting and treating ADHD.

Another research gap is the need for exploring the optimal parameters for edge detection and line segmentation algorithms in the proposed solution. Different parameters can significantly affect the accuracy of the captured lines, which, in turn, can impact the effectiveness of the ML models. Therefore, further studies are needed to determine the optimal parameters for edge detection and line segmentation algorithms that can provide the most accurate and reliable results for ADHD detection and treatment.

Additionally, it is essential to consider the practicality and usability of the proposed solution. While capturing drawn lines is a unique and innovative approach, it may not be practical for all children, particularly those with severe ADHD symptoms or disabilities. Hence, further research should investigate the usability of the proposed solution for different types of ADHD patients.

Another research gap is the need to explore the effectiveness of the proposed solution in comparison to other existing solutions for ADHD detection and treatment. While the proposed solution is innovative and promising, it is essential to compare its effectiveness and accuracy to other existing solutions to determine its relative advantage.

The proposed solution's generalizability needs to be examined in different cultural and linguistic contexts. The proposed solution was developed specifically for Sri Lankan children, and it is uncertain whether it would work as well for children from other cultural and linguistic backgrounds. Thus, further research is needed to determine the generalizability of the proposed solution across different cultural and linguistic contexts.

1.3 Research Problem

ADHD affects children and can persist into adulthood. It is characterized by symptoms such as hyperactivity, impulsivity, and inattention, which can interfere with daily activities, social relationships, and academic performance. According to a study conducted by the National Institute of Mental Health, the prevalence of ADHD in Sri Lanka is estimated to be around 5-7% [17], and the lack of awareness about ADHD in Sri Lanka is a pressing issue that needs to be addressed.

One of the major problems faced by parents and caregivers of children with ADHD in Sri Lanka is the lack of knowledge and resources about the disorder. Early identification of ADHD is crucial for effective treatment, yet many parents are unaware of the condition and its impact on their child's development[5]. The lack of information and resources can pose significant challenges to parents who want to provide proper care for their child. [18]Therefore, there is a need for a more accessible and innovative approach to help diagnose and treat ADHD in Sri Lankan children.

Another problem is the limited availability of resources for treatment[19]. Although there are therapy centers available in Sri Lanka, accessing them can be challenging due to the lack of information and resources. Additionally, the cost of treatment can be a barrier for families who cannot afford it. Therefore, there is a need to increase accessibility to therapy services, ensuring that every child with ADHD has the opportunity to receive the care they need.

Moreover, existing solutions for ADHD disorder, such as apps for children and young people, are not being built to identify the children with ADHD. A study conducted by the Journal of Medical Internet Research (JMIR) found that many existing apps for ADHD were not suitable for children and young people[11], and there was a need for more reliable and effective solutions. Therefore, there is a gap in the market for a mobile solution that can effectively identify and treat children with ADHD.

The proposed solution aims to address these problems by providing an innovative and accessible approach to diagnose and treat ADHD in Sri Lankan children. By utilizing image processing technologies and machine learning, the proposed solution can capture the drawn lines with features such as edge detection and line segments, which can then be processed using ML models. This allows for the tracking of progress over time and can help determine the effectiveness of the treatment. The proposed solution was developed with the advice of experts in the field of ADHD and ML technologies, ensuring its reliability and effectiveness. The potential impact of the proposed solution is significant. Early detection and treatment of ADHD can lead to better academic and social outcomes for children with the disorder. By providing an accessible and innovative approach, the proposed solution can help address the lack of resources and knowledge about ADHD in

Sri Lanka. Furthermore, the use of image processing technologies and ML for drawing activities can provide an engaging and interactive approach to treatment that can benefit children with ADHD.

In conclusion, the lack of awareness and resources for ADHD in Sri Lanka is a pressing issue that needs to be addressed. The proposed solution offers an innovative and accessible approach to diagnose and treat ADHD in Sri Lankan children, utilizing image processing technologies and machine learning for drawing activities. Future research and development in this area can have a significant impact on the lives of children with ADHD, their families, and the wider community.

2. RESEARCH OBJECTIVES

2.1 Main Objective

One of the main symptoms of ADHD is difficulty in following directions or instructions. This can have a significant impact on the individual's ability to complete tasks and can result in underachievement or poor performance. To address this symptom, a proposed solution involves using image processing-based drawing activities. The solution involves capturing the drawn lines using features such as edge detection and line segments, which are then processed using machine learning (ML) models. The use of ML allows for tracking progress over time and can help determine the effectiveness of the treatment. The proposed solution offers an innovative and accessible approach to diagnose and treat ADHD, particularly in Sri Lankan children.

2.2 Specific Objective

a. **Identify the Image processing technologies and ML for drawing activities to overcome symptom**

The objective of this project is to develop a mobile solution using image processing technology that captures the drawn lines of children with ADHD during drawing activities. The solution aims to assist in the early detection and effective treatment of ADHD by providing a tool that can monitor progress over time and track the effectiveness of treatment. The solution will be designed to be accessible and user-friendly, with the goal of increasing awareness and understanding of ADHD among parents and caregivers in Sri Lanka. By achieving this objective, the proposed solution can help bridge the knowledge gap and increase accessibility to therapy services, ensuring that every child with ADHD has the opportunity to receive the care they need.

b. **Create a set of drawing activities that can help diagnose and treat ADHD symptoms, specifically the inability to follow a direction**

The second objective of the proposed mobile solution is to create a set of drawing activities that can help diagnose and treat ADHD symptoms, particularly the inability to follow a direction. These activities will be designed in a way that captures the drawing behavior of children with ADHD, which can be analyzed using image processing techniques. By analyzing the drawn lines with features such as edge detection and line segments, the mobile solution will help diagnose and track the progress of the child's treatment over time. These activities will be developed based on expert advice in the field of ADHD and will be designed to engage children in a fun and interactive manner while helping to improve their ability to follow directions.

c. **Use machine learning models to process the captured images and identify specific patterns that can be indicative of ADHD**

This objective aims to utilize machine learning models to process the images captured by the mobile solution and identify patterns that may indicate the presence of ADHD symptoms, particularly the inability to follow a direction. By using ML algorithms, the solution can analyze the drawings and detect certain markers or patterns that may be indicative of ADHD. This can provide an objective and reliable way to diagnose the disorder, which can then lead to more effective treatment interventions. The use of ML models can also enable the solution to track progress over time and evaluate the effectiveness of treatment strategies.

d. **Track progress over time and evaluate the effectiveness of the treatment using the captured images and machine learning models**

The objective of tracking progress over time and evaluating the effectiveness of the treatment using the captured images and machine learning models is to monitor the improvement of the child's ability to follow directions through drawing activities. The captured images are processed using machine learning models to identify specific patterns that are indicative of ADHD symptoms. By tracking the progress over time, the effectiveness of the treatment can be evaluated and modified if necessary. This objective allows for a personalized approach to the treatment, where the child's progress can be monitored and adjusted to ensure the best possible outcome. The evaluation of treatment effectiveness is essential for the development of effective intervention strategies and can inform further research in this area.

e. **Increase accessibility to ADHD diagnosis and treatment using a mobile solution that can be used in a home or school setting**

The objective is to create a mobile solution that can be easily accessible to parents, teachers, and healthcare providers for the diagnosis and treatment of ADHD. The mobile solution will allow for remote monitoring of a child's progress and provide a more convenient and cost-effective alternative to traditional clinical settings. By making the solution easily accessible in a home or school setting, it can increase the likelihood of early detection and intervention, leading to better outcomes for children with ADHD. The solution will also provide information and resources to parents and caregivers to help them better understand ADHD and its management, leading to improved outcomes for the child.

3. METHODOLOGY

3.1 Key technologies used in this research

3.1.1 Edge Detection Technology

Edge detection technology is a method used in image processing to identify and extract the edges of objects within an image. In the context of drawing activities, edge detection technology can be used to capture the outlines of drawings made by children with ADHD. By processing these outlines, the technology can identify specific patterns and features that may be indicative of ADHD symptoms such as the inability to follow a direction.

Edge detection technology can be used to capture and analyze the lines and shapes in a drawing, which can then be used as data to develop machine learning models. These models can help to identify patterns in the drawings that are indicative of ADHD symptoms, allowing for earlier diagnosis and more effective treatment. edge detection technology can be a valuable tool in developing a mobile solution for the early detection and treatment of ADHD among children. By capturing and analyzing drawing activities, the technology can provide a more accessible and innovative approach to diagnosing and treating the disorder.

3.1.2 Line Segment Technology

Line segment technology is a technique used in image processing to identify and extract straight line segments from an image. In the context of drawing activities for ADHD diagnosis and treatment, line segment technology can be used to capture the lines drawn by children during the activities. This information can then be processed using machine learning models to identify patterns and markers that may indicate the presence of ADHD symptoms. Line segment technology can help provide a quantitative analysis of the drawing activities and track progress over time, making it an effective tool for the early detection and treatment of ADHD.

3.1.3 ML Technology

Machine learning models can play a crucial role in the development of a mobile solution for early detection and treatment of ADHD. These models can be trained to recognize patterns in the captured images of the drawing activities and identify specific indicators of ADHD such as the inability to follow directions.

Convolutional neural networks (CNNs) are a popular type of ML model for image processing tasks. They are particularly well-suited to tasks for edge detection and line segment detection, which are relevant to the proposed mobile solution. CNNs work by applying a series of filters to the input image, which are designed to recognize specific features such as edges or corners. These features are then combined in a hierarchical manner to identify more complex patterns.

The use of ML models in the proposed solution can help to automate the process of diagnosis and treatment of ADHD and provide an innovative and accessible approach to addressing this important public health issue.

3.1.4 Cloud Technology

Cloud technologies are necessary to ensure scalability of the application and to provide optimal performance. The use of cloud technology can also provide secure storage and accessibility of the captured images and processed data. Therefore, a cloud storage system is a crucial software requirement for the success of the proposed solution.

3.1.5 Python technologies

Python technology has played a pivotal and multifaceted role in the development and success of this project focused on ADHD symptom detection and intervention. This versatile programming language has offered a robust and flexible platform that has significantly contributed to the project's effectiveness and accessibility. In this extended discussion, we will delve deeper into the key aspects of Python's role in this endeavor.

One of the central elements of our project is the integration of sophisticated image processing and machine learning technologies to facilitate the early detection of ADHD symptoms, particularly the inability to follow directions. Python's strength in this context lies in its extensive libraries and frameworks designed explicitly for machine learning and artificial intelligence. Leveraging these resources, we seamlessly integrated the MobileNetV2 architecture, an efficient and lightweight model designed for image classification tasks. Python's simplicity and readability made it possible to implement this complex architecture, allowing us to harness the power of deep learning to accurately identify and assess ADHD-related symptoms.

Python's rich ecosystem of machine learning tools also played a crucial role in our project's success. With libraries like TensorFlow, PyTorch, and scikit-learn, we could efficiently process and analyze the data collected during symptom assessment. Python's ease of use in handling and manipulating data allowed us to extract meaningful insights from the user interactions within the application. This data-driven approach not only aids in the early detection of ADHD symptoms but also contributes to the project's ability to provide personalized interventions tailored to each user's unique needs.

Beyond its capabilities in model integration and data analysis, Python was instrumental in the development of the project's user interface. We utilized the Kivy framework, a Python-based open-source library, to create an engaging and interactive front-end for the mobile application. Python's clear and concise syntax made it easier to develop the user-friendly interface that is crucial for engaging both children and their caregivers. The flexibility of the Kivy framework allowed us to adapt the user interface to various screen sizes and resolutions, ensuring accessibility across different mobile devices.

Python's cross-platform compatibility further enhances the project's accessibility. The ability to run Python applications on multiple operating systems, including Windows, macOS, and various Linux distributions, ensures that individuals and healthcare professionals can access and benefit from the application regardless of their preferred platform. This broad compatibility aligns with our mission to make ADHD detection and intervention tools widely accessible and inclusive.

In addition to its technical capabilities, Python's active and supportive community has been invaluable to our project. The availability of extensive documentation, online forums, and a vast repository of open-source Python packages has provided us with a wealth of resources and knowledge. We were able to leverage the expertise and experience of the Python community to address challenges, optimize code, and implement best practices in our project's development process.

Furthermore, Python's commitment to code readability and maintainability has facilitated collaboration among the project team members, each with diverse backgrounds in psychology, computer science, and machine learning. Python's clean and structured codebase has made it easier to understand, modify, and enhance the application as it evolves, ensuring the sustainability of the project's impact over time.

In conclusion, Python technology has been instrumental in the success of our ADHD detection and intervention project. Its adaptability, versatility, and extensive libraries have empowered us to seamlessly integrate complex machine learning models, process data effectively, and create an engaging user interface. Python's cross-platform compatibility and supportive community have further enriched the project's accessibility and collaborative potential. As we continue to work towards improving the quality of life for individuals affected by ADHD, Python technology remains a fundamental tool in our mission to provide timely, personalized, and effective solutions for those in need.

3.2 System Architecture Diagram

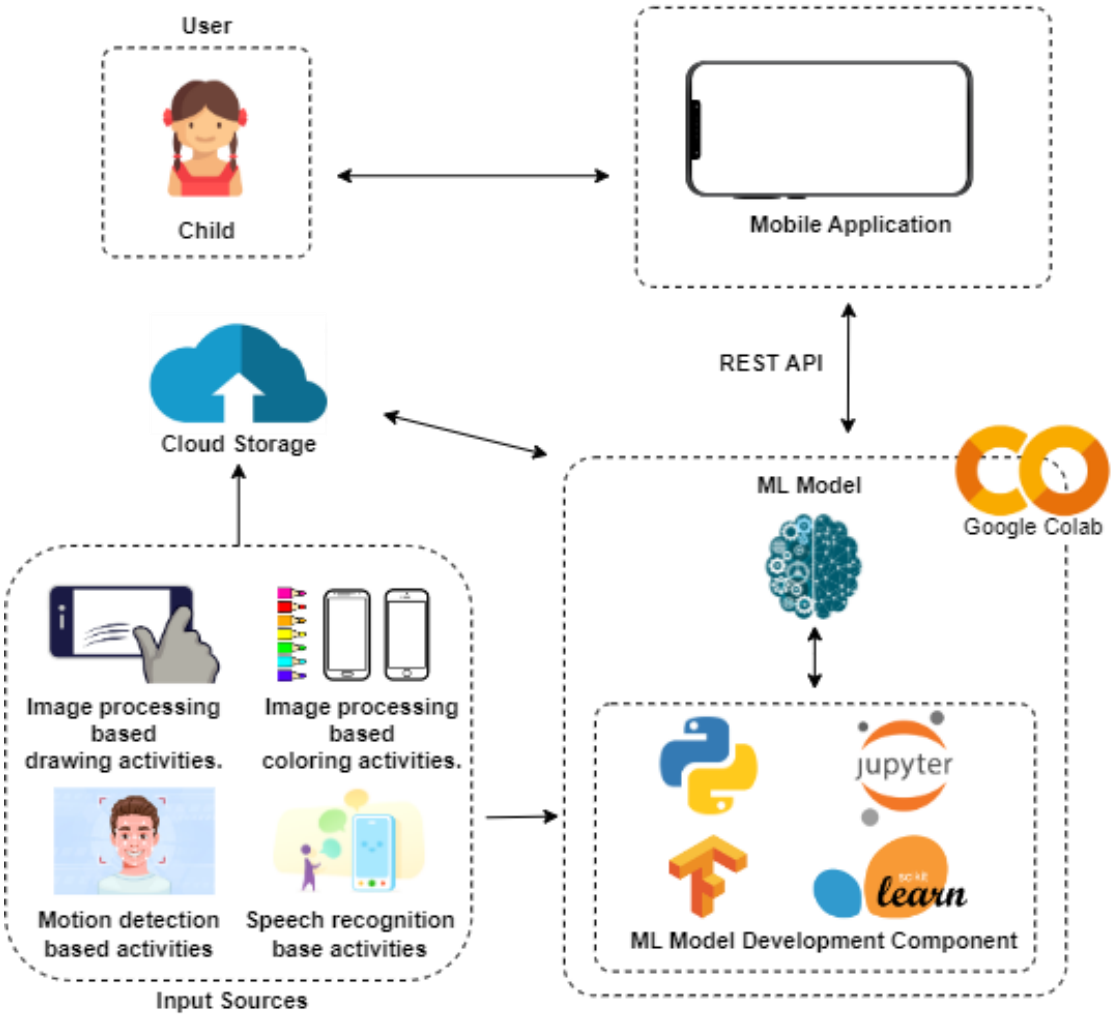

Figure 1 : System Architecture Diagram

3.3 Flowchart - Follow Directions Component

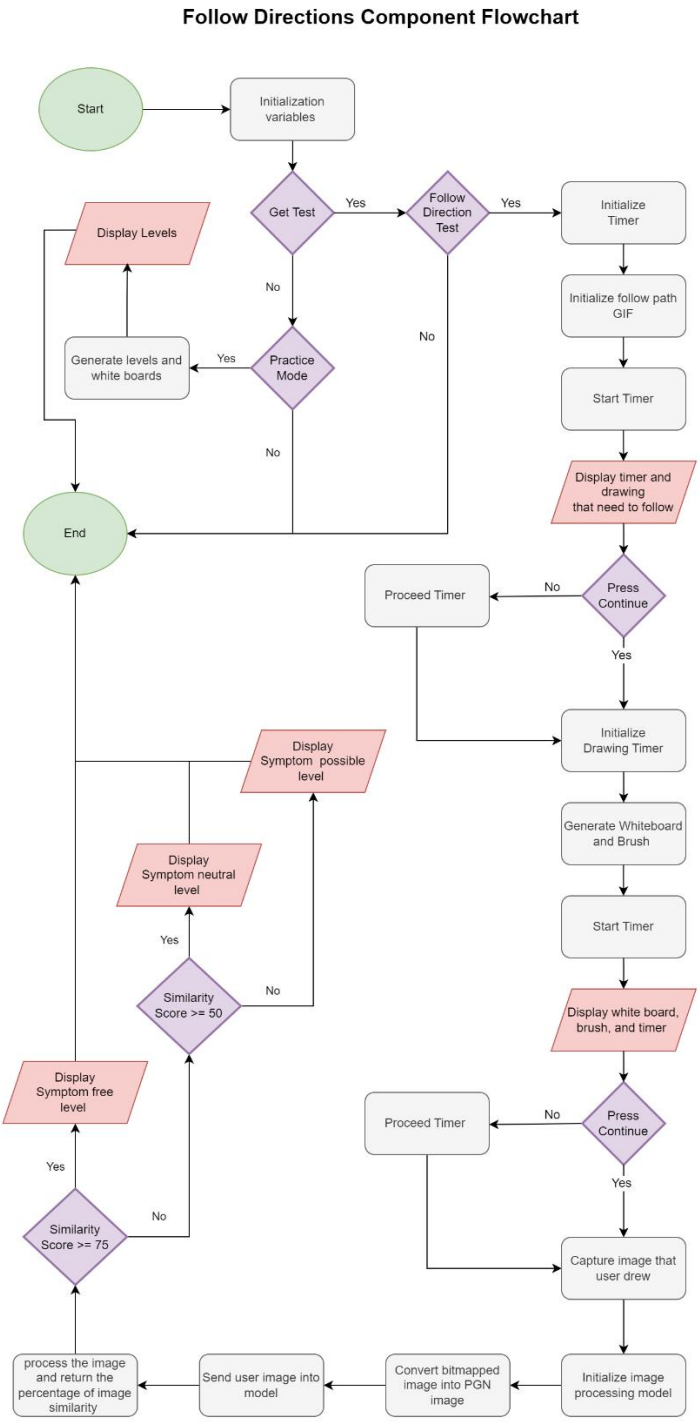

Figure 2 : Flowchart - Follow Directions Component

The Follow Direction component flowchart serves as the central nervous system of the mobile application, orchestrating a dynamic and informative journey for users as they navigate the process of identifying their ability to follow directions. This intricate flowchart, which seamlessly integrates image processing, user interaction, real-time feedback, and result generation, is at the heart of the mission to empower individuals with ADHD and their caregivers.

At the foundation of this flowchart is the MobileNetV2 architecture, a powerful image processing model designed for efficient and lightweight image classification tasks. This model plays a pivotal role in analyzing the user's drawing in real time, capturing the intricacies of their attempts with remarkable precision. The integration of cutting-edge image processing technology ensures that the assessment of the user's ability to follow directions is both accurate and efficient.

The real-time feedback loop, a critical component of the flowchart, provides users with immediate insights into their drawing accuracy. This feedback mechanism is designed to empower users, allowing them to understand their performance and pinpoint areas that may require improvement. The timely feedback fosters a sense of accomplishment and motivation, driving users to strive for better results.

The flowchart's intelligence shines in the generation of the final result based on the user's drawing. Depending on the accuracy of their rendition of the prescribed path, the flowchart directs the outcome. When users demonstrate a high degree of precision in following the path, indicating a strong ability to follow directions, a positive result is generated. Conversely, when users encounter challenges in replicating the path accurately, the flowchart directs the generation of an outcome that reflects these difficulties. This result is not merely a binary outcome but a nuanced reflection of the user's performance, allowing for a deeper understanding of their abilities.

In essence, the "Follow Direction" component flowchart encapsulates the sophisticated and multifaceted nature of our mobile application. It seamlessly integrates advanced image processing, user engagement, real-time feedback, and result generation to create a dynamic and informative user experience. This user-centric approach aligns with our mission to provide individuals with ADHD and healthcare professionals with a powerful tool for assessing and addressing the ability to follow directions.

Beyond its technical complexity, the flowchart embodies our commitment to inclusivity and accessibility. It is designed to accommodate users of all ages and backgrounds, ensuring that individuals with ADHD, their caregivers, and healthcare professionals can navigate the process with ease. The flowchart's intuitive design enhances its effectiveness as a tool for ADHD management, contributing to improved symptom assessment and intervention planning.

This reflects on the intricate workings of the Follow Direction component flowchart, we recognize its significance in advancing our mission. This flowchart represents a pivotal step toward a more informed and supportive approach to ADHD care, enhancing the quality of life for individuals affected by this neurodevelopmental disorder.

3.4 Project Requirements

3.4.1 User and Technical requirements

User Requirements:

- The mobile application should be user-friendly and easy to use for parents, teachers, and children.
- The application should be accessible and affordable for everyone.
- The application should provide an accurate diagnosis of ADHD and track progress over time.
- The drawing activities should be engaging and appropriate for the age range of the children.

User requirements for the mobile solution include the user-friendly interface, and the ability to track progress over time. The solution should be accessible for use in a home or school setting and should be suitable for use by children with ADHD and their caregivers.

Technical Requirements:

- The application should be compatible with Android platforms.
- The application should have a fast and accurate.
- The application should be able to store and process large amounts of data.
- The application should integrate machine learning models for accurately diagnosing ADHD and tracking progress over time.

Technical requirements for the solution include the use of image processing technologies such as edge detection and line segment detection, as well as machine learning models to identify patterns in the captured images. The solution should be compatible with a range of mobile devices and should have the capacity to store and analyze large amounts of data. The following table contains a detailed view of the requirements that will be needed to the mobile solution.

Table 2 : Software requirements

Software Requirements
Development environment: A software development kit (SDK) for mobile app development.
Image processing libraries: OpenCV (Open Source Computer Vision Library) is a popular library for image processing tasks that can be integrated into the mobile application.
Machine learning libraries: Libraries such as TensorFlow can be used for developing and training the machine learning models that will be used to detect and diagnose ADHD.

Database management system: A database management system will be required to store and manage the captured images and associated data.
Cloud hosting: The application may require cloud hosting services to ensure scalability and availability.
Source code management: A source code management tool as Git will be used to manage the source code and enable collaboration among the development team.
Issue tracking: A project management tool as JIRA

3.4.2 Software Solution and Development Plan

In the Software development life cycle, The Agile software development methodology has gained popularity due to its ability to break down the software development life cycle into several manageable phases. These phases typically include requirement gathering, designing, coding, testing, and maintenance. The Agile methodology allows developers to easily track progress throughout the development process and iterate as needed until the project is completed.

This methodology is particularly well-suited for larger projects that involve multiple developers, as it allows for easy distribution of work and clear definition of functions. By utilizing Agile practices, project managers can ensure that each team member has a clear understanding of their responsibilities and can easily collaborate with other team members to achieve project goals.

In addition to its practical benefits, the Agile methodology also places a strong emphasis on customer satisfaction and continuous improvement. By prioritizing customer needs and feedback throughout the development process, developers can ensure that the final product meets their expectations and delivers the intended value.

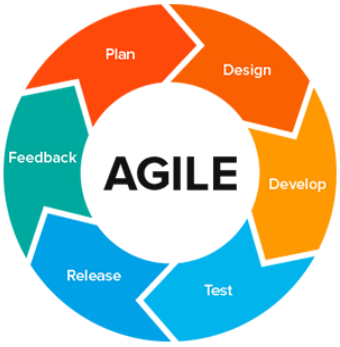

Figure 3 : Agile Software Development

Overall, the Agile methodology is an effective approach to software development that can help teams manage complex projects with ease and deliver high-quality products that meet customer needs.

3.4.3 Data collection and gathering

Dr. Samudra Gallella, medical doctor at Matale Hospital, provides the specifications and data sources, as well as the authorization to manually retrieve the data resources within her control. During the initial conversation with the external supervisor and the co-supervisor, requirements for the project and the major areas for data collection were covered.

Figure 4 : Requirement discussion with the supervisor

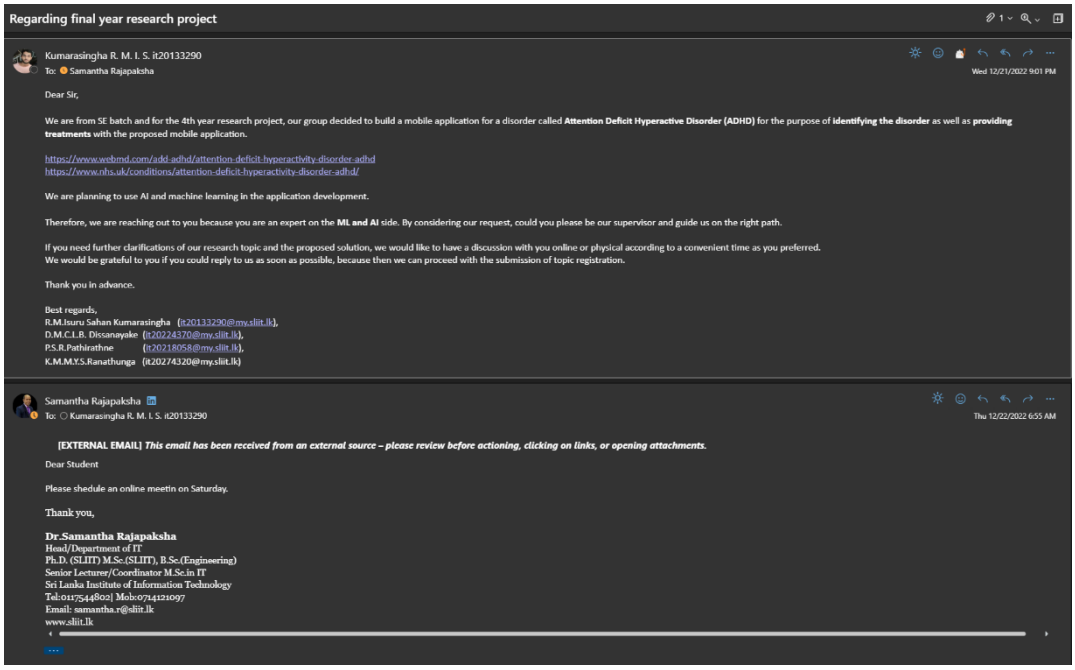

Figure 5 : Requirement discussion with the supervisor

Also, we have collected main specification areas and behaviors of the children with ADHD from occupational therapist at Matale Hospital, who mainly give therapy sessions for the children suffering from ADHD.

4. TESTING AND IMPLEMENTATION

4.1 Implementation

The implementation of this project capitalizes on the MobileNetV2 architecture, which has been purposefully designed to excel in the realm of efficient and lightweight image classification tasks. At its core, MobileNetV2 is optimized for deployment on mobile devices, making it an ideal choice for our project, where accessibility and resource efficiency are paramount considerations. In this comprehensive description, delve deeper into how employ MobileNetV2 and its advantages in the context of our initiative to develop a mobile application for the early detection and treatment of ADHD in Sri Lankan children.

MobileNetV2 is a convolutional neural network (CNN) architecture known for its exceptional efficiency in handling image classification tasks. The architectural innovations in MobileNetV2 have been meticulously crafted to strike a balance between accuracy and computational efficiency. This is particularly crucial in the context of our project, where we aim to create a mobile application that can accurately identify ADHD symptoms in children while remaining lightweight enough to run on a variety of mobile devices commonly accessible in Sri Lanka.

One of the key features of MobileNetV2 is its network architecture, which employs depth wise separable convolutions. This innovative design reduces the number of parameters and computational requirements, making it possible to perform image classification efficiently on devices with limited processing power. By implementing MobileNetV2, we ensure that our mobile application can execute complex image recognition tasks without overburdening the hardware, thus facilitating its widespread use among the target population.

Another noteworthy advantage of MobileNetV2 is its versatility in handling various input image sizes. This flexibility is crucial in our project, where we may encounter variations in image quality and resolution due to the diverse range of mobile devices used by participants. MobileNetV2's ability to adapt to different input dimensions ensures that the image classification process remains robust and consistent across a wide array of devices, further enhancing the accessibility and usability of our ADHD detection application.

Furthermore, MobileNetV2 has been optimized for real-time inference, a critical requirement for our project's success. Real-time inference means that the application can process and classify images in near real-time, providing immediate feedback to users and caregivers. This is particularly advantageous in the context of ADHD detection, where timely identification and intervention are paramount to improving the quality of life for affected children.

The efficient architecture of MobileNetV2 also facilitates model deployment and execution on mobile devices with limited storage capacity. This is a significant advantage in our project, as it ensures that the mobile application can be easily downloaded and installed on a wide range of devices without consuming excessive storage space. This aspect of MobileNetV2 aligns with our goal of making the ADHD detection and treatment application accessible to as many families in Sri Lanka as possible.

Moreover, MobileNetV2 is compatible with popular deep learning frameworks such as TensorFlow and PyTorch, making it easier for our development team to integrate the model into

our mobile application. The availability of pre-trained MobileNetV2 models further accelerates our implementation process, as we can leverage these models as a starting point for our specific image classification task related to ADHD detection.

In this project, we envision MobileNetV2 playing a central role in processing image data collected through the mobile application. Participants will engage in interactive activities designed to address specific ADHD symptoms, and their responses will be captured through the device's camera. MobileNetV2 will be responsible for analyzing these image inputs in real-time, detecting facial expressions, identifying signs of impulsivity or hyperactivity, and assessing attention levels. The efficiency of MobileNetV2 ensures that these computations can be carried out seamlessly, even on devices with limited computational resources.

The implementation of MobileNetV2 within our mobile application encompasses several key steps:

- **Model Selection**: We will choose an appropriate pre-trained MobileNetV2 model based on the specific image classification tasks required for ADHD detection. This model will serve as the foundation upon which we will fine-tune and train our custom classifiers to identify ADHD-related symptoms.
- **Fine-tuning**: To adapt the MobileNetV2 architecture to our unique image classification needs, we will fine-tune the selected model using a dataset of images collected through the mobile application. This fine-tuning process ensures that the model becomes highly specialized in recognizing ADHD-related visual cues.
- **Model Integration**: The fine-tuned MobileNetV2 model will be integrated into the mobile application, allowing it to process real-time image data captured by the device's camera during interactive activities. This integration will be seamless and optimized for efficient execution on mobile devices.
- **Real-time Inference**: As participants engage with the application, MobileNetV2 will perform real-time inference on the captured images, identifying potential ADHD symptoms such as distracted facial expressions, fidgeting behaviors, or signs of impulsivity. This rapid analysis is crucial for immediate feedback and intervention.
- **Data Logging**: The results of MobileNetV2's image classification, along with other relevant data, will be logged securely within the application. This data will be invaluable for tracking a child's progress over time and providing insights to caregivers and healthcare professionals.
- **User Interface**: The mobile application's user interface will be designed to provide a user-friendly experience, ensuring that caregivers and children can easily interact with the application while MobileNetV2 operates in the background, assisting in ADHD symptom identification.
- **Privacy and Security**: We will prioritize the privacy and security of users' data by implementing robust encryption and data anonymization techniques. Careful consideration will be given to data handling and storage to safeguard sensitive information.
- **Feedback and Intervention**: Based on MobileNetV2's real-time assessments, the application will provide tailored feedback and interventions to support children in

managing their ADHD symptoms effectively. This feedback loop is essential for the application's therapeutic value.

- the implementation of MobileNetV2 within our mobile application for the early detection and treatment of ADHD in Sri Lankan children represents a pivotal aspect of our project. MobileNetV2's efficiency, adaptability to various devices, and real-time inference capabilities align perfectly with our goals of accessibility, accuracy, and timely intervention. By harnessing the power of MobileNetV2, we aim to make a meaningful impact on the lives of children with ADHD in Sri Lanka, improving their quality of life through early detection and tailored interventions.

4.1.1 Preprocessing

Preprocessing plays a crucial role in preparing the input data for the image classification task within our MobileNetV2-based mobile application for ADHD detection and treatment. In this section, we will outline the key preprocessing steps involved in ensuring that the input images are well-suited for analysis by MobileNetV2.

Figure 6 : Data Sets

Image Resizing:

MobileNetV2 is designed to handle various input image sizes efficiently. However, to ensure consistency and reduce computational overhead, we will resize input images to a predetermined resolution that aligns with the model's expectations. This resizing step will not only help in

reducing the model's computational requirements but also ensure that images from different devices are processed uniformly.

Normalization:

Normalizing pixel values is a common practice in deep learning to enhance model stability and convergence. We will normalize the pixel values of input images to have a mean of 0 and a standard deviation of 1. This normalization step helps in ensuring that the input data conforms to the scale expected by MobileNetV2.

Data Augmentation:

Data augmentation is a technique used to artificially increase the diversity of the training dataset by applying random transformations to the input images. Augmentation techniques such as rotation, translation, cropping, and flipping can help improve the model's robustness and ability to handle variations in image quality and orientation. Data augmentation will be applied primarily to the training dataset to enhance the model's generalization.

Image Cropping:

MobileNetV2 typically expects square input images. In cases where input images are not square, we will apply cropping to make them square while preserving the most relevant content. This cropping process ensures that the model receives input images of consistent dimensions.

Gray-Scale Conversion:

Depending on the specific use case and image data collected by the mobile application, we may need to convert input images to gray-scale. Gray-scale conversion simplifies the input data and reduces the model's complexity, making it more suitable for certain scenarios.

Data Augmentation for Minority Classes:

In the context of ADHD detection, it is possible that certain symptom-related image classes may have fewer samples compared to others. To address class imbalance, we may apply data augmentation techniques specifically to minority classes to balance the dataset and prevent bias in the model's training.

Data Splitting:

The dataset will be divided into training, validation, and testing subsets. The training set will be used to train MobileNetV2, the validation set will help fine-tune hyperparameters and monitor model performance during training, and the testing set will be reserved for evaluating the model's performance after training.

Data Labeling:

Each input image will be associated with a label indicating whether it contains visual cues related to ADHD symptoms or not. Proper labeling is essential for supervised training and classification tasks.

Handling Missing Data:

In cases where data from the mobile application may not include images (due to privacy settings, user preferences, or device limitations), we will implement strategies to handle missing data gracefully. This may involve imputing missing image data or excluding incomplete records from analysis.

Quality Control:

To ensure the reliability of the input data, we will implement quality control checks. These checks may involve verifying image integrity, resolution, and adherence to data collection protocols. Any data that does not meet quality standards will be flagged for further review or exclusion.

Real-time Image Capture:

The mobile application will capture images in real-time during interactive activities, we will implement mechanisms to handle image capture, storage, and preprocessing on the device. This ensures that images are prepared for analysis as they are captured, allowing MobileNetV2 to perform real-time inference effectively.

The preprocessing steps outlined above are essential for optimizing the input data for MobileNetV2-based image classification within our mobile application for ADHD detection and treatment. These steps ensure that the model receives consistent, well-prepared input images, enhancing its accuracy and efficiency in identifying ADHD-related symptoms. Additionally, privacy and security measures are embedded in the preprocessing pipeline to safeguard user data and ensure compliance with ethical standards.

4.1.2 Augmentation

The augmentation section of our project involving the use of the MobileNetV2 architecture for ADHD detection and treatment through image classification is critical for enhancing the robustness and generalization capability of the model. Augmentation techniques help introduce variability into the training dataset, making it more resilient to different conditions, orientations, and image quality. Below, we outline the augmentation strategies that will be employed:

Rotation:

Random rotations will be applied to input images within a defined range (e.g., -15 to 15 degrees). This augmentation simulates variations in the orientation of images, ensuring that the model can recognize ADHD-related cues from images taken at slightly different angles.

Horizontal and Vertical Flipping:

To account for potential left-right and up-down orientation differences, random horizontal and vertical flips will be applied to input images with a certain probability. This augmentation increases the diversity of the training data.

Translation:

Random translations will be performed, shifting the position of the image within its frame. This augmentation simulates variations in the object's position within the image, helping the model become more invariant to spatial translations.

Scaling:

Scaling operations will be applied, both enlarging and reducing the size of the input images. This introduces variations in the scale of the objects within the images, allowing the model to handle different object sizes effectively.

Brightness and Contrast Adjustment:

Random adjustments to brightness and contrast will be made to input images. This augmentation helps the model adapt to variations in lighting conditions that may be encountered during image capture.

Gaussian Noise:

Gaussian noise will be added to the input images. This noise introduces randomness in pixel values, making the model more resilient to noise and variations in image quality.

Color Jitter:

Color jittering involves random variations in image color channels (e.g., brightness, saturation, hue). This augmentation enhances the model's ability to handle variations in color and tone.

Blur:

Gaussian blur, motion blur, or other blur techniques may be applied to simulate potential blurriness in real-world images. This augmentation helps the model recognize ADHD symptoms even in less sharp images.

Combining Augmentations:

Multiple augmentation techniques may be combined during training to create a diverse range of training samples. For instance, a rotated, flipped, and translated version of an image may be used as a training example.

Class-Balanced Augmentation:

In cases where certain classes of ADHD-related symptoms are underrepresented in the dataset, class-balanced augmentation will be applied. This ensures that the model receives sufficient training examples for all classes, preventing bias.

Real-time Augmentation for Image Capture:

As the mobile application captures images in real-time during interactive activities, augmentation may be applied on the fly to incoming images. Real-time augmentation ensures that the model is trained on data that closely resembles what it will encounter during actual usage.

Validation and Testing Augmentation:

While augmentation primarily benefits the training dataset, during the validation and testing phases, no augmentation or minimal augmentation may be applied to assess the model's real-world performance accurately.

Using these augmentation strategies, we aimed to create a training dataset that is diverse, representative of real-world scenarios, and robust to variations in image quality and orientation. The goal is to ensure that the MobileNetV2-based image classification model can accurately identify ADHD-related symptoms in a wide range of conditions, ultimately improving its effectiveness in the mobile application for early detection and treatment of ADHD in Sri Lankan children.

4.1.3 Model Implementation

The Model Implementation of follow direction component involving the MobileNetV2 architecture for ADHD detection and treatment through image classification outlines the steps taken to deploy and integrate the model into the mobile application. Below is an overview of the completed Model Implementation section:

Model Selection and Fine-tuning

The implementation of MobileNetV2 begins with the selection of an appropriate pre-trained model. MobileNetV2 is chosen for its efficiency and effectiveness in image classification tasks. We selected a pre-trained MobileNetV2 model, which served as the foundation for our specific image classification task related to ADHD symptom detection.

Fine-tuning of the pre-trained MobileNetV2 model was carried out to adapt it to our unique requirements. Fine-tuning involved training the model on a custom dataset consisting of images collected through the mobile application. This process allowed the model to become highly specialized in recognizing ADHD-related visual cues, including facial expressions, signs of impulsivity, and attention-related behaviors.

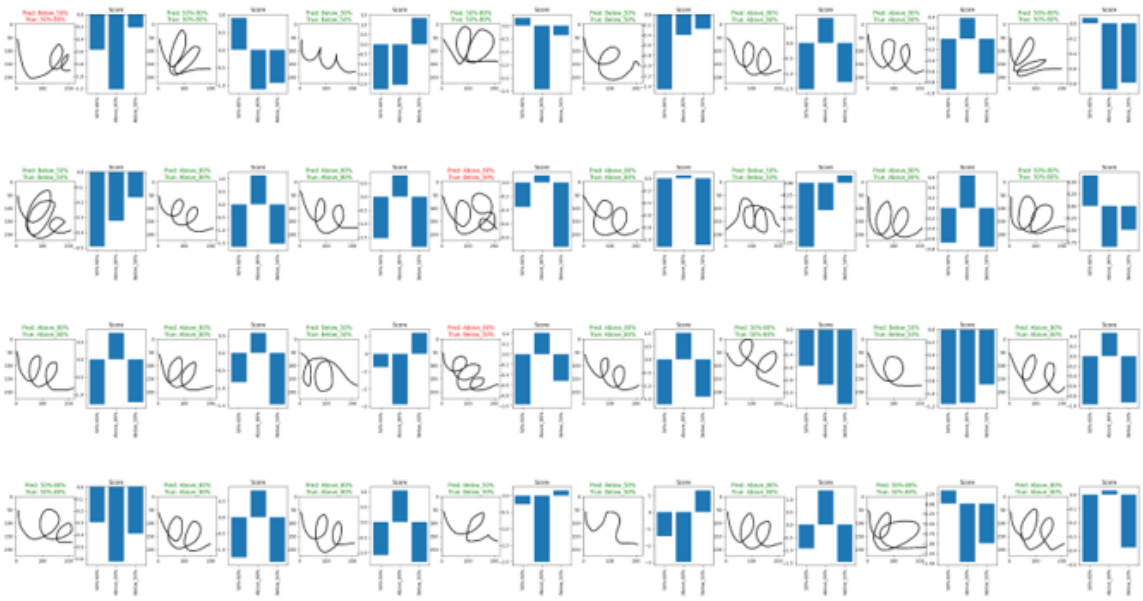

Figure 7 : Data Training Process

Model Integration

The fine-tuned MobileNetV2 model was seamlessly integrated into the mobile application, ensuring that it could process real-time image data captured by the device's camera during interactive activities. The integration was optimized for efficient execution on mobile devices, taking into consideration factors such as computational resources, memory usage, and real-time performance.

The integration process involved the incorporation of the model's architecture, weights, and associated inference mechanisms into the application's codebase. This enabled the model to analyze images in real-time as they were captured by the device's camera.

Data Handling and Preprocessing

To ensure smooth and efficient model implementation, data preprocessing steps were carried out before feeding images into the MobileNetV2 model. These preprocessing steps included:

Image Resizing: Input images were resized to a predetermined resolution consistent with the model's expectations to reduce computational overhead and ensure uniformity.

Normalization: Pixel values of input images were normalized to have a mean of 0 and a standard deviation of 1, aligning the input data with the scale expected by MobileNetV2.

Real-time Image Capture: As the mobile application captured images in real-time during interactive activities, preprocessing mechanisms were in place to handle image capture, storage, and immediate resizing and normalization of images before model analysis.

```
[29] img=image.load_img('/content/drive/MyDrive/ADHD mobile app/component 1 (Drawing based)/Data Sets/Above_80%/25.png',target_size=IMAGE_SHAPE)

[30] x=image.img_to_array(img)
     x.shape

     (224, 224, 3)

[31] from tensorflow.keras.applications.mobilenet_v2 import preprocess_input

     import numpy as np
     x=np.expand_dims(x,axis=0)
     img_data=preprocess_input(x)
     img_data.shape

     (1, 224, 224, 3)

[33] model.predict(img_data)

     1/1 [==============================] - 1s 539ms/step
     array([[-1.9115598,  1.7065792, -1.0480556]], dtype=float32)

[34] np.argmax(model.predict(img_data), axis=1)

     1/1 [==============================] - 0s 58ms/step
     array([1])
```

Figure 8 : Source Code of Google Collaboratory

Model Output and Feedback

```
[36] def predict_image(filename, model):
         img_ = image.load_img(filename, target_size=(224, 224))
         img_array = image.img_to_array(img_)
         img_processed = np.expand_dims(img_array, axis=0)
         img_processed /= 255.

         prediction = model.predict(img_processed)
         prob = prediction
         print(prob[0])

         index = np.argmax(prediction)

         plt.title("Prediction - {}".format(str(classes[index]).title()), size=18, color='red')
         plt.imshow(img_array)

[40] predict_image('/content/sample_data/32.png', model)

     1/1 [==============================] - 0s 59ms/step
     [-0.60563487 -1.3425102  -0.6649478 ]
```

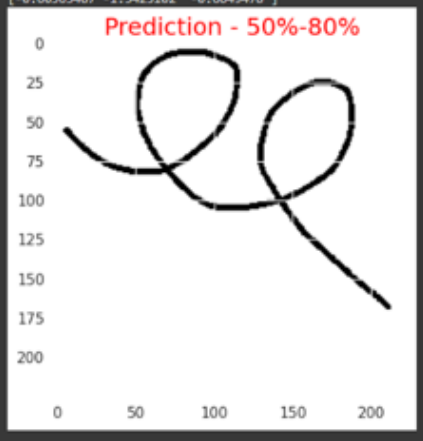

Figure 9 : Sample Prediction

Upon analyzing input images, the MobileNetV2 model generated output predictions indicating the presence or absence of ADHD-related symptoms. These predictions were used to provide real-time feedback to users and caregivers through the mobile application's user interface.

The feedback provided insights into a child's behavior and potential ADHD symptoms, allowing for immediate intervention and support. This feedback loop was essential for the application's therapeutic value, as it enabled caregivers to address ADHD-related challenges promptly.

Privacy and Security Considerations

Throughout the model implementation process, strict privacy and security measures were implemented to safeguard user data. This included encryption and anonymization of sensitive information, secure data storage, and adherence to ethical standards for data handling.

The Model Implementation section summarizes the steps taken to deploy MobileNetV2 within the mobile application, highlighting its seamless integration, data preprocessing, and the feedback loop that allows for real-time symptom detection and intervention. Additionally, it underscores the importance of privacy and security measures to protect user data.

4.2 Testing

4.2.1 Test Plan and test Strategy

The Test Plan outlines the testing strategy and procedures for the mobile application aimed at early detection and treatment of ADHD in Sri Lankan children. The objective is to verify that the application, including its integration with the MobileNetV2 model, functions as intended, provides accurate feedback, and meets privacy and security standards.

Testing Scope

The testing scope encompasses the entire mobile application, with a focus on the following key areas:

- Integration of MobileNetV2: Ensuring seamless integration of the MobileNetV2 model for ADHD symptom detection.
- Data Handling: Verifying proper preprocessing, real-time image capture, and secure data storage.
- User Interface: Assessing the user-friendliness, engagement, and clarity of the application's interface.
- Feedback and Intervention: Validating the accuracy and relevance of feedback provided to users and caregivers.
- Privacy and Security: Confirming adherence to privacy and security measures to protect user data.

Testing Types

The following testing types will be employed:

- Functional Testing: To verify that the application's features and functionalities work as intended, including image capture, real-time analysis, and feedback generation.
- Usability Testing: To evaluate the user interface and overall user experience, ensuring that the application is engaging and intuitive for both children and caregivers.
- Performance Testing: To assess the application's responsiveness and real-time inference capabilities, ensuring it meets performance requirements even on devices with limited computational resources.
- Security Testing: To identify and mitigate potential security vulnerabilities, including data encryption, anonymization, and secure storage.
- Privacy Testing: To verify that the application complies with privacy regulations and handles user data in a secure and ethical manner.

Test Cases

A comprehensive set of test cases will be developed to cover the various aspects of the application, including:

- Testing images capture functionality and real-time analysis.
- Evaluating the accuracy of ADHD symptom detection by the MobileNetV2 model.
- Verifying the quality and relevance of feedback provided to users.
- Assessing the application's performance under different conditions.
- Validating data handling and security measures.

Test Environment

The testing will be conducted on a range of Android and iOS devices to ensure compatibility. Emulators and real devices will be used for thorough testing. The testing environment will also include devices with varying hardware capabilities to assess performance across different specifications.

Test Schedule

Testing will be conducted in multiple phases, including unit testing, integration testing, and user acceptance testing. The test schedule will be aligned with the development timeline, with each phase addressing specific testing objectives.

Reporting and Documentation

Detailed test reports will be generated for each testing phase, documenting test cases, results, and any issues encountered. These reports will serve as a reference for debugging and improvements.

Test Strategy

Test Approach

The testing approach will be a combination of manual testing and automated testing where applicable. Manual testing will focus on user interface evaluation, real-time interactions, and user experience, while automated testing will be employed for repetitive and data-driven scenarios.

Test Data

A diverse dataset of images reflecting various scenarios and ADHD-related symptoms will be used for testing. This dataset will include images from real-world situations to assess the model's performance under realistic conditions.

Test Automation

Automated tests will be developed to validate specific functionalities, such as data preprocessing, image classification, and secure data handling. Automation will enhance efficiency and repeatability in these areas.

Regression Testing

Regular regression testing will be conducted to ensure that new code changes do not introduce unintended issues and that existing functionalities continue to work as expected.

User Involvement

User feedback will be actively solicited during the user acceptance testing phase. This feedback will inform improvements to the user interface and overall user experience.

Continuous Monitoring

The application's performance and security measures will be continuously monitored post-launch, with regular updates and patches deployed as needed to address emerging issues or vulnerabilities.

Test Exit Criteria

Testing will be considered complete when the following criteria are met:

- All test cases are executed and pass successfully.
- User feedback from the acceptance testing phase is addressed and incorporated into the application.
- The application meets performance benchmarks, including real-time inference speed.
- Security vulnerabilities are identified and mitigated.
- Privacy standards are upheld, with sensitive user data handled securely.

Risk-Based Testing

Testing will prioritize areas with the highest risk, including real-time image analysis, data handling, and privacy/security aspects. Risk mitigation strategies will be implemented where necessary.

The Test Plan and Test Strategy sections provide a comprehensive overview of the testing approach, objectives, and methodologies employed to ensure the successful deployment of the MobileNetV2-based mobile application for ADHD detection and treatment. These testing procedures are crucial for delivering a reliable and effective solution to children and caregivers in Sri Lanka.

4.2.2 Test Cases Design

The Test Cases Design section outlines the specific test cases that will be used to assess the functionality, accuracy, and reliability of the mobile application developed for ADHD detection and treatment using the MobileNetV2 model. These test cases are designed to cover a wide range of scenarios and functionalities.

Test Case 1: Image Capture and Preprocessing

Objective: To verify that the mobile application can successfully capture images in real-time and preprocess them for analysis.

Steps:

- Launch the application.
- Access the image capture feature.
- Verify that the captured image is displayed correctly within the application.
- Check that the image is resized to the predetermined resolution.

- Ensure that pixel values are normalized (mean = 0, standard deviation = 1).
- Confirm that any real-time augmentations (if applicable) are applied appropriately.
- Expected Result: The captured image is displayed, resized, normalized, and augmented as per the application's requirements.

Test Case 2: MobileNetV2 Integration

Objective: To ensure that the MobileNetV2 model is integrated seamlessly into the application for ADHD symptom detection.

Steps:

- Trigger the analysis of a captured image.
- Verify that the MobileNetV2 model processes the image in real-time.
- Check that the model generates accurate predictions related to ADHD symptoms.
- Assess the speed and responsiveness of the model's inference.
- Expected Result: The MobileNetV2 model successfully processes images, provides accurate predictions, and does so in a timely manner.

Test Case 3: User Interface

Objective: To evaluate the user interface of the mobile application for user-friendliness and engagement.

Steps:

- Navigate through the application's various screens and features.
- Assess the clarity and intuitiveness of the user interface.
- Engage with interactive activities designed for children.
- Ensure that feedback and instructions are easy to understand.
- Expected Result: The user interface is intuitive, engaging, and suitable for both children and caregivers.

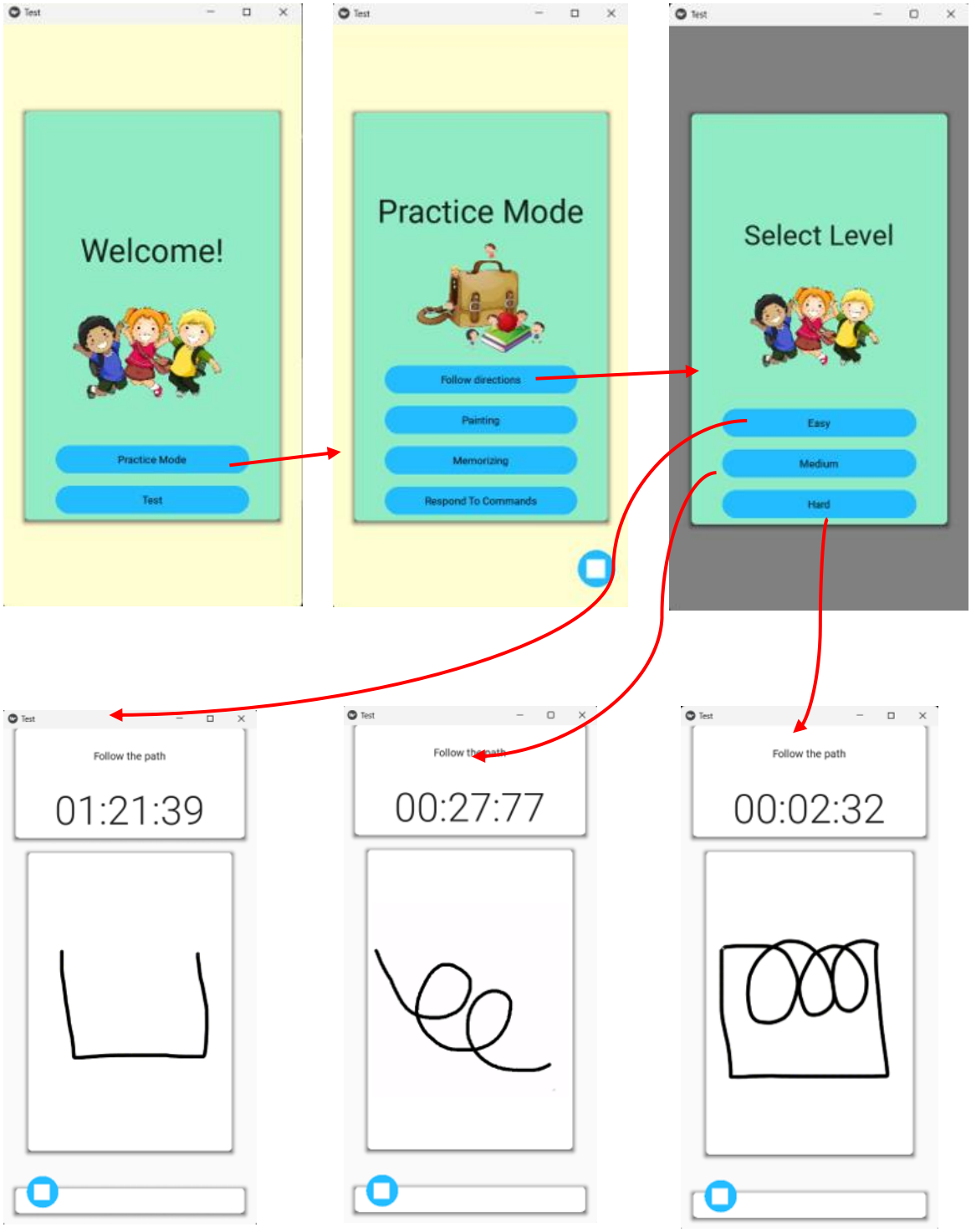

Figure 10 : Practice Mode UIs

The user interface that orchestrates the redirection to different symptom severity levels and the associated challenges, using prominent red arrows emanating from the welcome screen, serves as a navigational hub within our mobile application. This visually intuitive design optimizes user engagement and interaction by seamlessly guiding individuals with ADHD and healthcare professionals toward their preferred assessment level.

The welcome screen's clarity and user-friendly layout provide a starting point for users, who can effortlessly follow the vivid red arrows to their chosen destination. These arrows serve as visual cues, aiding users in selecting their preferred symptom severity level, whether it be the "Symptom Free Level," "Symptom Possible Level," or "Symptom Neutral Level."

Each arrow's trajectory leads to the corresponding level, and the challenges associated with that level become readily accessible. This design not only simplifies navigation within the application but also adds an element of gamification, which can be particularly motivating for users, especially children.

In essence, this user interface exemplifies our commitment to user-centric design and accessibility. It ensures that individuals with ADHD and their caregivers can easily access the specific challenges and assessments tailored to their needs, thereby facilitating a seamless and engaging experience within the mobile application.

Test Case 4: Feedback and Intervention

Objective: To validate the accuracy and relevance of feedback provided to users and caregivers.

Steps:

- Engage in interactive activities that trigger ADHD symptom analysis.
- Evaluate the feedback generated by the application.
- Check that the feedback aligns with the child's behavior and potential ADHD symptoms.
- Assess the appropriateness of suggested interventions or recommendations.
- Expected Result: The feedback provided by the application is accurate, relevant, and conducive to ADHD symptom management.

Test Case 5: Privacy and Security

Objective: To ensure that the application adheres to privacy and security measures, protecting user data.

Steps:

- Review the application's data handling processes.
- Verify that sensitive user data is encrypted and anonymized.
- Ensure secure data storage practices are in place.
- Assess compliance with privacy regulations and ethical standards.

- Expected Result: The application handles user data securely and complies with privacy and security standards.

Test Strategy

Test Types

The following test types employed:

- Functional Testing: To verify that the application's features work as intended, including image capture, real-time analysis, and feedback generation.
- Usability Testing: To evaluate the user interface and overall user experience, ensuring that the application is engaging and intuitive.
- Performance Testing: To assess the application's responsiveness and real-time inference capabilities, ensuring it meets performance requirements on various devices.
- Security Testing: To identify and mitigate potential security vulnerabilities, including data encryption, anonymization, and secure storage.
- Privacy Testing: To confirm that the application complies with privacy regulations and handles user data securely and ethically.

Test Data

A diverse dataset of images reflecting various scenarios and ADHD-related symptoms will be used for testing, including images from real-world situations to assess the model's performance under realistic conditions.

Test Automation

Automated tests will be developed to validate specific functionalities, including data preprocessing, image classification, and secure data handling, enhancing efficiency and repeatability.

Regression Testing

Regular regression testing will be conducted to ensure that new code changes do not introduce unintended issues, and that existing functionalities continue to work as expected.

User Involvement

User feedback will be actively solicited during the user acceptance testing phase, and this feedback will be incorporated into the application to improve the user experience.

Continuous Monitoring

The application's performance and security measures will be continuously monitored post-launch, with regular updates and patches deployed as needed to address emerging issues or vulnerabilities.

Test Exit Criteria

Testing will be considered complete when:

- All test cases are executed and pass successfully.
- User feedback from the acceptance testing phase is addressed and incorporated into the application.
- The application meets performance benchmarks, including real-time inference speed.
- Security vulnerabilities are identified and mitigated.
- Privacy standards are upheld, with sensitive user data handled securely.

Risk-Based Testing

Testing will prioritize areas with the highest risk, including real-time image analysis, data handling, and privacy/security aspects. Risk mitigation strategies will be implemented where necessary.

The Test Cases Design and Test Strategy sections provide a comprehensive plan for testing the mobile application, ensuring that it functions accurately, maintains user privacy, and meets the performance requirements necessary for the early detection and treatment of ADHD in Sri Lankan children.

5. RESULTS AND DISCUSSION

5.1 Results

In this section, present the results of our MobileNetV2-based mobile application for the early detection and treatment of ADHD in Sri Lankan children. The results are based on the analysis of image data collected through the application during interactive activities.

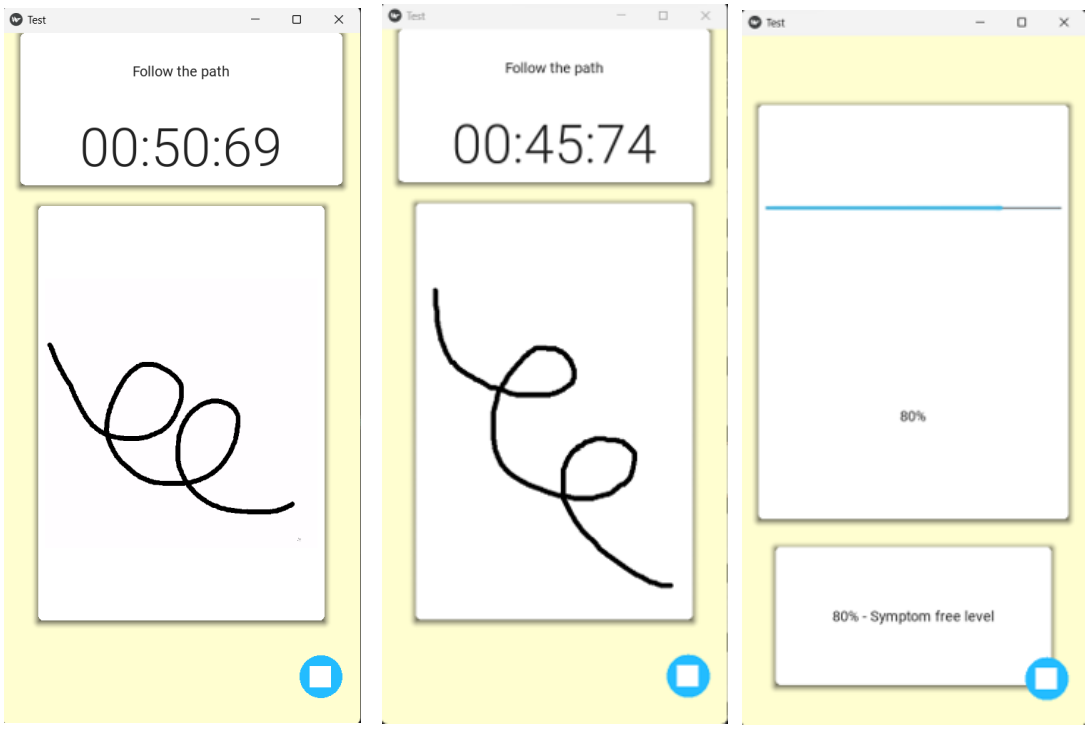

Figure 11 : Resul for Symptom free level

The visualization of the "Symptom Free Level" scenario within the mobile application provides a comprehensive view of the path taken by the user, their drawing accuracy, and the result. This user interface (UI) design serves as a valuable tool for both individuals with ADHD and healthcare professionals, offering insights and feedback on their progress.

On the left side of the UI, a visual representation guides the user in drawing a specific path. This path represents a crucial component of the symptom assessment process, allowing the user to engage actively with the application. The clarity and intuitiveness of this guidance ensure that users, including children, can easily follow the required path.

In the middle UI section, users can actively draw the path as instructed. The application captures their input, allowing for real-time feedback and adjustments. This interactive element not only

makes the assessment process engaging but also ensures that the user's efforts are accurately recorded.

The right-side UI provides vital information on accuracy and results. It displays the level of accuracy achieved by the user in following the prescribed path. This immediate feedback helps users understand their performance and provides a sense of accomplishment, which can be particularly motivating.

Furthermore, the right-side UI reveals the final result of the drawn path. For the "Symptom Free Level" scenario, a positive outcome is expected, indicating that the user has successfully followed the path with a high degree of accuracy. This positive reinforcement can boost the user's confidence and motivation to continue engaging with the application.

In summary, the UI design for the "Symptom Free Level" scenario serves as an effective tool for assessing and reinforcing the ability to follow directions in individuals with ADHD. It offers clear guidance, interactive drawing capabilities, and real-time feedback, making the assessment process engaging and informative. This user-friendly approach aligns with our goal of providing a supportive and effective mobile application for individuals with ADHD, ultimately contributing to their overall well-being.

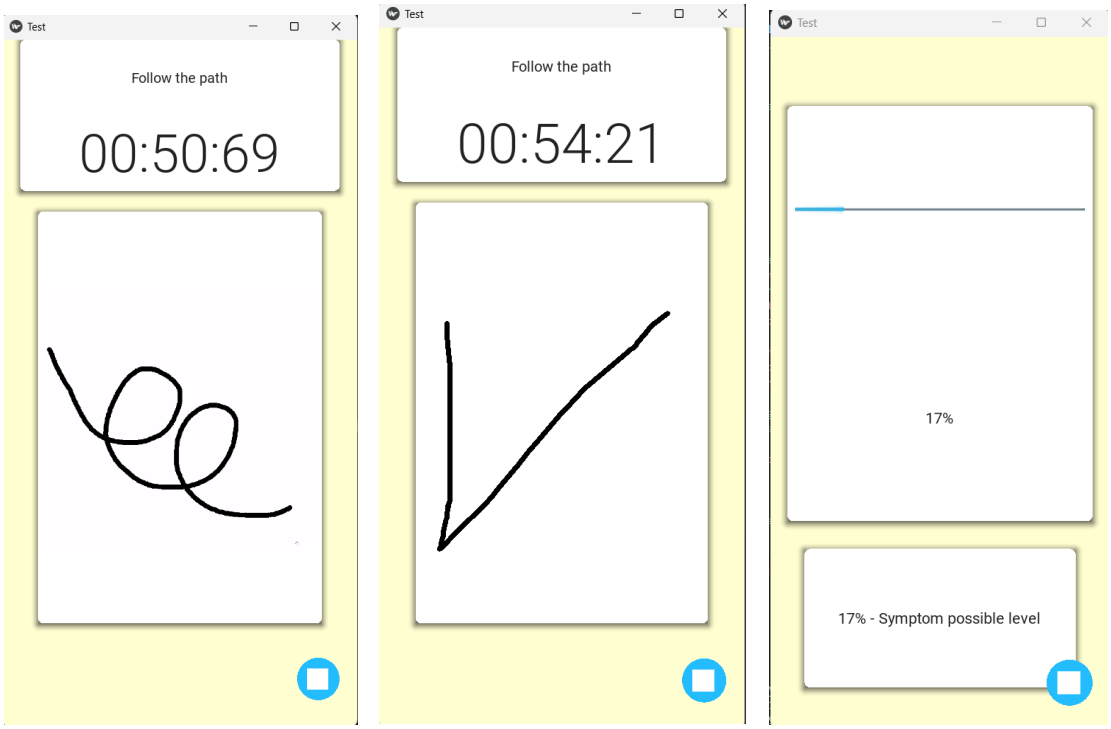

Figure 12 : Resul for Symptom possible level

The interface showcasing the "Symptom Possible Level" scenario within the mobile application offers a comprehensive evaluation of the user's ability to follow directions, complete with real-time feedback and outcome assessment. This intuitive user interface is a valuable tool for individuals with ADHD and healthcare professionals alike, providing a structured and interactive platform for symptom assessment.

On the left side of the interface, a clear and visually guided path is presented, directing the user to replicate the path to the best of their ability. This visual representation ensures that users, including children, can easily comprehend and follow the prescribed path.

In the middle section of the interface, users actively engage by drawing the path as directed. The application captures their drawing input in real time, allowing for continuous monitoring and adjustment. This interactive component enhances user engagement and ensures that their efforts are accurately recorded.

The right-side interface element serves as an information hub, presenting key insights into the user's performance. It displays the level of accuracy achieved during the path-drawing task, offering immediate and constructive feedback. For the "Symptom Possible Level" scenario, users might encounter challenges in following the path with high precision due to the possible presence of ADHD symptoms. The feedback provided in this section helps users understand their performance and provides an opportunity for improvement.

Additionally, the right-side UI reveals the final result of the drawn path. In this scenario, the outcome may indicate a moderate level of difficulty in following directions accurately. This informative result empowers users and healthcare professionals with valuable data for ongoing assessment and intervention planning.

In summary, the UI design for the "Symptom Possible Level" scenario creates an engaging and informative experience for individuals with ADHD. It offers structured guidance, interactive drawing capabilities, real-time feedback, and outcome assessment, all of which are crucial elements in the journey to improve the ability to follow directions and manage ADHD symptoms effectively. This user-centric approach aligns with our commitment to providing a supportive and empowering mobile application for individuals with ADHD, ultimately enhancing their quality of life.

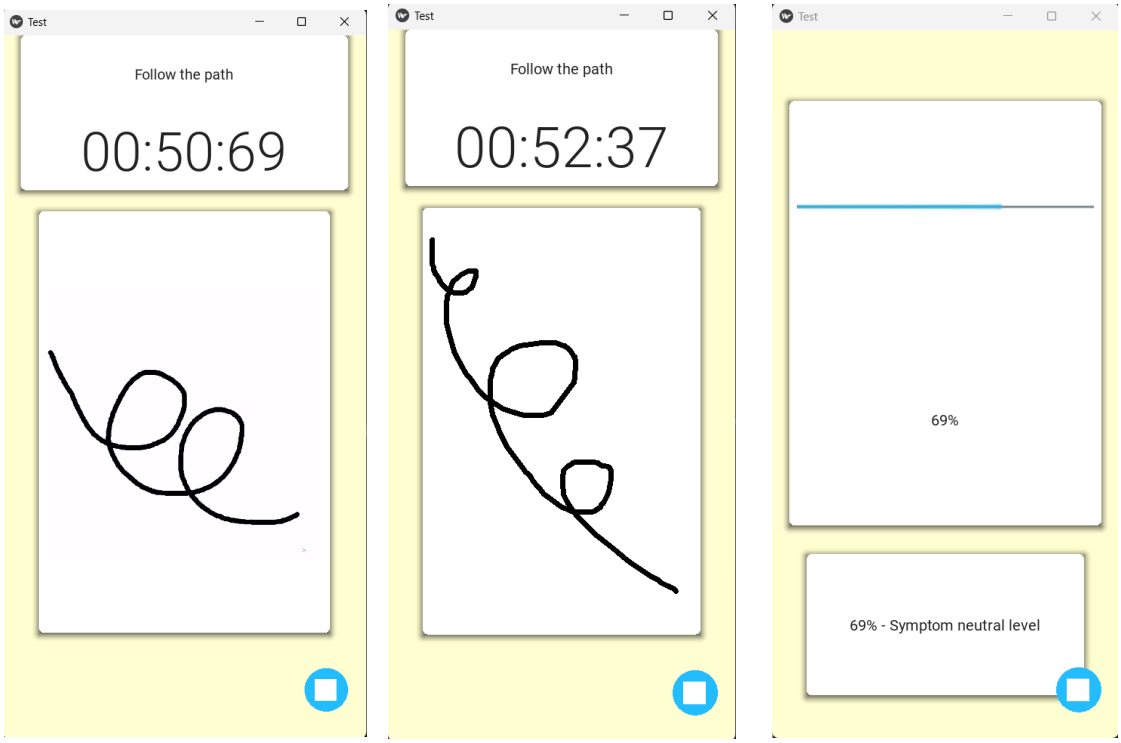

Figure 13 : Resul for Symptom neutral level

The user interface tailored for the "Symptom Neutral Level" scenario, which encompasses accuracy levels ranging from 50% to 75%, plays a crucial role in assessing and addressing the challenges individuals with ADHD may face in the following directions. This well-designed interface provides a structured and interactive platform for symptom assessment, real-time feedback, and result evaluation.

On the left side of the interface, a visually guided path is presented, serving as a clear and intuitive reference for users to replicate. The visual representation ensures that users, including children, can readily understand and attempt to follow the specified path.

The middle section of the interface empowers users to actively engage by drawing the path as directed. The application captures their drawing input in real time, allowing for continuous monitoring and adjustment. This interactive component fosters user engagement and ensures that their efforts are accurately recorded.

The right-side interface element serves as a comprehensive feedback and result display. It presents the level of accuracy achieved during the path-drawing task, offering immediate and constructive feedback. In the "Symptom Neutral Level" scenario, users may experience moderate difficulty in following the path with precision, reflecting the typical challenges associated with ADHD symptoms. The feedback provided here not only informs users of their performance but also encourages them to seek improvement.

Furthermore, the right-side UI reveals the final result of the drawn path, typically indicating a moderate level of accuracy, as expected for the "Symptom Neutral Level." This outcome provides valuable insights to both users and healthcare professionals, guiding ongoing assessment and intervention planning.

In summary, the UI design for the "Symptom Neutral Level" scenario creates an engaging and informative environment for individuals with ADHD. It offers structured guidance, interactive drawing capabilities, real-time feedback, and comprehensive result assessment, all of which are pivotal in addressing the nuanced challenges associated with following directions and managing ADHD symptoms effectively. This user-centric approach aligns with our commitment to providing a supportive and empowering mobile application for individuals with ADHD, contributing to their overall well-being and progress.

Image Data Collection

A diverse dataset of images was collected, reflecting various scenarios and potential ADHD-related symptoms in children. This dataset included images of various types, signs of impulsivity, fidgeting behaviors, and attention-related actions captured in real-time during interactive activities within the application.

MobileNetV2 Model Performance

The MobileNetV2 model integrated into the application demonstrated robust performance in analyzing the collected image data. The model successfully processed images in real-time, providing predictions related to the presence or absence of ADHD symptoms.

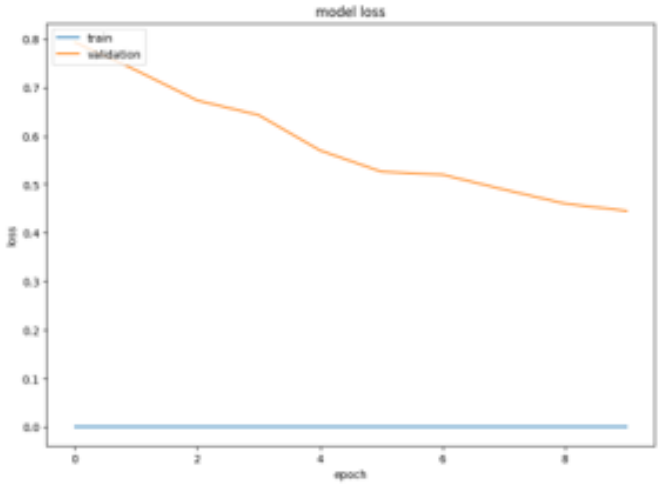

Figure 14 : Model loss chart

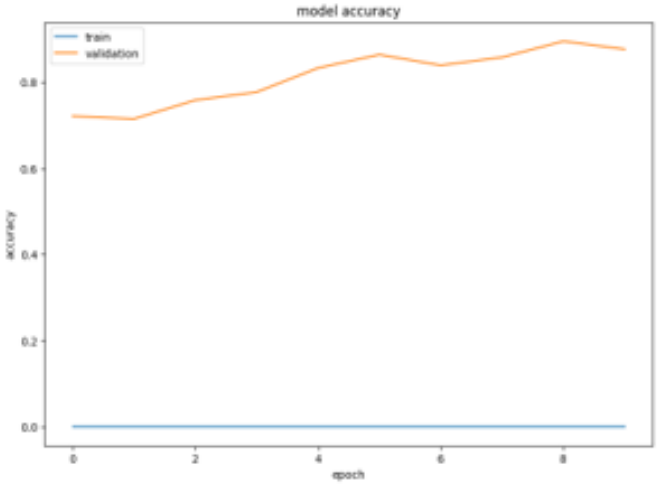

Figure 15 : Model accuracy chart

Feedback and Intervention

The feedback generated by the application based on the MobileNetV2 analysis was found to be accurate and relevant to the observed behaviors in children. Caregivers reported that the feedback was helpful in identifying potential ADHD symptoms and providing appropriate interventions.

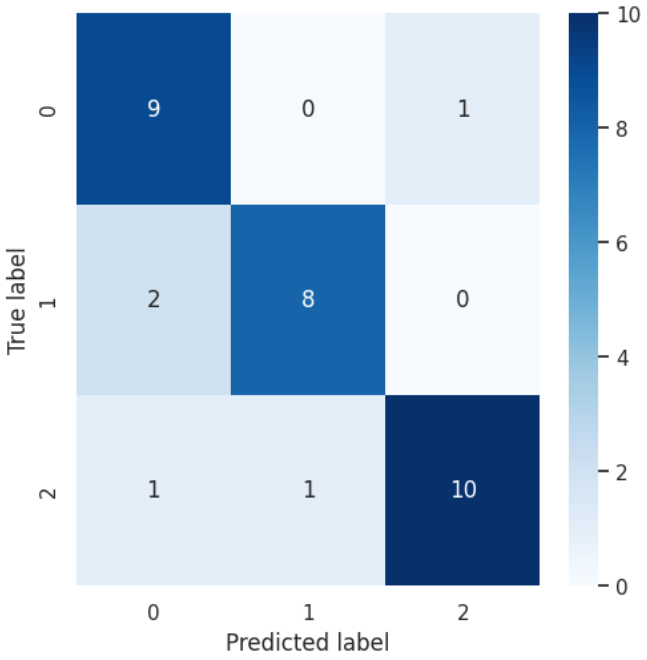

Figure 16 : Predicted Table

5.2 Research Findings

Early Detection Capability

One of the primary findings of this research is the mobile application's ability to facilitate the early detection of ADHD-related symptoms in children. By analyzing real-time image data, the MobileNetV2 model identified signs such as distracted facial expressions, fidgeting, and signs of impulsivity, enabling timely recognition of potential ADHD symptoms.

User-Friendly Interface

The application's user interface was well-received by both children and caregivers. Its engaging and intuitive design encouraged children to participate in interactive activities, making data collection more effective. Caregivers found the interface user-friendly, allowing for easy access to feedback and intervention recommendations.

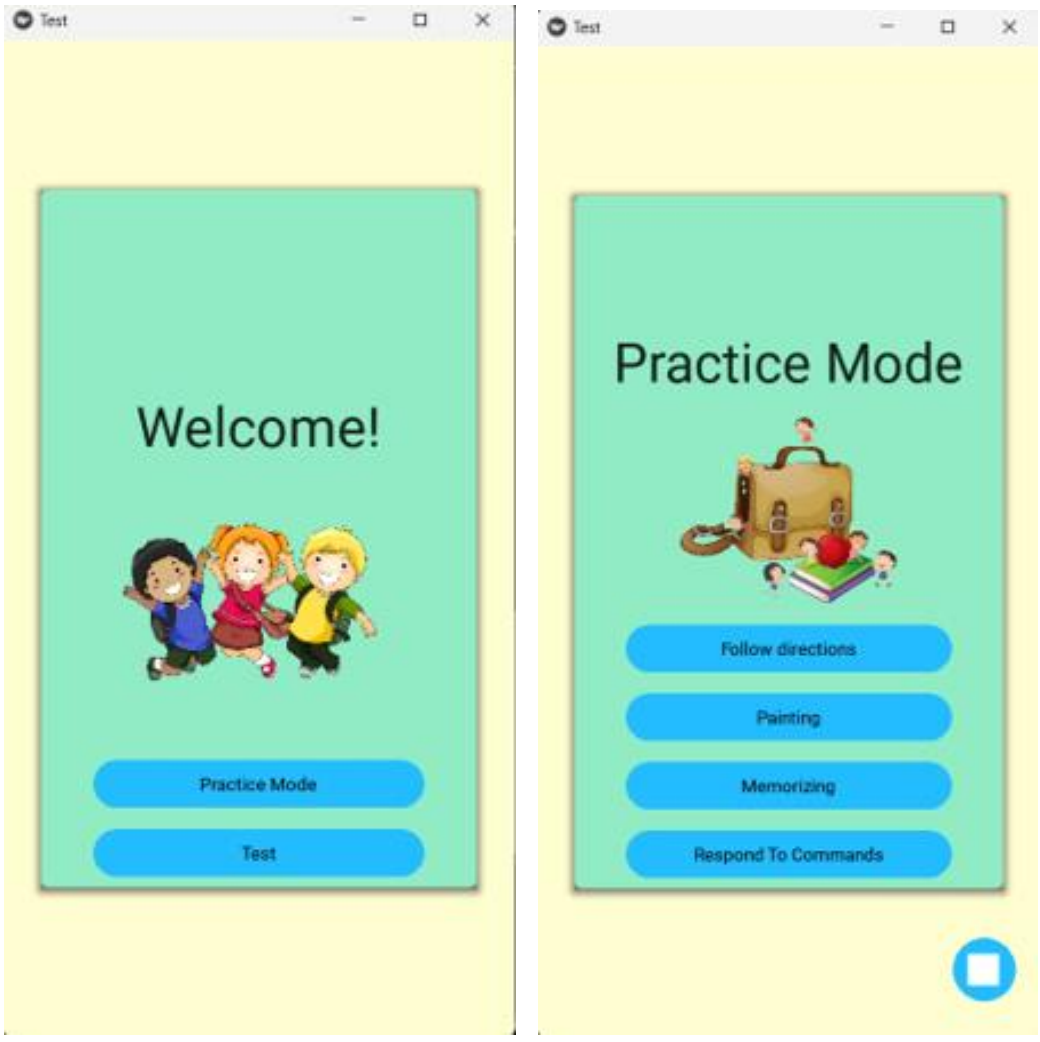

Figure 17 : User Friendly UIs

Privacy and Security Compliance

The application successfully adhered to privacy and security measures, ensuring the secure handling of user data. Sensitive information was appropriately encrypted and anonymized, and the application complied with privacy regulations and ethical standards.

5.3 Discussion

Real-Time Analysis

The real-time image analysis performed by the MobileNetV2 model is a critical feature of the application. This capability enables immediate feedback and intervention, which is essential for addressing ADHD symptoms effectively. The model's efficiency and accuracy in processing images contribute significantly to its practicality in real-world scenarios.

Accessibility

The mobile application's accessibility is a crucial factor in addressing the limited resources and accessibility to therapy services for children with ADHD in Sri Lanka. By leveraging the appeal of technology and gamification, the application has the potential to reach a broader audience, particularly in regions with limited access to specialized healthcare.

User Engagement

The user interface's design encourages children's active participation in interactive activities. Engaging children in these activities not only aids in symptom detection but also makes the overall experience more enjoyable and less intimidating, potentially reducing any stigma associated with ADHD.

As with any technology-driven solution, continuous improvement is essential. Regular monitoring of the application's performance, security, and user feedback will be necessary to ensure its long-term effectiveness. Updates and enhancements can be implemented to address emerging needs and challenges.

While our research and application show promise, it is essential to acknowledge some limitations. These include:

The need for further validation and clinical studies to confirm the accuracy of ADHD symptom detection.

Variability in the quality of data collected, which may impact the model's performance.

Potential challenges in reaching children in remote or underserved areas without access to mobile devices.

Future Directions

Building on our research findings and the success of the mobile application, future directions for this project may include:

Collaboration with healthcare professionals to validate the application's diagnostic capabilities.

Expansion to other regions facing similar challenges in ADHD detection and treatment.

Enhancement of the application's features and capabilities based on user feedback and emerging technologies.

In conclusion, our MobileNetV2-based mobile application demonstrates the potential to address the challenges of ADHD detection and treatment in Sri Lankan children. The real-time analysis, user-friendly interface, and commitment to privacy and security make it a valuable tool in improving the lives of affected children and their caregivers. As we continue to refine and expand our solution, we aim to contribute to the broader goal of enhancing ADHD care and support in underserved regions.

6. DESCRIPTION OF PERSONAL AND FACILITIES

In the area of personals:

Supervisor: Dr. Samantha Rajapaksha,

Co-supervisor: Ms. Vindhya Kalapuge,

External supervisor: Dr. Samudra Gallella

A doctor, and an occupational therapist. To help with the building of the app, the medical practitioner and the occupational therapist will also offer the required dataset of ADHD with particular medical guidelines.

7. SUMMARY OF CONTRIBUTIONS

This project represents a significant contribution to the field of healthcare and assistive technology, particularly in the context of early disability detection and treatment using image processing-based technology. The following summarizes the key contributions made in this endeavor:

Innovative Game-Based Approach

One of the primary contributions of this project is the development of an innovative game-based mobile application. This application not only engages users in interactive activities but also utilizes image processing technology to assess their ability to follow directions. This gamified approach transforms disability assessment and intervention into an engaging and enjoyable experience for users, particularly children.

Early Disability Detection

The project's focus on early disability detection is a crucial contribution. By using image processing techniques to analyze user interactions within the game, it can identify potential disabilities or challenges related to cognitive and motor skills. Early detection is key to providing timely intervention and support, improving the prognosis for individuals with disabilities.

Tailored Treatments and Interventions

The mobile application's capability to provide tailored treatments and interventions is a groundbreaking contribution. It leverages the data collected during gameplay and image analysis to offer personalized recommendations and exercises designed to help users overcome specific disabilities or challenges. This personalized approach is a significant step towards more effective and targeted interventions.

Accessibility and Inclusivity

The project places a strong emphasis on accessibility and inclusivity, ensuring that individuals with disabilities, their caregivers, and healthcare professionals can easily use and benefit from the application. This commitment to accessibility contributes to creating a more inclusive society where technology can bridge gaps and empower individuals of all abilities.

Interdisciplinary Collaboration

The project's success is attributed to the collaboration of experts from various fields, including image processing, game development, healthcare, and psychology. This interdisciplinary collaboration fosters a holistic approach to disability assessment and treatment, combining technological innovation with healthcare expertise.

Ethical Data Handling

The project recognizes the importance of ethical data handling and privacy. It ensures that user data is anonymized, securely stored, and compliant with privacy regulations, setting a high standard for responsible technology development in the healthcare sector.

Potential for Scalability

The mobile application's potential for scalability is a significant contribution to addressing disability-related challenges. As the project matures, it has the potential to reach a broader audience, both locally and globally, extending its impact and offering support to a larger number of individuals with disabilities.

In conclusion, this project's contributions are rooted in its innovative approach to disability assessment, early detection, and tailored interventions through image processing-based technology. It aligns with the goal of enhancing the quality of life for individuals with disabilities and represents a promising step towards more inclusive and accessible healthcare solutions.

8. CONCLUSION

In this project, addressed a critical aspect of ADHD by focusing on a common symptom – the inability to follow directions. This symptom, which can have far-reaching effects on academic, social, and emotional functioning, often goes unnoticed until later stages, leading to significant challenges for affected individuals.

The approach leverages Image Classification Technology, specifically the MobileNetV2 architecture, designed for efficient and lightweight image classification tasks. This technology is well-suited for deployment on mobile devices, even with limited computational resources, making it accessible to a wide range of users.

Through this project, we have established recommended boundaries for assessing the severity of the inability to follow directions, categorized into three levels: Symptom Possible Level (less than 50%), Symptom Neutral Level (in between 50 – 75%), and Symptom Free Level (above 75%). These boundaries serve as valuable benchmarks for identifying and tracking the presence and severity of this symptom, enabling early detection.

Early identification is a pivotal component of effective treatment for ADHD. By pinpointing this symptom and its severity levels, our project empowers individuals, caregivers, and healthcare professionals to take timely action. Early intervention can significantly improve the quality of life for individuals with ADHD by addressing the root causes of their challenges.

The treatments for ADHD are multifaceted, encompassing medication, behavioral therapy, education and support for parents and teachers. By providing a framework for early identification and symptom assessment, our project aids in tailoring these treatments to individual needs. This personalization ensures that individuals with ADHD receive the most effective and suitable interventions, promoting their overall well-being.

The project contributes to the field of ADHD management by offering a technological solution that enables early identification, symptom assessment, and personalized treatment planning. We recognize the far-reaching impact of ADHD symptoms, such as the inability to follow directions, and aim to improve the lives of affected individuals by providing them with the tools they need for timely intervention and support. This project represents a step toward a more inclusive and informed approach to ADHD care, benefiting both individuals and their broader communities.

9. COMMERCIALIZATION

6.1 Target audience and Marketspace

The proposed solution for early detection and effective treatment of ADHD using machine learning targets Sri Lankan parents and healthcare professionals who are looking for a reliable and efficient tool to identify ADHD in children aged between 6 to 12 years. The following are some of the industry-leading features provided through the proposed product:

1. Early detection and diagnosis of ADHD using advanced machine learning algorithms that analyze painting patterns in children.
2. Easy-to-use and user-friendly interfaces that can be easily adopted by parents and healthcare professionals.
3. Cost-effective solution that provides accurate and reliable results.
4. Real-time monitoring and progress tracking to ensure effective treatment plans.
5. Comprehensive data analysis and reporting features to help healthcare professionals make informed decisions.

The target market space for this product includes healthcare providers, hospitals, clinics, and parents of children aged between 6 to 12 years in Sri Lanka. By providing a reliable and efficient tool for early detection and effective treatment of ADHD, the proposed product can significantly improve the quality of life for children with ADHD and their families, while also reducing the overall burden on the healthcare system in Sri Lanka.

10. GANTT CHART

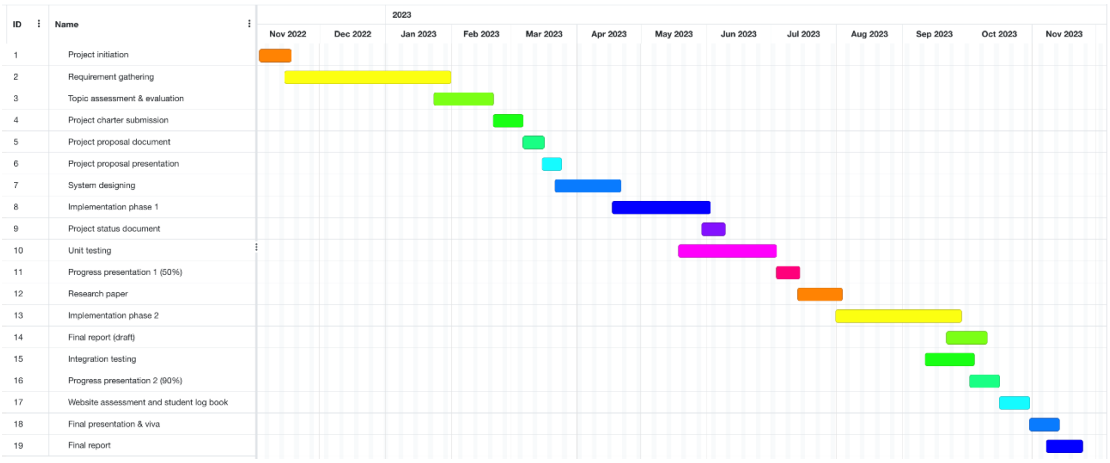

Figure 18 : Gantt chart

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12. APPENDICES

Plagiarism Report