Smart Educational Tool for Early Detection of Learning Disabilities in Primary School Students

Heshan W.A.S.
Department of information technology
Sri Lanka Institute of information technology
Malabe, Sri Lanka
it21183768@my.sliit.lk

Bandara N.G.S.S.M
Department of information technology
Sri Lanka Institute of information technology
Malabe, Sri Lanka
it21186424@my.sliit.lk

Gamlathge G.G.A.U.
Department of information technology
Sri Lanka Institute of information technology
Malabe, Sri Lanka
it21173868@my.sliit.lk

Jayathilaka P.A.D.S.L
Department of information technology
Sri Lanka Institute of information technology
Malabe, Sri Lanka
it21183454@my.sliit.lk

Wishalya Tissera
Department of Computer Science
Sri Lanka Institute of information technology
Malabe, Sri Lanka
wishalya.t@sliit.lk

Dharshana Kasthurirathna
Department of Software Engineering
Sri Lanka Institute of information technology
Malabe, Sri Lanka
dharshana.k@sliit.lk

***Abstract*-Learning disabilities such as dyslexia, dyscalculia, dysgraphia and ADHD have a major effect on students' education and development, traditional approaches to diagnosing these conditions are usually inadequate. This research suggests a mobile app that uses machine learning, deep learning, image processing and NLP to recognize these disabilities and provide appropriate support for students. It considers how well a person with dyslexia reads, the math errors in subjects with dyscalculia, handwriting in individuals with dysgraphia and the behavior of those with ADHD. Assisting with these tools, the app offers special lesson schedules and acts promptly when identifying students who may have learning disabilities. Because of its culturally sensitive and context-aware features, the system can be applied in numerous kinds of education systems. Moreover, educators and parents receive constant feedback from the app which helps them choose the most helpful ways to support the child's education. The purpose of the suggested solution is to be available to everyone, fit different situations and to be user-friendly, mainly working towards improving educational equity and access for all. Results so far suggest that the system helps determine if a student has learning disabilities and offers the best ways to assist them. It focuses on changing how learning disabilities are identified and managed, improving the outcomes of students with various learning needs well into the future.**

Keywords-Learning Disabilities, Dyslexia, Dyscalculia, Dysgraphia, ADHD, Machine Learning

I. INTRODUCTION

Learning disabilities such as dyslexia, dyscalculia, dysgraphia and ADHD are brain-related conditions that influence students' capabilities in school, learning processes and emotional well-being. It is thought that worldwide, between 5% and 15% of children attending school have a neurodevelopmental condition. Many situations involving mental health are not cared for correctly, mainly due to there being not enough accessible, scalable and culturally relevant ways to diagnose them. With fewer specialists and support, it can be much more challenging to detect and address issues as soon as they arise in schools. Consequently, diagnosing the issue takes time and educational assistance may be lacking, harming students' future academic achievements overall. Usually, professionals use standardized exams and special reviews to diagnose learning disabilities. Such techniques may accomplish certain things, though they are likely to take much time, cost a great deal and not always respond to the needs of various student populations. Because of this, many learners do not get the attention and support they should have at the right time. Therefore, this research has designed a mobile application integrated with the technologies of machine learning, deep learning, image processing and natural language processing to help in spotting and supporting learners with learning disabilities early. It is created to recognize dyslexia by studying reading and spelling, dyscalculia by examining math skills and dysgraphia by checking handwriting, among other things. Using these technologies, the application strives to supply helpful and accurate assessments, offering personalized interventions to better identify students' needs. The platform is easy to use for anyone, as it is both culture-inclusive and user-friendly.

Besides that, teachers and parents get practical advice and suggestions from the system to help their students with learning disabilities. This study aims to blend technology with approachable ways of teaching to shape the way we handle learning disabilities now, so that diverse learners can achieve better results in the long run..

II. LITERATURE REVIEW

Many studies have examined various resources to diagnose and sustain children with Dysgraphia. Though observations and filling out papers remain common, they tend to take a lot of time and may not pinpoint problems early on [1]. Systems for handwriting analysis are often attached to computers and miss a crucial element in practicing writing by hand. While the online screeners are basic, a reliable internet connection is necessary and there is hardly any interacting with their lessons [2]. Apps such as Write Well help you practice writing, but most of the interaction involves using a digital screen rather than writing by hand [3]. Thanks to recent studies in machine learning, especially CNNs, it is now possible to accurately recognize Dysgraphia through handwriting. Even so, these models are typically used in research settings and not applied in everyday practice. Handwriting by hand is still very important for academic improvement and merging it with technology-based coaching brings clear improvements in the way a person writes [4]. Most current tools provide delayed feedback, so this research developed an app to improve real-time support while practicing handwriting. It offers worksheets for writing that students can print, filling them in as normal. Afterward, users scan the works and put the scans online for evaluation by

CNN. The four levels of feedback are Very Poor (0–30), Intermediate Level(31–70) and Excellent(71–99). Writing activities provide instruction through Line Writing, Block Writing and giving feedback on letter shapes.

Research on dyslexia tends to use tools such as "The Hope," which assist in reading, writing and speaking; these tools, however, do not provide quick, adaptive guidance. Arunalu [6] provides more help in Sinhala reading but is limited to only reading features. Still, the model built by Divakar and Mookkaiah [7] for identifying dyslexia at an early stage doesn't include education-oriented features such as handwriting analysis and phoneme tracking. Most of these systems do not contain important features such as AI speech recognition, instant analysis of speech or the ability to judge handwriting. It deals with these issues by providing a platform with many useful features.

Usually, ADHD is found after watching clinical behavior and centering on self-report forms which delays the process. Now, we can use AI and ML to ensure answers are objective and can be applied on a large-scale [9]. It has been recently discovered that CNNs can determine if a child is focused by looking at their faces. Here, CNNs help analyze images of faces by identifying if they are in focus. Using eye tracking, experts can detect problems in concentration and CNN models can track how the person uses eye movement while videos are playing. CPRS [11] is a way to measure the probability of having ADHD in children. Neural CPRS uses algorithms to ensure the data is accurate. Focus Timer Task and Memory Match Game can help improve attention and memory skills for dyscalculia. The Dyscalculia Screener [12] online tool provides tests, but it cannot develop the required skills and features. Standardized test results were used with machine learning in the work by Giri et al. [13] for screening pupils, but their scheme did not have modules for training or tracking progress. Using ANN models, Ganitha Piyasa [14] saw improvements in evaluating how numbers are written but was not able to add screening features. Kalcal [15] helped students succeed in structured lessons and lift their test scores, but it did not target at-risk children. This research suggests a single app that can recognize when a child is likely to have dyscalculia using CNNs, as well as includes numerous activities and checking progress to help them improve in math.

III. METHODOLOGIES

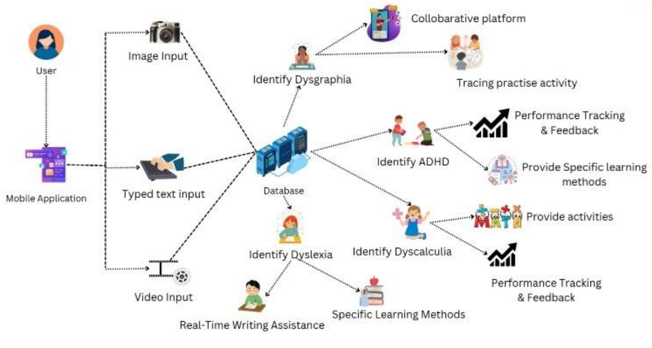

Fig 1. Overall System Diagram

An application that supports students with learning disabilities included dyslexia, dyscalculia, dysgraphia and ADHD has been developed and explored in this research. Step one is to collect data, move to designing the system, build the model and then test things out. In school settings, data about each child's reading, math, handwriting and behavior can help detect dyslexia, dyscalculia, dysgraphia and ADHD. Fig. 1 gives a summary of how all the steps in the system will be integrated for the four learning disabilities.

A Convolutional Neural Network (CNN) is used to analyze handwritten samples when detecting Spatial Dysgraphia. Learners share their work on the app and it reviews their spacing, positioning and letter size. There are three Conv2D layers, three MaxPooling2D layers, a Flatten layer and two Dense layers in the CNN architecture used for classification. Using TensorFlow and Computer Vision, the model accurately identified 96% of the data on its test set. With an API that uses Flask, the mobile app and the server can communicate in real time. Intervention activities were organized for students with Dysgraphia to work on their handwriting, sense of space and muscle coordination. In the Line Writing Activity, students are required to write sentences within two lines; the system counts the number of times writing goes outside the lines. The students in the Block Writing Activity are asked to keep their writing inside the blocks to improve their ability to write appropriately and neatly. Letter structures are checked in the Letter Shape Feedback Activity. The levels of feedback are named Very Poor (0–30), Intermediary Level (31–70) and Excellent Improvement (71–99), making recommendations in real time. This module is included in the mobile app and offers a friendly user interface to students, teachers and parents. Students' writing skills are given priority even with the use of AI in tests. The system provides regular performance reports and follows up on progress to ensure correct and continuous supervision.

For dyslexia support, samples of how dyslexic and non-dyslexic individuals write are collected. When Speech-to-Text (STT) is used, the system assesses how well and smoothly the reading is being done. These models pay attention to both the way letters are formed with a pen and the preceding pen strokes. CNN detects unusual writing habits using TensorFlow and algorithms that compare phonemes analyze speech problems related to reading. Because the system replies instantly, students' learning outcomes are better. App features interactive lessons that help students with dyslexia. Audio-visual tutorials are available which assist users in choosing particular objects and help them improve their knowledge of sounds and fast naming. Sound-to-letter relation tasks are used and these immediately feedback to help build phonological skills. On touch-screen tablets, students can practice writing letters and learn instantly if they are made correctly. Assessments for reading look for pauses, use of incorrect words and missed words. Furthermore, marker tracing allows people with double deficit dyslexia to better remember movements and learn better letter recognition.

ADHD detection is achieved by using facial emotion analysis, eye-tracking and a behavioral questionnaire. The facial emotion model uses CNN to analyze images caught by the camera in real-time and determine if a player is "focused" or "not focused." The model improves by being trained step by step for better classification. Students' eye movements are recorded every time they look at animated images and videos. I also used another CNN model to sort and classify the directional gaze snapshots. Training a model several times improves its dependability. The classifier takes text-based responses from the Conners' Parent Rating Scale (CPRS) and uses them in its analysis. An individual's risk band for ADHD is determined by their percentile score. The Flask API helps manage communication between the frontend and the predictive models. All of these approaches support a reliable system for detecting ADHD and providing prompt assistance to the affected students.

For dyscalculia, a questionnaire designed to cover basic mathematical concepts is used for the dyscalculia identification process, and the risk of having dyscalculia is predicted based on whether the answers given to those questions are correct, incorrect, or omitted. To train the model required to make this prediction, data was collected through a questionnaire given to more than 200 school students (aged 7-8). The same questionnaire used to collect the data is also used to predict dyscalculia risk through the mobile application. For this purpose, logistic regression, support vector machine (SVM), and random forest algorithms were tested, and the logistic regression algorithm that gave the highest accuracy was selected for this purpose. Students identified as being at high risk for dyscalculia are provided with skill enhancement activities to improve their mathematical abilities, where they are given the opportunity to identify the mathematical concepts in which they are most weak and have them do more mathematical activities related to them, thereby minimizing their weaknesses. The progress they make when repeating skill enhancement activities is also monitored, and that progress is also shown in a comparative manner.

IV. RESULTS AND DISCUSSION

A. *Dysgraphia*

The Convolutional Neural Network (CNN) model was created using a dataset with more than 400 handwritten samples. The quality of the data was improved with steps such as binarization and skew correction. The model was accurate 96% of the time on the test data, suggesting it can identify Dysgraphia by noticing unevenly spaced letters, poor way lines are drawn and irregular character body. After 10 epochs, the results showed the model became more accurate and improved, with little chance of overfitting. These three activities in the application allow handwriting exercises with instant AI feedback. While practicing in the Line Writing Activity, students got their writing better aligned between the lines which improved by 30% in only two weeks. When doing the Block Writing Activity, students were asked to fit their responses in boxes and this led to writing with 35% smaller letters and a 25% better spacing standard. In this Letter Shape Feedback Activity, students' skills at making letters were assessed, with the results falling into Very Poor (0–30), Intermediary (30–70) and Excellent Improvement (71–99). People who were given the designation "Very Poor" saw their scores go up by an average of 20 points within three weeks of practice. Unlike typical ways of diagnosing and treating, this application is unique because it focuses on handwriting and offers immediate feedback to each individual. Even though it works well, the current approach relies heavily on the quality of the sample, is limited by little data and looks only at Dysgraphia in space. In the future, the goal is to broaden the range of case studies, include game aspects and detect forms of Dysgraphia other than the first sign, bringing early intervention tools within reach of more people.

B. *Dyslexia*

A Convolutional Neural Network (CNN) was used to develop a system that can detect dyslexia-related patterns in people's writing. To create the model, data from 10,000 handwritten letters was used. The API was built with Flask so that users could interact with the handwriting program in real time by uploading images through the app. When the patient's picture is sent for analysis, the system reviews it and makes a prediction about dyslexia. Among other things, the system helped detect letter and word reversals in the writing sample, whether the image was of just one letter or of several lines. A STT tool was introduced in addition to handwriting analysis to discover phonological signs of dyslexia. It noticeably pointed out the problems people face in reading, particularly if they regularly take breaks or put in the wrong words. After every session, users received feedback which kept them on track with their reading and writing skills. Four intervention activities were put in place to evaluate the effectiveness of the system. Following the guidance from the Letter Formation Activity led users to trace letters with a better and more even stroke after a few weeks. In the Reading Difficulties Recognition Task, participants had to link the spoken sounds to the words which improved how well they pronounced and helped find situations where they skipped or pronounced a word incorrectly. Two more games were introduced to improve phonological awareness. During this activity, users were shown images and the system read out a word for them to choose the proper image. Doing this task made it easier for the students to notice and recognize different sounds. In this activity, the users heard the sound and chose the associated letter or syllable. Giving quick feedback improved the student's ability to connect phonemes with letters. It was found that the suggested system is more effective and structured, using real-time feedback along with exercises that use writing and speech. However, researchers pointed out flaws, including variations in handwriting styles, different qualities of datasets and the difficulty in recognizing speech from people with special accents. Online speech recognition development will involve broadening the database, enhancing sound matching methods and adding playful learning elements to engage and improve users' learning results.

C. *ADHD*

In this research, an approach combining computers and tests aimed at measuring cognitive functions was used to support children living with ADHD. CNNs were used to develop a model that detected whether an individual was focused or not. Through training and enhancing its ability, the model ended up being right 88% of the time. This means that data on facial emotions can be used as a reliable and objective sign of how attentive and engaged a child is. Study of eye movements added to the process and allowed the team to find where participants looked closely and for how long, with an 85% accurate average in these categories. Using CNN to analyze visual tracking revealed that attention can be measured with a new technique that is not intrusive and still very reliable. Data about children's behavior from the CPRS was analyzed using a classifier that uses information from percentiles as guidelines. As a result, the method could determine ADHD with 90% accuracy by analyzing parents' reports of their children's behaviors. The combination of these detection models with mini-games for the mind produced results that were clear to measure. My working memory and concentration improved after using the Focus Timer Task for several sessions. It was clear from the Memory Match Game that recalling information was made easier and mental processing sped up, as there were no delay times and results were more accurate. Overall, it is clear that using machine learning along with specific brain exercises works well. Through this extensive system for ADHD, it is easier to identify and manage the disorder in various settings.

D. Dyscalculia

According to Figure 2, the logistic regression, random forest and support vector machine (SVM) models recorded accuracies of 93.75%, 91.67% and 93.75%, respectively.

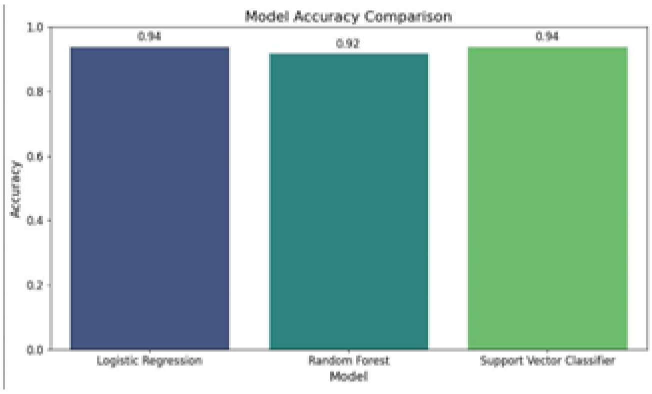

Fig 2. Models Accuracy Comparison

It was decided that logistic regression would be the most suitable model since it works accurately, is straight forward and can be understood quickly. Rather than producing challenging results, logistic regression lets educators and parents know the likelihood that a student will succeed, which makes it a better choice for practice. It is clear from the results that using data from children's interactions such as task scores and behavioral aspects was highly effective in predicting dyscalculia. Therefore, machine learning can be useful for identifying who is struggling in education, so support can be provided quickly. The system included activities designed to help individuals strengthen their areas of weakness. The activities helped students strengthen number sense, recognizing patterns, basic math skills and spatial ability which are often weak in children with dyscalculia. Users had different learning experiences and got instant tips, leading them to take part in the learning process. Exercises were given to children at risk based on the model and their development was continually tracked. Users' progress over time indicated that the method used for identification and application of intervention was successful. Having two main features, the system proves very useful in schools for diagnosing difficulties and providing support to students. Even so, problems still exist. Problems such as changing interactions by users, noisy surroundings or confusion over the device functions can affect the outcome. In addition, conducting experiments with data from more age groups is needed to know how the model performs for children of different ages. It is proven that with this application, technology can help find students at risk of dyscalculia as well as give them assistance to improve their understanding of basic math.

CONCLUTION

The purpose of this research is to introduce an advanced mobile app that helps in identifying and supporting students who have learning disabilities such as dyslexia, dyscalculia, dysgraphia and ADHD. Because of machine learning, deep learning, natural language processing and computer vision, the system can identify problems early and implement personalized strategies for each person. The app supplies instructors and parents with instant results, individual lesson plans and helpful information for supporting every student's learning.

Since the solution is flexible, user-friendly and can grow with your needs, it can be used in different school settings. The reason it is valuable in these areas is that it is available to all and it helps learners without costing too much. Using data from behavior and academics, the system ensures that interventions are adaptable and always appropriately tailored to every pupil. By using this approach, students gain equal opportunities and people involved have accurate ideas to support their growth. In general, this study opens up new ways to manage learning disabilities. By applying intelligent technologies and putting the user first, the system might help students with various educational challenges achieve better educational achievements over time.

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