**ARUNALU: LEARNING ECOSYSTEM TO OVERCOME SINHALA READING WEAKNESS DUE TO DYSLEXIA**

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**ARUNALU: DETECTING AND PROVIDING SOLUTION FOR READING DISABILTY DUE TO DYSLEXIA IN SINHALA USING VOCAL PATTERN ANALYSIS THROUGH LETTERS AND WORDS**

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Dissertation submitted in partial fulfillment of the requirements for the Degree Bachelor of Science Special (Honors) Degree in Information Technology

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**DECLARATION**

We declare that this is our own work and this dissertation 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 my 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.

…………………………… ……………………...

Signature of the Supervisor Date

Prof. Samantha Thelijjagoda

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**ABSTRACT**

Dyslexia is a major barrier to success in education and later the job as reading skills are fundamental for personal competence development. Children with dyslexia have special learning needs (e.g., more teacher support), which currently only specialized institutions can provide. Comprehension of text and spelling are also affected. The diagnosis of dyslexia involves the use of reading tests, but the continuum of reading performance means that any cut off point is arbitrary. The IQ score does not play a role in the diagnosis of dyslexia. The cognitive difficulties of dyslexics include problems with speech perception, recognizing and manipulating the basic sounds in a language, language memory, and learning the sounds of letters. Dyslexia is a neurological condition with a genetic basis. There are abnormalities in the brains of dyslexic individuals. There are also differences in the electrophysiological and structural characteristics of the brains of dyslexics. Physicians play a particularly important role in recognizing children who are at risk for dyslexia and helping their parents obtain the proper assessment . However, this takes children out of their earl group and causes social problems . A significant problem faced by dyslexic children is a lack of learning technologies designed to help children learn in settings when there is no personal teaching support. Arunalu presents Learning Ecosystem to Overcome Sinhala Reading Weakness Due to Dyslexia, and interactive gaming techniques to provide dyslexic children with an engaging learning environment within which to identify where their faults in reading.

Whoever suffers from Dyslexia or anyone who is willing to improve their writing, reading and speaking skills can use “Arunalu” with a parent or a guardian and can get a clear improvement by following the therapies that the application provides daily. Application will provide an appreciation and a reward system to motivate and encourage the user to use the application daily. Following the therapies daily will improve the user skills. This tool lets users easily recognize their reading weaknesses and will help to overcome them in a creative and accurate way.

**Keywords:**Dyslexia, learning disabilities, Reading disability.

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# **INTRODUCTION**

## **1.1. Background**

The formal definition of dyslexia by the International Dyslexia Association is: “Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge.” [4].

Dyslexia is believed to be caused by both genetic and environmental factors. Some cases run in families. The fundamental mechanisms of dyslexia are problems within the brain's language processing Dyslexia is diagnosed through a series of tests of memory, spelling, vision, and reading skills. Dyslexia is separate from reading difficulties caused by hearing or vision problems or by insufficient teaching [15]. Treatment involves adjusting teaching methods to meet the person's needs. While not curing the underlying problem, it may decrease the degree of symptoms. Treatments targeting vision are not effective. Dyslexia is the most common learning disability and occurs in all areas of the world. It affects 3–7% of the population; however, up to 20% may have some degree of symptoms [18]. While dyslexia is more often diagnosed in men, it has been suggested that it affects men and women equally. Some believe that dyslexia should be best considered as a different way of learning, with both benefits and downsides [16]. By focusing on maintenance of engagement, we hope to improve learning outcomes and motivate students to also play the game outside of school [17]. People with developmental dyslexia show different levels of difficulties in psychoacoustic and psycholinguistic processing.

Symptoms & Causes:

Dyslexia is a learning disorder that involves difficulty reading due to problems identifying speech sounds and learning how they relate to letters and words (decoding). Also called reading disability, dyslexia affect areas of the brain that process language.

Signs of dyslexia can be difficult to recognize before your child enters school, but some early clues may indicate a problem. Once your child reaches school age, your child's teacher may be the first to notice a problem. Severity varies, but the condition often becomes apparent as a child starts learning to read.

Identification of dyslexia clinical symptoms areLate talking, learning new words slowly, Difficulties forming words correctly, such as reversing sounds in words or confusing words that sound alike, Difficulties remembering or naming letters, numbers and colors, Difficulty learning nursery rhymes or playing rhyming games before school and also school age Reading well below the expected level for age, Problems processing and understanding what he or she hears, Difficulty finding the right word or forming answers to questions, Problems remembering the sequence of things, Difficulty seeing (and occasionally hearing) similarities and differences in letters and words, Inability to sound out the pronunciation of an unfamiliar word, Difficulty spelling, Spending an unusually long time completing tasks that involve reading or writing, Avoiding activities that involve reading [6].

## **1.2. Literature Survey**

**‘Dyslexia Baca’ Mobile App - the learning ecosystem for Dyslexic Children [7]**

According to their research main objectives of inventing ‘Dyslexia Baca’ are;

* Support children in recognizing the alphabet
* To motivate dyslexic children to read and learn

Patients are motivated to learn and recall alphabet using multisensory environment. From the studies they have found that visual, auditory and kinaesthetic is very helpful in teaching the learning-disabled learners.

A picture containing clipart

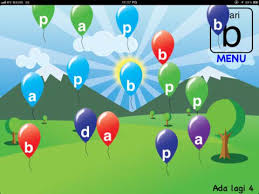
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Figure 1.1: Conceptual model of Dyslexia Baca

Source: ‘Dyslexia Baca’ Mobile App -The Learning Ecosystem for Dyslexic Children’.

Online dyslexia screening test for Malaysian young adults in Bahasa Melayu [8]

Their main intent is to propose a dyslexia screening test for young adults in rural areas of Malaysia who lack proficiency in English. It targeted for people around 16–25 years. MaDIST website is a flexible website which users can customize font colors and background colors. They hope it will lead to improve readiness of dyslexic people.

In more detail, it consists of two main parts namely questionnaire and reading assessment test. Questionnaire contain questions about disease history. After completing questionnaire, they must complete reading assessment test. Timer is recorded for this activity. Data from those activities are analyzed to check whether user is potential suffered from dyslexia. Conclusion that they have predicted is that dyslexia cannot be cured but there are intervention programs that make them aware and live healthier. From there research they have highlighted that users who recognized as dyslexic are subjected to immediate treatments.

**Mobile Application to Support Dyslexia Diagnostic and Reading Practice [9]**

Main objective of this mobile app is to diagnose and improve reading practice of dyslexic people. This mobile app was built with Brazilian language and this app was tested using some students of a private school in the city of São Paulo (Brazil).

Set of predefined Brazilian words are trained into the system which Brazilian people find hard to spell. This app will have matched the input user’s voice with existing predefined datasets in databases. If something goes wrong with that pronunciation, similar kind of words are suggested to patients. But this model hasn’t used any machine learning algorithms, so accuracy is very low. Another main drawback of their system is they match user’s input voice with existing data in database it is more error prone because noise can add to speech as well as pronunciation will be differed according to accent. Even though correct word is spelt out it will be identifying it as wrong due to accent.

**Diagnosis of Dyslexia using Computation Analysis [10]**

In this paper they have focus on diagnosing Dyslexia using computing system, considering the difficulties that people face while reading and spelling. Three computational classifiers were used. They are K-means, ANN, and Fuzzy. Based on the above classifier's analysis of the data items of the proposed dataset, the elements that have high impacts are Word attack and reading strategy, Auditory processing and Visual processing

**Meister Cody, learning game for children struggling in math and reading [11]**

A scientific study by the University of Münster showed CODY training showed significant learning outcomes in children with dyscalculia. One group of children participating in CODY training for six weeks was compared to two other groups of children. One received no training, the other completed a six-week training session. In order to determine the learning increase, all children processed a calculation test with addition and subtraction tasks before and after the training. The learning increase corresponded to the difference between the two tests. The CODY group was the only one to achieve meaningful learning growth. In the other two groups, the test results before training did not differ from those after training. In these groups, the learning growth was not different from zero.

**The Hope: An Interactive Mobile Solution to Overcome the Writing, Reading and Speaking Weaknesses of Dyslexia [12]**

The Hope application provides a tool for students to work on their literacy skills following a personalized teaching program. The design of the game and adaptation mechanisms integrated with it is aimed at maintaining student engagement for the duration of an open-ended number of playing sessions, while using a limited quantity of assets and literacy content. By focusing on maintenance of engagement, improve learning outcomes and motivate students to also play the game outside of school.

## **1.3. Research Gap**

Although analyzing past researches relating to learning disabilities dyslexia, we found that there are fewer apps supporting these disabilities but none of them are accurate and none of them are supporting Sinhala language. All most all existing apps support English language & other languages. The existing apps have focused mainly on broader field of learning disabilities. Arunalu will separately identify whether child has dyslexia. According to type of disability & propose a solution. Another key thing that lacks in most apps is that they do not track level of that disability but have common treatments.

So, Arunalu giving treatments based on disability level detected at beginning and maintain a profile for each user to control whether the child has progressed with treatments or not. It will be more beneficial for parents and medical specialists to track the child.

### **1.3.1. Research gap in Voice Recognition**

There has been a significant amount of research done in voice recognition where a system can be trained to recognize a variety of accents based on various voice models which are trained to recognize voice. But a perfect software solution has not been invented yet. Another problem unique to Sri Lankan users is because Sri Lankans have a unique accent. Voice recognition systems fail to detect some words pronounced by Sri Lankans. Along with that there is a need to address this problem with our research. Voice recognition systems also take high processing power and the motive to reduce processing power is another area of concern.

When going through the existing applications for dyslexia, none of them are supporting an automated screening and intervention apparatus for dyslexia. In existing applications, there are many boundaries in technologies, age gap and user-friendliness.

Table 1.1: Comparison with Available system

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Features | **EasyLexia** | **Dyslexia Baca** | **YALU** | **The Hope** | **ALEXZA** | **ARUNALU** |
| Dyslexia Screening | 🗶 | 🗶 |  |  | 🗶 |  |
| Machine Learning | 🗶 | 🗶 | 🗶 |  |  |  |
| Gaming Environment | 🗶 |  |  |  | 🗶 |  |
| Dyslexia Intervention |  |  | 🗶 |  |  |  |
| Support Sinhala Language | 🗶 | 🗶 |  | 🗶 | 🗶 |  |
| Letters and word recognition |  |  |  |  |  |  |
| Voice recognition |  |  |  |  |  |  |
| Progress analysis through statistics | 🗶 | 🗶 |  |  |  |  |
| Mobile solution |  |  | 🗶 |  |  |  |
| Focused on specially reading ability enhancement | 🗶 |  | 🗶 | 🗶 | 🗶 |  |
| Monitoring by multiple users | 🗶 | 🗶 | 🗶 |  | 🗶 |  |

## **1.4. Research Problem**

Dyslexia is the most common disorder in the world that have weaknesses in writing, reading and speaking. As a well spread disorder there are several stages of Dyslexia that must recognize before giving the treatments. The current treatment is known as “Speech Therapy” which is given by a doctor or a therapist in a hospital or in a special education unit [12]. A lot of researches have been done to treat several diseases and disorders but still there are some disorders which are left unnoticed.

Particularly when it comes to evolving countries like Sri Lanka most of the people are unaware of these disabilities. But unfortunately, some students are categorized as weak students by teachers or parents due to these disabilities. So, the purpose of our research is to classify these students and help them to overcome with these learning disabilities and guide them. So, Arunalu up with an idea to develop a mobile solution to help these children [14]. “Arunalu” is an android based mobile solution which will be co-operative for children who are suffering reading disabilities. The application will have user-friendly interfaces which will help children to recognize letters. The activities given for children will be in Sinhala language. Also, these interfaces will be designed more nicely so that the children will select to use this application.[19]

* Traditional diagnosis methods are not reliable

Presently, in Sri Lanka, there are no automated screening and intervention tools for dyslexia. Pediatricians diagnose differently abled children through DSM criteria, a paper-based mechanism which is very time consuming [16].

* Not supporting local language

None of the local applications are supporting both screening and intervention of dyslexia in the Sinhala language. Though there are some supportive international applications for screening of dyslexia in the English language, in Sri Lanka children must emphasize on Sinhala language rather than other languages, as in early stages of childhood children are most familiar with the Sinhala language.

* Minimal accessibility

A major limitation of existing applications is that they are designed with complex UI which makes children tedious. But in Arunalu application a multisensory gaming environment is provided which makes children very enthusiastic to cooperate with the application.

* High medical discussion fees

Currently most parents with differently able children are unable to afford consultation fees of health professionals as they must visit them regularly for therapies although there is no suggested treatment to make them free from disabilities. But in Arunalu application children can practice pronunciation exercises daily from home without consulting health professionals regularly.

* Without children from educational opportunities

Normally schoolteachers are unable to identify differently abled children as there are no any exact screening mechanisms currently operating in Sri Lanka. These dyslexic children will be labeled as weak students in classrooms which will cause them to be eventually excluded from educational opportunities. Inappropriately, they will not be able to identify hidden disabilities in them. Arunalu proposed application is intended to identify the hidden disabilities in children and to give a supportive hand for them without excluding differently abled children from educational opportunities.

## **1.5. Objectives**

### **1.5.1. Main Objectives**

Dyslexia is a disorder, characterized by trouble with reading despite normal intelligence. Different people are affected to varying degrees. Problems may include difficulties in spelling words, reading quickly, writing words, "sounding out" words in the head, pronouncing words when reading aloud and understanding what one reads[12]; support them to overcome these difficulties in a more user-friendly environment providing easy, time saving and all in one solution which needs a lesser amount of guidance through a mobile solution.

### **1.5.1. Specific Objectives**

### 1.5.1.1 Method and Solution for Dyslexia

Dyslexia can be explained as a neurological learning disability which causes difficulties in reading, word decoding, comprehension, short-term memory, writing, spelling, and speaking [13]. The final goal is to diagnose whether people are dyslexic or not and aid carry out their day to day events efficiently and easily.

* Dyslexia Detection

Through a series of reading tests (corresponding letters, words are displayed in mobile screen), the system will detect if the user is artificial Dyslexia by considering facts like incorrect word count, correct word count and time. Pronunciation tests are divided in to three phases namely First Step (Letters), Second Step (Two Letter Words) and Third Step (Three Letter Words).

* Dyslexia remedy

First, user enter to the system then select the remedy (First Method, Second Method etc.) and then user can start the remedy. After that Start first step in remedy display letter next two letter words & next three letter words. When there are two letters if the first letter is pronouncing correctly only it highlights and move to the next letter and after pronouncing hold word correctly the user can see a GIF related to the word. After that word recognition & comparison and system will get voice input and identifying the stage through NLP. Finally compare with predefined data then system will provide progress chart.

* Method and Solution for Dyslexia in Sinhala

Currently there are many English apps & other foreign language apps that support Dyslexia but among our countries they continue unfocused. This will produce better answers for those.

## **1.6. Research Questions**

* What are the features that dyslexic child expects from a mobile application?
* What are the languages that used for the input voice?
* How to deliver the GIF message to the child?
* What are the technologies worked out?

# **RESEARCH METHODOLOGY**

Method and Solution for Dyslexia remain series of pronunciation tests. Firstly, define two categories namely First Step and Second Step . Then for corresponding categories specific predefined words are well-defined.

For example:

First Step: ම, ල

Second Step: තාත්තා , අයියා.

system will keep track of words that user finds difficult to read, then those words are suggested to user to read at next level. Through Natural Language Processing, Arunalu is going to achieve this specific target.

The project has a very significant research areas like, Natural Language Processing (NLP), Voice Detection, Machine learning, Artificial Intelligence, Graphic Interchange Format (GIF) and Mobile platform development. Machine Learning and GIF important for the identification of individual words. Research conducted further study on above mentioned research areas then the information can be used to achieve the objectives [20].

## **2.1. System Overview**

Considering the outcome of the literature review, it is imaginable to decide the most appropriate tools, technologies and software solutions for the implementation phase. In some cases of design conclusions, study more than one possible technology and take performance and dependencies into negotiation.

Since the app was proposed to support children with disabilities, the team met with medical and educational professionals to gather related information. After gathering all the information, the team was divided into four main components to develop the solution in order to fulfill the requirements of the system.

Thereafter, for the screening and providing intervention for dyslexia vocal pattern analysis through letters and words the ER diagram, use case diagrams, use case scenarios and user interfaces were drawn up for the development process[19].

A close up of a clock

Description automatically generated

Figure 1.2 Detecting and providing solution for reading disability due to Dyslexia in Sinhala using vocal pattern analysis through letters and words

### **2.1.1. Dyslexia Screening**

In dyslexia screening, a series of pronunciation tests were carried out to differentiate dyslexic and non-dyslexic children. As the first step, a single Sinhala letter was displayed as shown in Fig. 3.d. In screening process, total number of correctly pronounced letters/words, total number of incorrectly pronounced letters/words, total number of attempts and total time taken to complete task were taken as inputs to the model. Since audio clips were gathered in their natural environment, preprocessing was done in order to remove noise. Noise removal process was carried out using python algorithm considering FFT and thresholding. Frequencies outside human vocal frequencies (80Hz -4000Hz) were identified by voice activity detection and were eliminated as noise [21]. MFCC technique was used to concisely describe the overall shape of the spectral envelope by eliminating unwanted features. At present MFCC, features are commonly being used in automatic speech and speaker recognition systems [22].



1. Dyslexia main menu

A close up of text on a white background

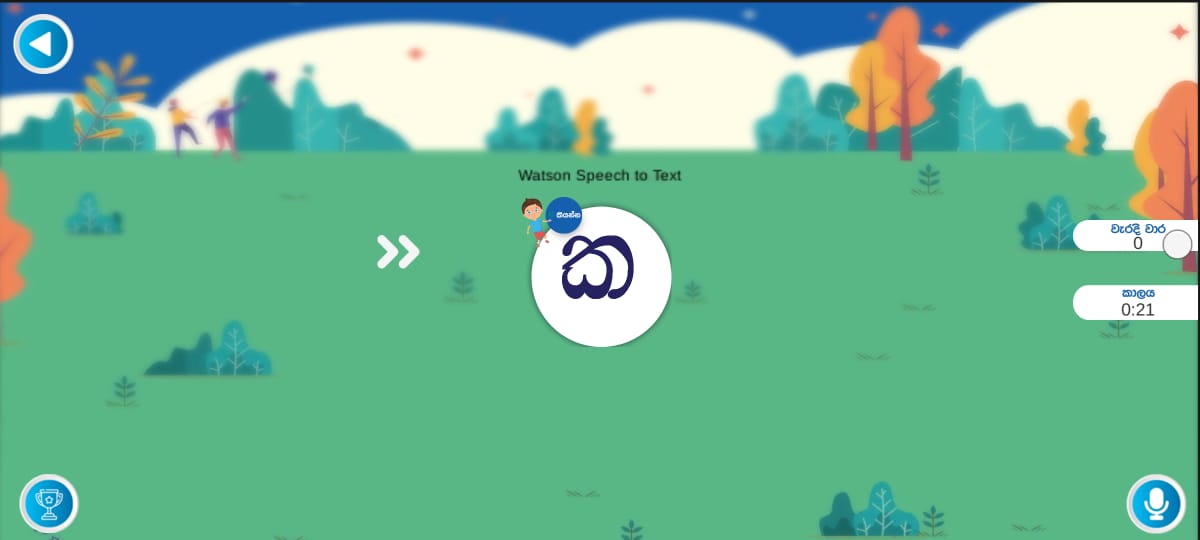
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(b) Dyslexia letter screening

A close up of text on a white background

Description automatically generated

(c)Dyslexia letter screening



(d)Dyslexia letter screening

First, user enter to the system then select the remedy (First Method, Second Method etc.) and then user can start the remedy. After that Start first step in remedy display letter. When there are five letters if the first letter is pronouncing correctly only it highlights and move to the next letter and after pronouncing letter correctly the user can see a pop-up message if it’s correct or not.

![A screenshot of a cell phone

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4SmQRXhpZgAATU0AKgAAAAgABgALAAIAAAAmAAAIYgESAAMAAAABAAEAAAExAAIAAAAmAAAIiAEyAAIAAAAUAAAIrodpAAQAAAABAAAIwuocAAcAAAgMAAAAVgAAEUYc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFdpbmRvd3MgUGhvdG8gRWRpdG9yIDEwLjAuMTAwMTEuMTYzODQAV2luZG93cyBQaG90byBFZGl0b3IgMTAuMC4xMDAxMS4xNjM4NAAyMDIwOjA5OjE0IDE1OjExOjAxAAAGkAMAAgAAABQAABEckAQAAgAAABQAABEwkpEAAgAAAAMyOQAAkpIAAgAAAAMyOQAAoAEAAwAAAAEAAQAA6hwABwAACAwAAAkQAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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(e)popup in screening test

Figure 2.1: Dyslexia screening interfaces

**Dyslexia system diagram**

A screenshot of a cell phone

Description automatically generated

Figure 2.2 Dyslexia system diagram

### **2.1.2. Dyslexia Intervention**

In dyslexia intervention, a series of pronunciation tests were carried out to differentiate dyslexic and non-dyslexic children. As the first step, a single Sinhala letter was displayed as shown in Fig. 3.b and gradually the difficulty level was increased up to words as shown in Fig. 3.c. In intervention process, total number of correctly pronounced letters/words, total number of incorrectly pronounced letters/words, total number of attempts and total time taken to complete task were taken as inputs to the model.

If the child is predicted to be dyslexic a set of intervention procedures were proposed. Results were fed back into the model for higher accuracy. In dyslexia intervention, children were given a training based on recalling words through GIFs as shown in Fig. 4.b and Fig. 4.c. First, user enter to the system then select the remedy (First Method, Second Method etc.) and then user can start the remedy. After that Start first step in remedy display letter next three letter words. When there are three letters if the first letter is pronouncing correctly only it move to the next letter and after pronouncing hold word correctly the user can see a GIF related to the word.



(a) Dyslexia intervention menu

A close up of text on a white background

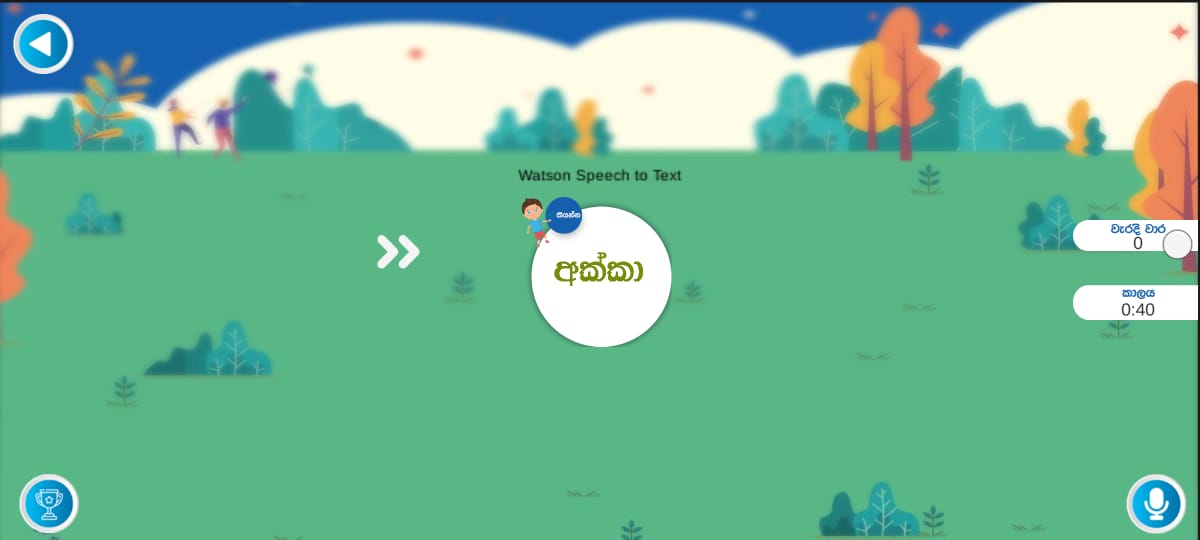
Description automatically generated

(b) Dyslexia intervention-easy

A picture containing text

Description automatically generated

(c) Dyslexia intervention-hard



(d) Dyslexia intervention-hard

**Dyslexia screening result interface**

A close up of a logo

Description automatically generated

(e) Dyslexia report screen

Figure 2.3: Dyslexia intervention interfaces

Figure 2.2: Dyslexia intervention interfaces

## **2.2. Resources Needed**

### **2.2.1. Software Boundaries**

* Android Studio

Application should be compatible with android devices. Android Studio is the fundamental tool used for developing the application. Since it is the official development IDE for Android development. Android Studio is mainly used for Java language to development of sound recognition part.



* IBM Watson

A dermatology app called schema allows doctors to input patient data and, using natural-language processing (NLP), helps identify potential symptoms and treatments.

* SQLite Database

A picture containing computer, computer

Description automatically generated

* Photoshop CC

A close up of a sign

Description automatically generated

* Adobe Illustrator

A close up of a sign

Description automatically generated

* Rest API

A RESTful API is an application program interface (API) that uses HTTP requests to GET, PUT, POST and DELETE data. The API spells out the proper way for a developer to write a program requesting services from an operating system or other application.

* MS Office Package (2016)

Microsoft Office 2016 is a suite of productivity applications that includes Microsoft Word, Microsoft Excel, Microsoft PowerPoint and Microsoft Outlook. Users can also share documents quickly and easily using the "Share" button in the Ribbon in Word, Excel and PowerPoint.

### **2.2.2. Hardware Boundaries**

Hardware requirements will need to run the developed application without having any problem. For the designing, implementation and testing purposes we have identified few hardware requirements. Suchlike,

* Mobile phones – Android
* Microphone

A good quality microphone is needed to record user input and feed into the application. A higher quality microphone will result in more accuracy.

### **2.2.3. Communication Boundaries**

* 4G - 3G connection of the mobile phone will be used for data transmission between the mobile app and the web server.
* Wi-Fi - If the mobile data is not available, user can connect to an available Wi-Fi router to get the internet connection in order to use the application. And this will also be used for data transmission between the mobile app and the web server.

## **2.4. Time Frame**

Table 2.1: Gantt chart

A picture containing screenshot

Description automatically generated

## **2.5. Commercialization aspects of the product**

Sri Lanka’s latest Population Census of 2012 indicates that around 2% of children between the ages 5-14 have some form of disability, of which around only three-fourths attend school, compared to the near-universal enrolment of other children. In addition, this share falls considerably with age; as shown in Figure 10, the share of total disabled students engaged in educational activities ranges from a high of 80% among 5-9-year-olds who attend primary school. Figure 9 indicates that the collegiate level is also marked by a skewed composition in enrolments by type of disability, compared to a more balanced distribution at the primary and secondary levels.[13].

From statistics throughout the world, it has been estimated that around 10% of people are dyslexic [1]. Initial target users will be basically dyslexic children in Sri Lanka and next will be foreign children. As most parents and teachers in Sri Lanka are unaware of dyslexia, they will label these children as weak students in class. Currently, we are planning to conduct awareness programs in schools in collaboration with Col.Prasana director *of* SERRICand with guidance of Dr.Kamalani Wanigasinghe. We are maintaining a cost-effective plan on customer point of view regarding the purchase of our application. We have focused in designing of our application to purchase on component wise based on the disability.

### **2.5.1. Business Pitch**

**Cost Structure**

Table 2.2: Cost structure of ARUNALU

|  |  |
| --- | --- |
| **Component** | **Amount (LKR)** |
| **Direct Cost**   * Stationary and Binding * Printing * Other | 3000.00 |
| 2000.00 |
| 3000.00 |
| Total | 8000.00 |
| **Indirect Cost**   * Hosting (Entire solution) * Wi-Fi and electricity | 8000.00 |
| 7000.00 |
| Total | 15000.00 |

This solution is mainly categorized as a charitable natured product. Therefore revenue flows are limited.

Expected revenue streams are,

1. Government funds via special projects
2. Endorse through health care exhibitions and offering trials

* Charge for elementary application – free
* Charge for advance features – Rs.2 per download

1. Downloads from local and foreign context after launching in App store ( Entire solution)

Table 2.3: Packages provided by ARUNALU for customers

|  |  |  |
| --- | --- | --- |
| Package | Local context(LKR) | Foreign context(LKR) |
| Monthly | 500 | 1000 |
| Annual | 5000 | 10000 |

Apply the revenue for better improvement of the solution is proposed. For better maintenance and better promotion need to be done reach to a prominent client base. Following (Table 3) illustrates, how the revenue will be applied for maintaining the quality and marketing cost.

Table 2.4: Fixed cost and variable cost of ARUNALU

|  |  |
| --- | --- |
| **Component** | **Amount (LKR)** |
| **Fixed Cost**   * Servers | 6000.00 |
| Total | 6000.00 |
| **Variable Cost**   * Social media promotion |  |
| 5000.00 |
| Total | 11000.00 |

How do we earn revenue

* Government funds via special projects.
* Invest through Independent Software Vendors (ISV) in Private Organizations & Government Taring Centers.
* “Senehasa Education Resource Research & Information Centre” will be the most prominent client for the product, ARUNALU.

Launch a product with following features,

* Generate a GIF under successful voice pattern matching
* Phonological training through Interactive game
* Phonological training through success voice pattern matching
* Phonological training through story reciting
* Digital Marketing
* Facebook

A picture containing drawing

Description automatically generated

* Twitter

A close up of a logo

Description automatically generated

* Linked In

A close up of a sign

Description automatically generated

* Forming partnerships with companies like Microsoft



* Through advertisements
* Google AdSense

Google AdSense is an advertising placement service by Google. The program is designed for website publishers who want to display targeted text, video or image advertisements on website pages and earn money when site visitors view or click the ads.

## **2.6. Testing & Implementation**

Mobile application testing is both a critical and a complex component of mobile application development. It is crucial to have a clearly defined and well-developed mobile testing strategy and framework. The main components of a mobile application testing strategy include usability, performance, security and functional and nonfunctional testing across multiple platforms, devices and browsers.

A complete mobile testing strategy must also account for testing across differing network connection speeds and geographical locations, as well as address the use of Wi-Fi, 3G or 4G connections. Testing must confront such issues as screen resolution and brightness, CPU, memory and OS optimization. The mobile testing strategy must be geared to the architecture of the applications under test whether they are Web, mobile Web, native applications or hybrids. Finally, an organization must consider the test approach, primarily the use of emulators versus actual devices, or even real user monitoring.

**Test Scenarios for Child Profile function**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Scenario ID** | View Child - 1 | **Test Case ID** | **View Child – 1A** |
| **Testcase Description** | View Child – positive | **Test Priority** | **High** |
| **Pre-requisite** | Should be a valid User | **Post-requisite** | **NA** |

**Test Execution Steps:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Step number** | **Action** | **Inputs** | **Expected result** | **Actual result** | **Test results** |
| **1** | **Click the My profile interface** | **-** | **Click the my profile interface** | My profile page is appeared | Pass |
| **2** | **Click the view children button** | **-** | **Child profile is appeared** | **Child profile is appeared** | **Pass** |
| **3** | **User can see child profile** | **-** | **Name : Anne**  **Age : 06**  **Gender: F**  **Progress Chart** | **Name : Anne**  **Age : 06**  **Gender: F**  **Progress Chart** | **Pass** |

**Test Scenarios for Dyslexia screening function**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Scenario ID** | Dyslexia Sceening-1 | **Test Case ID** | Letters, Words pronunciation test-1A |
| **Testcase Description** | Successful screening Letters, Words pronunciation test | **Test Priority** | High |
| **Pre-requisite** | User should have access to the component | **Post-requisite** | **NA** |

**Test Execution Steps:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Step number** | **Action** | **Inputs** | **Expected result** | **Actual result** | **Test results** |
| 1 | Directs to the homepage of Dyslexia screening Letters, Words pronunciation test | **-** | Home page of Dyslexia screening and intervention | Home page of Dyslexia screening and intervention | **Pass** |
| **2** | Select “Dyslexia හදුනාගැනීම​” Button | **-** | Redirects to the dyslexia pronunciation test environment provided for dyslexia screening | Redirects to the dyslexia pronunciation test environment provided for dyslexia screening | **Pass** |
| **3** | After pronouncing the letter click next button | Speech input of the user | Success popup message box seems. Success popup contains the time duration spent, and the success rate | Success popup message box seems. Success popup contains the time duration spent, and the success rate | **Pass** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Scenario ID** | Dyslexia Sceening-2 | **Test Case ID** | Letters, Words pronunciation test-2B |
| **Testcase Description** | Unsuccessful screening Letters, Words pronunciation test | **Test Priority** | High |
| **Pre-requisite** | User should have access to the component | **Post-requisite** | **NA** |

**Test Execution Steps:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Step number** | **Action** | **Inputs** | **Expected result** | **Actual result** | **Test results** |
| 1 | Directs to the homepage of Dyslexia screening via Letters, Words pronunciation test | **-** | Home page of Dyslexia screening and intervention | Home page of Dyslexia screening and intervention | **Pass** |
| **2** | Select “Dyslexia හදුනාගැනීම​” Button | **-** | Redirects to the dyslexia pronunciation test environment provided for dyslexia screening | Redirects to the dyslexia pronunciation test environment provided for dyslexia screening | **Pass** |
| **3** | After pronouncing the letter click next button | Speech input of the user | Error popup appears. Error popup contains the time duration spent, wrong pronunciation count and success rate according to the correctly pronunciation letters. | Error popup appears. Error popup contains the time duration spent, wrong pronunciation count and success rate according to the correctly pronunciation letters. | **Pass** |

**Test Scenarios for Dyslexia intervention function**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Scenario ID** | Dyslexia intervention -1 | **Test Case ID** | Letters, Words pronunciation test- Intervention-1A |
| **Testcase Description** | Successful intervention process using Letters, Words pronunciation test | **Test Priority** | High |
| **Pre-requisite** | User should have access to the component | **Post-requisite** | **NA** |

**Test Execution Steps:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Step number** | **Action** | **Inputs** | **Expected result** | **Actual result** | **Test results** |
| 1 | Directs to the homepage of Dyslexia intervention Letters, Words pronunciation test | **-** | Home page of Dyslexia screening and intervention | Home page of Dyslexia screening and intervention | **Pass** |
| **2** | Select “Dyslexia හදුනාගැනීම​” Button | **-** | Redirects to the dyslexia pronunciation test environment provided for dyslexia intervention | Redirects to the dyslexia pronunciation test environment provided for dyslexia intervention | **Pass** |
| **3** | After pronouncing the letter click next button | Speech input of the user | Success popup message box seems. Success popup contains the time duration spent, and the success rate and GIF | Success popup message box seems. Success popup contains the time duration spent, and the success rate  and GIF | **Pass** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Scenario ID** | Dyslexia Intervention -2 | **Test Case ID** | Letters, Words pronunciation test-2B |
| **Testcase Description** | Unsuccessful Intervention Letters, Words pronunciation test | **Test Priority** | High |
| **Pre-requisite** | User should have access to the component | **Post-requisite** | **NA** |

**Test Execution Steps:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Step number** | **Action** | **Inputs** | **Expected result** | **Actual result** | **Test results** |
| 1 | Directs to the homepage of Dyslexia Intervention via Letters, Words pronunciation test | **-** | Home page of Dyslexia screening and intervention | Home page of Dyslexia screening and intervention | **Pass** |
| **2** | Select “Dyslexia හදුනාගැනීම​” Button | **-** | Redirects to the dyslexia pronunciation test environment provided for dyslexia Intervention | Redirects to the dyslexia pronunciation test environment provided for dyslexia Intervention | **Pass** |
| **3** | After pronouncing the letter click next button | Speech input of the user | Error popup appears. Error popup contains the time duration spent, wrong pronunciation count, GIF and success rate according to the correctly pronunciation letters. | Error popup appears. Error popup contains the time duration spent, wrong pronunciation count, GIF and success rate according to the correctly pronunciation letters. | **Pass** |

**View report test cases:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Test case ID** | **Test case name** | **Test input data** | **Test procedure** | **Expected output** | **Actual output** | **Test result** |
| TC\_01 | View report | Time period | 1. Select my profile interface menu 2. Select view children ibutton 3. User select valid time period | Graphs should generate for time period given | Graphs should generate for time period given | **Pass** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Test case ID** | **Test case name** | **Test input data** | **Test procedure** | **Expected output** | **Actual output** | **Test result** |
| TC\_02 | View report | Invalid time period | 1. Select my profile interface menu 2. Select view children ibutton 3. User select invalid time period | Should notify as invalid time period | Should notify as invalid time period | **Pass** |

Once it determined the team's mobile needs and developed a complete mobile testing strategy, the question becomes how to effectively execute such complex testing as a part of an on-going mobile application lifecycle strategy. Although cloud-based testing using emulators may have been enough of the mobile device.

Table 2.5: Mobile application testing process

|  |  |
| --- | --- |
| Test case preparation | Start by preparing test cases. |
| Automated script identification and modification | Identify the refillable automation scripts and modify the scripts as per the requirement. |
| Manual and Automated Testing | Execute both manual and automation test cases. |
| Usability Testing | User experience is key for applications to be recognized by end users. Check usability issues, navigation and content. |
| Performance Testing | Test the performance of the mobile application for its sensitivity, scalability, resource usage and stability based on standards. |
| Security and Compliance Testing | Warrant the application is secure by checking SQL injection, data dump and validation. |
| Device Testing | Execute test cases in other family of devices and testing simulation tools. |

Separately that some other testing processes are also important to our application.

**Identified Types of Testing**

It was a compulsory requirement that the application must work in Android devices as the end consumers can have diverse devices. To ensure that the application worked in all the devices we selected combination of manual testing, automation testing and testing in cloud simulator – Device Wherever.

**Performance Testing**

The functionality, performance (stability, responsiveness, resource usage, stability parameters as per standards) and user interface for the delivered build was thoroughly tested.

**Device Testing**

The application was tested across multiple OS versions/devices using the Device Anywhere simulation tool and tested in dedicated mobile application testing labs.

**Maintained Test Case Sheet**

During the whole process the Arunalu team maintained the test case sheet (with all functionality implemented). The entire end-to-end mobile application testing process involved collective effort between Arunalu team and our clients.

**Generated Test Summary Report**

Lastly, Arunalu team created the test summary report. This is a management report which provides details of any significant information uncovered by the tests conducted, includes assessments of the quality of the testing struggle, the quality of the software system under test and statistics derived from incident reports. The report also records different types of testing performed and how long did it take to complete the testing. This helps to recover any future implementations. This final document specifies whether the software system under test is fit for use and has met acceptance criteria defined.

# **RESULTS AND DISCUSSION**

## **3.1. Results**

The main result of this research is to overcome all the weaknesses of Dyslexia and improve reading skills. This is an Android based mobile application. In the analysis, we used Unity game engine. To give a different experience to the children who using this and to be more accurate. According to voice recognition components, it was revealed that detect the stage of Dyslexia and weaknesses of Dyslexia can overcome. It provides more accurate results than the current solution. Detecting the Dyslexia stage is 72% accurate by using Feature extraction has been done using MFCC (Mel-frequency cepstral coefficients) technique and the model raining was done using CNN (Convolutional Neural Networks).

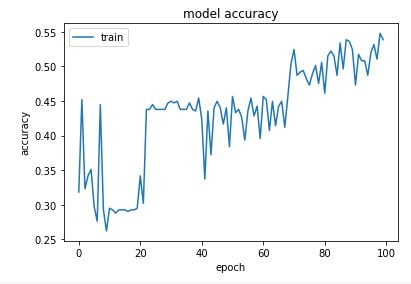


Figure3.1: Accuracy function graph

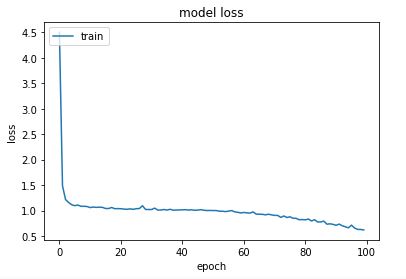


Figure3.2: Loss function graph

## **3.2. Research Findings**

Speech recognition is the ability of a machine or program to identify words and phrases in spoken language and convert them to a machine-readable format. Elementary speech recognition software has a limited vocabulary of words and phrases, and it may only identify these if they are spoken very clearly. More urbane software can accept natural speech. Speech recognition works using algorithms through audio and language modeling. [18] Audio modeling represents the relationship between linguistic units of speech and audio signals; language modeling matches sounds with word sequences to help distinguish between words that sound similar. Speech recognition performance is measured by accuracy and speed. Accuracy is measured with word error rate. A variety of factors can affect computer speech recognition performance, including pronunciation, accent, pitch and volume and background noise [19]. “Arunalu” developed for Sinhala language and can only improve reading skills. Authors are planning to deliver a new update for English language in future. Currently the application is running for android devices. Supporting for IOS is the next task. It will be a huge advantage for the IOS users.

## **Discussion**

Speech recognition is the ability of a machine or program to identify words and phrases in spoken language and convert them to a machine-readable format. Fundamental speech recognition software has a limited vocabulary of words and phrases, and it may only identify these if they are spoken very clearly. More sophisticated software can accept natural speech. Speech recognition works using algorithms through acoustic and language modeling.

Rather than traditional model, deep learning-based model will bring more accurate results. This study presents CNN based raw speech recognition model.

Speech recognition performance is measured by accuracy and speed. Accuracy is measured with word error rate. A variety of factors can affect computer speech recognition performance, including pronunciation, accent, pitch and volume and background noise [19]. “Arunalu” developed for Sinhala language and can only improve reading skills. Authors are planning to deliver a new update for English language in future. Currently the application is running for android devices. Supporting for IOS is the next task. It will be a huge advantage for the IOS users.

# **CONCLUSION**

Conclusion has many different definitions. One may the conclusion pushes beyond the boundaries of the prompt and allows you to consider broader issues, make new connections, and elaborate on the significance. “Arunalu” has been implemented to make user friendly communication among the differently able people through pronunciation test . There are many more applications available for this purpose. Those application support features such as stage identification, user friendly gaming environments . Most of the applications focused on stage identification between normal people and therefore normal users gain lots of advantages from it. In literature survey, were found most of the differently able people not having advantages from the development of information technology because of their disability. Most of the available systems not having user friendly gaming environments facility, “Arunalu” attempt is to eliminate the barriers between the normal and differently able people. To do that team “Arunalu” provides more user friendly featured application.

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# **GLOSSARY**

|  |  |
| --- | --- |
| **Term** | **Definition** |
| **Arunalu** | Learning ecosystem to overcome Sinhala reading weakness due to Dyslexia |
| **Voice recognition** | It is referred to **as speech or voice recognition.** It includes making audio signals meaningful by sampling, artificial neural networks, machine learning. |
| **Real time** | A system in which input data is processed within milliseconds so that it is available  virtually closely as response to the process from which it is coming |
| **Natural Language Processing** | Natural language processing (NLP) is a field of computer science, artificial intelligence and computational linguistics concerned with the interactions between computers and human (natural) languages |
| **Machine Learning** | Machine learning is a type of artificial intelligence (AI) that provides computers with the ability to learn without being explicitly programmed. Machine learning focuses on the development of computer programs that can change when exposed to new data. |
| **GIF** | The Graphics Interchange Format is a bitmap image and lossless format for image files that supports both animated and static images. |
| **IBM watson** | The IBM Watson Speech to Text service provides speech transcription capabilities for your applications. The service leverages machine learning to combine knowledge of grammar, language structure, and the composition of audio and voice signals to accurately transcribe the human voice. |

# **APPENDICES**

A picture containing text, map

Description automatically generated

Figure 1: Use Case Diagram

A picture containing drawing

Description automatically generated

Figure 2: Activity Diagram-Start the Game

A picture containing screenshot

Description automatically generated

Figure 3: Activity Diagram- Convert Speech to Text

A close up of a logo

Description automatically generated

Figure 4: Activity diagram – GIF procedure