AUTONOMOUS DYSLEXIA EVALUATION SYSTEM

Capstone Project

REPORT END SEMESTER EVALUATION

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ABSTRACT

The Autonomous Dyslexia Evaluation System is a website-based application to track a child's progress and evaluate the child dealing with Dyslexia through a series of tests. These tests will focus on the following areas: the ability to write down heard letters and syllables, recognize whole words, and recognize objects (letters, words, symbols, and images) quickly and automatically and correctly pronounce displayed words. A track record of the entire test history and the child's progress are maintained.

It is a platform well integrates all tests targeting each difficulty area for Dyslexia. We have devised unique and skillfully crafted trials targeting major parameters essential for dyslexia evaluation. Tests include spelling orientation, pronunciation, object classification-based spelling orientation, and rapid color recognition-based fluency tests.

It includes maintaining the patient's track record, which helps monitor the patient's progress, and these track records can also be presented to a doctor for proper treatment. It provides a personalized remote-based solution that helps evaluate Dyslexia at anytime and anywhere free of cost.

It involves gathering information to identify the factors contributing to a child’s difficulty learning to read and spell. First, information is gathered from parents and teachers to understand the development and the educational opportunities that have been provided. Then, tests are given to identify strengths and weaknesses that lead to a diagnosis and a tentative road map for intervention. Conclusions and recommendations are developed and reported.

DECLARATION

We hereby declare that the project's design principles and working prototype model are entitled.

The Autonomous Dyslexia Evaluation System is an authentic record of our work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Prashant S Rana during the 7th semester (2022).

Date: 10/12/2022

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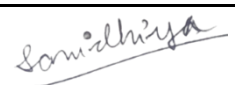
101917126	SANIDHIYA	
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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ANN	Artificial neural network
API	Application Programming Interface
ASQF	Association for Software Quality and Further education
AWS	Amazon Web Service
CNN	Convolution Neural Network
CSS	Cascading Style Sheets
CV	Computer Vision
DFD	Data Flow Diagram
ER	Entity Relationship Diagram
GUI	Graphical user interface
HTML	Hyper Text Markup Language
HTTPS	Hypertext Transfer Protocol Secure
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
JS	JavaScript

LSTM Long short-term memory

MERN MongoDB, Express, React, Node

RNN Recurrent neural network

INTRODUCTION

1.1 Project Overview

Imagine when a child is struggling to read or write, someone will probably suggest that he or she be tested for Dyslexia. Dyslexia is the most common learning disability. Individuals with this medical condition have difficulty in the areas of language processing. What does it mean to be tested? You might think of a test as something you take in an afternoon. Someone scores it and tells you how you did. Evaluation is a more accurate word for determining if someone has Dyslexia. Yes, this is possible to do so.

The project aims to track a child's progress and evaluate the child dealing with Dyslexia through a series of tests. These tests will focus on the following areas: the ability to write down heard letters and syllables, recognize whole words, and recognize objects (letters, words, symbols, and images) quickly and automatically and correctly pronounce displayed words. A track record of the entire test history and the child's progress are maintained.

The project involves the integration of the Audio Classification module, OCR module, and web application module and implementing the deep learning model. It is an autonomous system, requires a minimal interface, is user-friendly, and is accessible to everyone.

Spelling Orientation Test aims to evaluate letter orientation written by the child as a dyslexic child faces many difficulties in recognizing similar types of alphabets, and sometimes, they get confused with the direction of alphabets. They also get confused with similar letters that are reverse or mirror images of each other. E.g.: ‘b’ and ‘d’ are quite similar letters (they are mirror images of each other). This problem is usually arising because of the motor part of the brain. The three parameters tested here are Vision, Spelling, and Hearing senses. Vision is for writing the word correctly on the screen. Spelling is for checking whether the child is aware of the word. Hearing is for checking whether the child can identify the word accurately or not.

Talking about pronunciation test, the main problem in Dyslexia is trouble recognizing phonemes **(**These are the basic sounds of speech (the "b" sound in "bat" is a phoneme, for

example). So, it is a struggle to connect the sound and the letter symbol for that sound and blend sounds into words. The pronunciation Test is designed using phonemes so that we can test the perplexity of the child for pronouncing each word correctly. We are testing the child's motor skills, reading, and phonic awareness. Phonic Awareness is checked by checking the fact that whether the child is aware of the word or not. (He/she might not have seen the word before). Reading skills are tested by quickly identifying the word written on the screen before pronouncing it.

A rapid color naming test is a fluency-based test that aims to evaluate the ability of the child to check the fluency in speech and correctly name the colors in the correct order within a given time limit. Rapid Naming depends on processing speed, i.e., how quickly a person retrieves the desired information. Dyslexic children usually tend to perform slowly on such tasks. This test evaluates the child based on four parameters (Tenets of Reading) which include Phonemic Awareness, Phonics, and Fluency. Phonemic Awareness deals with the ability of the child to see and process the colors on the screen. Phonics is the ability of the child to speak whatever he/she is processing in their brain. Fluency deals with the correctness of the naming of the colors.

Object Classification Test aims to evaluate the child's object recognition and spelling orientation selection of the words. This test directly tests the motor skills of the child. The idea of this test is taken from the above the taken tests. The parameters being tested are the mixture of the above two tests taken. The main parameters tested here are Vision, Spelling, and Phonemic Awareness. Vision and Phonemic Awareness are being tested by checking the correctness of identifying the image. The options are designed, so a child has to work hard to identify the correct choice. Phonemic Awareness is also being tested to determine the right option.

Dyslexia is a common condition that makes it hard to work with language. Dyslexic subjects have difficulty reading comprehension, spelling, and writing. The International Dyslexia Foundation states that between 15% and 20% of the population have a language-based learning disability, Dyslexia being the most common of these. How many times have

you seen a child struggling to read simple words? How often have you encountered a child unable to differentiate between similar-looking alphabets like ‘b’ and ‘d’? How frequently have you seen a child unable to organize letters in the correct order when spelling them? How recurrently have you witnessed a child being unusually slower in processing information than his/her peers?

The main goal of our project is to automate the process of a dyslexic child’s evaluation and track the progress of the dyslexic child. The maintenance of the patient's track record helps monitor the patient's progress, and these track records can also be presented to a doctor for proper treatment. The test of a patient for Dyslexia using an autonomous system eliminates the requirement of a doctor. Increase the efficiency of the dyslexic evaluation process and optimize the overall cost. Provide a personalized remote-based solution that helps evaluate Dyslexia at any time and anywhere free of cost.

1.2 Need Analysis

- Children in almost every class face reading, writing, or spelling difficulties. While most parents and teachers struggle with or completely give up on them, it is essential to identify if they have Dyslexia.
- Traditional Dyslexia evaluation requires a supervisor to be physically present to conduct the tests and monitor the assessment.
- A physical evaluation is not always free of cost, thus depriving children of humble homes a fair opportunity to progress and succeed in overcoming this disorder.
- A skilled doctor is required to conduct this test in the traditional evaluation. The efficiency and accuracy of the doctor conducting the tests are vital factors on which the success of the assessment majorly depends.
- The physical evaluation is a scheduled test date at a particular time and location. This can be cumbersome for parents to take their children to appointments due to prior commitments or unforeseen issues.
- Analysis of the progress made by the child based on previous tests may not be accurate subject to the criteria involved, and in some cases, the track record of the child may not have been maintained.

1.3 Research Gaps

Speech, Writing and Reading Problems, Disorders in Developmental and Congenital Dyslexia and Therapy of Dyslexic Patient

This paper discusses major issues faced by a dyslexic subject. The general trend observed disorders in Speech, Writing, and Disorder. Dyslexia is a reading disability that primarily concerns a particular language base, which affects the ability to learn words and compose words even though the child has an average or above-average intelligence level, sufficient motivational and educational opportunities, and normal vision and hearing. Some experts also define Dyslexia as a condition of input processing or different information (from normal children) often characterized by reading difficulties that may affect the areas of cognition, such as memory, input processing speed, timing ability, coordination, and control motion.

Dyslexia may be due to genetic and heredity factors as well. It is also observed in children with normal vision and intelligence. The former is also known as developmental Dyslexia, and the later is a congenital disorder. The later can be cured using proper treatment by the appropriate physician and training. Please note that we are not focusing on the Therapy of the patient as the primary purpose is to evaluate/train a dyslexic patient.

The causes of each of the mentioned disorders, along with the symptoms, are discussed below:

- Speech Disorder

  It is observed that such children struggle to understand "spoken language." This disorder is responsible for brain abnormalities affecting sound processing and spoken language. This is usually a congenital disorder involving decomposing complex/difficult words. The paper referred here conducts a test on different children with dyslexic disabilities. These children are asked to pronounce certain words as part of this test. Later appropriate surveys are conducted on the result. The most common trend observed is that such children get confused with the terms that are phonemes of each other. (Phonemes are words that sound very similar).

- Reading Disorder

  A general trend observed after conducting required tests is that they often get confused with the letters of the language. For Ex, they often get confused with reversed or mirror characters. (Ex “b and d are mirror images of each other”). Another trend is that they fail to connect the letters to form the word if the word they are trying to read is too large.

  Interruptions are also observed while reading rhyming/ repeating words or sentences. Apart from this, if they are asked to recite a complex sentence phrase or something similar, they might face many interruptions for the same.

- Writing Disorder

  As stated above, such children get confused with alphabets/words, which are mirror images of each other or that have been reversed. They fail to connect the letters to form the desired word. Specific words like “bad” are sometimes written as “dab” by these students, as stated in the paper.

- Color-Naming Defects in Dyslexic Boys

  This paper has surveyed students aged b/w 7.5 – 8 years for color naming defects in Dyslexic Boys. It is observed that dyslexic children (especially boys) find it harder to recognize the colors shown.

  A proper study has been conducted on such students by taking appropriate tests. Children were asked to name strips of colors in the right order from left to right. Each strip was formed only from five colors shuffled in separate strips. Students faced difficulty in naming the colors correctly. They faced interruptions in naming the colors that start with the same letter (for, black and blue). So, keeping this in mind, few have designed our rapid color naming test similarly.

- Picture Naming Deficits in Developmental Dyslexia

  This paper conducted surveys on students by conducting picture naming tests. Each student is given a list of pictures and is asked to select the correct options out of the given options. Dyslexic children tend to face difficulty co-relating the picture with the

image shown on the screen. The object classification test we designed is inspired by the above fact, which concludes the given paper.

- Speech Recognition — Feature Extraction MFCC & PLP

  We have already discussed the symptoms students face in speech recognition tests. The problem arises here to convert speech to appropriate text that the children spoke. If we use Google translator API or some other speech-to-text conversion API, this will not work because they try to match it with the closest correct word. They do not match the speech with incorrect words. So, we are required to train our custom ANN (Artificial Neural Network). We have collected custom audio samples from dyslexic patients to understand the sounds they might often get confused with. Then we try to score these based on the similarity index metrics, one of them being the Jaccard Similarity Index. This paper deals with methods to extract relevant features from audio samples (e.g., Wavelength using MFCC) and then designing a proper neural network architecture for the same. It also discusses the requirement of the LSTM layer for training the desired neural network.

- Jaccard Similarity Metric

  Three tests, namely Rapid Color Naming, Spelling Orientation Test, and Pronunciation test, aim to compare strings to generate desired scores. Rapid Color Naming converts speech to test, then the first letter of each color is taken and compared with the answer string for scoring purposes. Similarly, the Spelling Orientation Test compares words written by the student on the screen with the correct word and so with the third test. One famous algorithm compares strings by using Jaccard Similarity Index. It reaches two lines by matching appropriate alphabets in the string and their relative ordering.

1.4 Problem Definition and Scope

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 affects areas of the brain that process language. The scope of the evaluation is gathering information to identify the factors contributing to a child's difficulty with learning to read and spell. First, information is gathered from parents and teachers to understand the development and the educational opportunities that have been provided. Then, tests are given to identify strengths and weaknesses that lead to a diagnosis and a tentative road map for intervention. Conclusions and recommendations are developed and reported.

1.5 Assumptions and Constraints

The given tables summarize the assumptions & constraints of our project, respectively:

Assumptions

Table 1: Assumptions for the System

Sr. no.	Assumptions
1.	The child has a device to access the website.
2.	A stable Internet Connection is available.
3.	The child understands basic English.

Constraints

Table 2: Required Constraints for the system to work smoothly

Sr. No.	Constraints
1.	The person must be still and look at the camera for a short time.
2.	The person should be at some minimum distance from the system.
3.	The User must have an account to login into the website.

1.6 Standards

Software Test documentation is the vital element that raises any experimental activities to the level of a software test. International abortionists like the IEEE & ISO have published standards for software test documentation.

IEEE 829 Standard for Software Test Documentation –

IEEE 829-2008, also known as the 829 Standard for Software and System Test Documentation, was an IEEE standard that specified the form of a set of documents for use in 8 defined stages of software testing and system testing, each step potentially producing its particular type of document. The standard specified the format of these documents. The standard formed part of the training syllabus of the Information Systems Examination Board (ISEB) Foundation and Practitioner Certificates in Software Testing promoted by the British Computer Society. The International Software Testing Qualifications Board (ISTQB), following the formation of its syllabus based on ISEB's and Germany's Association for Software Quality and Further Education (ASQF) syllabi, also adopted IEEE 829 as the reference standard for software and system test documentation.

ISO 9126 and ISO 14598 (which are standards on Software Evaluation) –

The objective of the ISO/IEC 9126 standard is to address some of the well-known human biases that can drastically affect the delivery & perception of a software development project. These biases include changing priorities after the start of a project or not having any clear definitions of success by clarifying, then agreeing on the project priorities and subsequently converting abstract priorities (compliance) to measurable values.

Code Standard:

The layout and white-spaces, comments, imports, documentation strings, version book keeping, programming recommendations, and naming conventions are all PEP8-compliant. We have also deviated from the Basic Standards a little.

Software Process Quality Standard:

ISO/IEC 15504, also known as Software Process Improvement and Capability Determination (SPICE), is a collection of technical standards documents for the computer software development process.

1.7 Approved Objectives

The following objectives have been approved, which are listed below:

- The main aim of our project is to automate the process of a dyslexic child's evaluation and track the progress of the dyslexic child.

- Web Interface for all types of Tests, which includes Spelling orientation, pronunciation, object classification-based spelling orientation test, and color recognition-based fluency test, is to be implemented.

- Statistical Reports generation feature to keep track of dyslexic subjects has to be generated.

- CNN (Convolution Neural Network) for Handwriting Recognition and ANN (Artificial Neural Network) for Speech-to-text conversion are to be trained and deployed.

- Virtual Painter Module for Spelling Orientation Test which uses Mediapipe for Hand tracking and Open CV for Computer Vision, is to be implemented.

- An autonomous system has to be set up to eliminate a doctor's requirement.

- Increase the efficiency of the dyslexic evaluation process and keep a track record of the progress.

- Provide a personalized remote-based solution that helps to evaluate Dyslexia at any time and any place free of cost

1.8 Methodology

Our project is based on four tests: Pronunciation Evaluation, Rapid Color Naming, Handwriting Evaluation, and Object Classification. The method deployed to implement each test is enlisted below:-

- Pronunciation Evaluation – It involves data collection, Data/Audio Preprocessing wherein audio is converted to monotonic type from stereotype and is stored in the form of Mel-Frequency Cepstral Coefficients, and implementation of a deep learning model using Tensor Flow Library.

- Rapid Color Naming involves audio conversion into text using speech recognition libraries. A string is created from the converted text using the first word of each color. This string is matched with the answer string, and the score is generated based on the similarity of the two strings. The similarity b/w two strings are calculated using the Jaro–Winkler distance metric.

- Spelling Orientation – It involves designing a specific set of problems which includes spellings/wordings for a particular object created so that it will be difficult for the dyslexic child to write. The source of the Spelling/Wordings will be an experienced psychiatrist or a recognized research paper.

- Object Classification – It involves the implementation of a basic module of our web application developed using the MERN stack. The design consists of specific problems, including images for a particular object. Each problem will also contain a set of similar-looking options, making it difficult for the dyslexic child to distinguish the right choice.

1.9 Project Outcomes and Deliverables

- Evaluation of Dyslexia –Automate the process of dyslexic subjects' evaluation through various tests specially designed for them.

- Track record - A track record of the entire test history of the taker will be maintained. This record will help analyze the progress of the child after each test.

- Accessible – The evaluation system will be accessible anywhere and at any time. The child will be free to take the test at his/her leisure.

- Inexpensive – The system will require a stable internet connection, and no additional cost will be incurred. We promise to deliver an evaluation system with no financial constraints.

- No supervision – The tests will not require supervision by an adult. Each test will be designed so that the child will quickly understand how to proceed and will not face any trouble while taking it.

- Minimal interface – The evaluation system will be designed while acknowledging the targeted age group. Hence, it will have a minimal interface and will be child friendly.

1.10 Novelty of Work

Some websites for Dyslexia evaluation provide information and resources necessary to help parents, educators, and learning specialists understand how to meet the needs of children with Dyslexia better and include quizzes targeting a particular area of weakness. However, the concept of a platform well integrates all tests targeting each difficulty area for Dyslexia has not yet been implemented. We have devised unique and skillfully crafted tests targeting major parameters essential for dyslexia evaluation. Tests include spelling orientation, pronunciation, object classification-based spelling orientation tests, and color recognition-based fluency tests. Our platform logs in the responses evaluated using Machine Learning Models and sent to the API, which processes the data and provides a

personalized overview of the examinee's performance graph. It is free of cost, child friendly with no supervision required, and accessible from anywhere with an up and running stable internet connection.

REQUIREMENT ANALYSIS

2.1 Literature Review

2.1.1 Theory Associated With Problem Area

Dyslexic is a perusing inability that concerns a specific language base, which influences the capacity to learn words and make words even though the child has a normal or better than expected knowledge level, adequate persuasive and instructive open doors, normal vision, and hearing. Developmental Dyslexia is inborn and because of hereditary or genetic elements. Individuals with Dyslexia experience issues not only concerned with perusing, they additionally experience the boundaries to spelling, composing, and some other language perspectives. Notwithstanding, dyslexic kids have typical or even better than expected levels of knowledge. With extraordinary taking care, the hindrances they experience can be limited.

2.1.2 Existing Systems and Solutions

Websites analogous to the Autonomous Dyslexia System in aspects of the various tests incorporated in our project include:-

- 'Dyslexia Training Modules' is a website that provides the information and resources necessary to help parents, educators, and learning specialists understand how to meet the needs of students with Dyslexia better.

- 'Lexercise.com' is a website that comprises a library of learning disability assessments below to measure a child's risk level. It includes comprehensive quizzes that are available online and can be administered by the child's guardian. Some screeners require the child to be present, while others can be taken without the child being present.

2.1.3 Research Findings for Existing Literature

Table 3: Research Findings for Existing Literature

SNo	Roll No	Name	Paper Title	Tools/ Technology	Findings	Citation
1	101917126	Sanidhiya	Speech, Writing Disorder, and Therapy of Dyslexic Patient [1]	Word Pronunciation Test and its Evaluation	Individuals with Dyslexia experience issues not only concerned with perusing, they additionally experience the boundaries to spelling, composing, and some other language perspectives	Gustianingsih1, Elmeida Effendi and Ali
2	101917126	Sanidhiya	Writing Problems in Developmental Dyslexia: Under-Recognized and Under-Treated [2]	Writing Test and its Evaluation	Handwriting automaticity has a unique path to written composition in individuals with Dyslexia.	Virginia W. Beninger, Kathleen H. Nielsen, Robert D. Abbott, Ellen Wijsman, and Wendy Raskind
3	101917118	Paras Bakshi	Color-Naming Defects in Dyslexic Boys [3]	Rapid Color Naming Test and its Evaluation	Highly specific differentiation of function exists within the cerebral language areas, and discrete malfunction can account for particular subtypes of Dyslexia.	Martha Bridge Denkla
4	101917118	Paras Bakshi	Picture Naming Deficits in Developmental	Object Detection Test and its Evaluation	The dyslexics' picture naming errors are particularly marked on	Denise Swan and Usha Goswami

			Dyslexia: The Phonological Representations Hypothesis [4]		polysyllabic and low-frequency words, indicating a possible phonological basis for the picture naming deficit of dyslexic children.	
5	101917127	Shreya Somani	Speech Recognition using Feature Extraction techniques – MFCC & PLP [5]	MFCC, RNN, LSTM's, Neural Networks	A technique to apply speech recognition using knowledge of suitable Artificial Intelligence methods.	Hiroshi Shimodaira , Steve Renals
6	101903120	Kashish	Jaro-Winkler Distance [6]	Jaro Similarity, Pattern Matching Algorithms	A metric to find similarity b/w two strings.	Matthew A. Jaro

2.1.4 Problem Identified

The current scenario for dyslexia evaluation involves frequent visits to the physician. All sort of reports for such patients is created manually, and keeping all the records of a dyslexic subject in one place is challenging. All types of communication with Guardians of the patient are done through the physician. It is difficult to track the patient's progress by analyzing different reports.

Our system tries to eliminate all these problems by providing a full-fledged solution as an independent application for dyslexia evaluation. All the tests are conducted in the system itself. The intervention of a Physician is not required for performing the tests. The system can generate reports for all such tests, and we can keep track of the patient's progress with just a click of a button.

2.1.5 Survey of Tools And Technologies Used

The libraries, languages, and tools used by this system are:

- Languages: HTML, CSS, Python, JavaScript
- Frameworks: Flask Framework, Node JS, React JS
- Libraries: TensorFlow, OpenCV, Mediapipe

The web-based application is being deployed using ReactJS, NodeJS, and Flask.
The technologies used for each module are described below:

- Hand Tracking – implemented using the Mediapipe library.
- Speech-to-Text Conversion - We have trained in a custom Artificial Neural Network with LSTM.
- Handwriting recognition - Custom Convolution Neural Network is built using TensorFlow Library, including an IAM dataset.

2.2 Software Requirement Specification

2.2.1 Introduction

2.2.1.1 Purpose

This paper aims to provide a complete description of the software component that will be utilized in our 'Autonomous Dyslexia Evaluation System,' as well as how it should work. It describes the system's goal and characteristics, what it will perform, the limitations it must work under, and how it will react to external stimuli. This paper is intended for both stakeholders and developers of the system.

2.2.1.2 Intended Audience And Reading Suggestions

The document aims to assist both developers and stakeholders. This document will aid developers in fully comprehending requirements and stakeholders in better documenting them. This document will provide a clear picture of the system we are creating. It can be utilized in any situation depending on the project's requirements, and the solutions chosen.

2.2.1.3 Project Scope

The scope of the Autonomous Dyslexia Evaluation System includes:

- The software consists of a website that acts as
- This system will be a website-based application.
- Any registered person can access all the tasks and his/her previous track records, if any.
- It will require a stable Internet Connection for access.
- The website will be completely child friendly and will not require any adult supervision.
- It will incur no cost and will be accessible from anywhere.

2.2.2 Overall Description

2.2.2.1 Product Perspective

Students in almost every class face reading, writing, or spelling difficulties. While most parents and teachers struggle with or completely give up on them, it is crucial to identify if they have Dyslexia.

Traditional Dyslexia evaluation requires a supervisor to be physically present to conduct the tests and monitor the evaluation. The Autonomous Dyslexia Evaluation System is fully automated, free of cost, user-friendly, accessible from anywhere, and includes a progress tracker.

2.2.2.2 Product Features

The features of the Autonomous Dyslexia Evaluation System are:

- A track record of the entire test history of the taker is maintained.
- Easy sign-in using email-ID and One-time password delivered through text.
- The evaluation system is accessible at any place and at any time.
- The system requires a stable internet connection.
- It has a minimal interface and is child friendly.
- It is available completely free of cost.

2.2.3 External Interface Requirements

2.2.3.1 User Interfaces

- The GUI should be user-friendly.
- The GUI should be highly responsive.
- The user's data should be secured.

2.2.3.2 Hardware Interface

- The hardware device records accurate data.
- The hardware device and the software should be connected to the Internet 24*7.

2.2.3.3 Software Interface

- The application is built using React Framework.
- NodeJS is used for API Development.
- MongoDB Is Used For Database Management.

2.2.4 Other Non-Functional Requirements

2.2.4.1 Performance Requirements

The performance requirements include the following features:

- Performance: Our system is reliable. The camera and display are placed at eye level, making the system easy to use. Our face recognition model takes time for training and a few seconds on average for authentication. So, it is better to use a pre-trained model. The web app designed for this project also reveals the Database of users and their entry/exit status. The system shall be installed in an air-conditioned environment to keep the system cool.

- Scalability: Our system is working on the local server. Therefore, the range is

confined, and users bounded by that region can easily use the system.

- Portability and Compatibility Web: The web app and API for this system are designed using Python and JavaScript and corresponding web frameworks, providing tools, libraries, and technologies that allow us to build a web application. Our method comprises hardware and software components: Raspberry Pi, Face Recognition, Camera, Monitor, and Temperature Sensor. A person can access the web portal to access their entry/exit data.

- Maintainability: Our system is built modularly using readily available components and is easily maintainable with easily replaceable individual parts.

- Availability: Our system is available for users at any time, except during maintenance.

- Localization: We used an actual universal language, English, for our web application and user interface, which users can easily understand.

- Usability: The system is not at all hard to use. It is efficient, learnable, and memorable for users. The User has to stand in front of the camera to scan their Face, mark their attendance, and place their hand in the temperature sensor range to record their temperature.

2.2.4.2 Safety Requirements

- Webcam with good resolution for face recognition-based authentication.
- Stable Internet Connection to access the website.

2.2.4.3 Security Requirements

- **Encryption of Transferred Data:** Transfer of data over the internet over HTTPS protocol is required to avoid data spoofing. This requires an SSL Certificate from a reputed organization.
- **Encryption of Database:** Important information of each user stored in the Database should be encrypted with encryption algorithms like SHA256.
- **Authentication:** Aadhar Based authentication is being used to identify each user uniquely.

2.3 Cost Analysis

To keep the cost as low as possible to reach a more significant portion of the population, we propose the cost analysis or the checklist developed after doing an online market survey of various storage devices and testing tools.

Table 4: Cost Analysis of the System

S No.	Service	Cost (INR)
1.	Domain Name	300
2.	EC2 **g4dn.xlarge** Instance (AWS) (For Testing purposes only)	5000 (5 days reserved)
3.	Google Collab Pro Account (For Training Required Neural Networks)	1600 (2 months reserved)
	Total Estimated Cost	6900

2.4 Risk Analysis

To do the risk analysis, we first need to identify and then do a qualitative study of each identified risk. Once this is done, we define a risk management plan to track breaches and develop a service routine to maintain the normal functioning of the development process.

2.4.1 Risk Identification

The risk that can be identified related to tour project can be tabulated as shown in table 5.

Table 5: Table depicting the risk register with ID and corresponding Description.

Risk Register	
ID	**Description**
1.	Software Error
2.	Loose Connections
3.	Wrong Detection
4.	No Detection

2.4.2 Risk Management Plan

- Software Error: There might come some bugs that we are currently unaware of; the software is well-tested and reliable to date, but as we know, nothing is perfect, so that some bugs might come after full-fledged implementation. It will cost us time, money, and quality. The trained professionals will solve this by re-installing the software and finding the root of the problem.

- Loose Connections: The connections will be firm and tight, but there might be a chance that connections may get loose. It may occur by a strike or poor manufacturing. It might also happen if someone willingly pulled them off. It will cost us resources that are time and money. The trained hardware engineers will solve this by fixing or changing the connection wires, whichever is necessary, and finding the root of the problem.

- Wrong Detection: This might sometimes happen if the model is not trained correctly. Input images for training might not be of good quality. There might be dust on the camera, not giving the camera a clear picture. It will be solved by providing a new dataset to be trained.
- No Detection: It might be due to some software issue. The camera might be blocked

will be the main reason, or some serious issue or bug in the algorithm might be the reason. Restarting the system should solve the problem, but if it persists and continues to occur at intervals. This will be a severe problem that will be dealt with by software professionals.

METHODOLOGY ACCEPTED

3.1 Investigative Techniques Involved

This project aims to create a web-based application to expose dyslexic children through a series of skillfully crafted tests to improve their reading, writing and memorizing abilities. Existing websites are based on arming parents and educators with the skills and providing material to teach and help dyslexic children. This makes the children dependent on their educators. Our project's unique architecture eliminates the need for a supervisor. It is entirely free of cost and extremely child friendly.

Started by designing a front End using a JavaScript framework called react; all the modules were created using various software engineering practices and then implemented accordingly. After that, a backend server is made for serving and communicating with our front-end application. Here node.js and expess.js are used for designing the backend. Our two modules are created using node.js, and two are implemented using flask and CNN. Mediapipe is used for the hand tracking module, CNN is used for handwriting recognition, and ANN (with LTSM) is deployed for speech-to-text conversion.

Our system comprises four tests designed after having relevant case studies and surveys and considering various other factors.

Spelling Orientation Test aims to evaluate letter orientation written by the child as a dyslexic child faces many difficulties in recognizing similar types of alphabets, and sometimes, they get confused with the orientation of alphabets. They also get confused with similar letters that are reverse or mirror images of each other. E.g.: ‘b’ and ‘d’ are quite similar letters (they are mirror images of each other). This problem is usually arising because of the motor part of the brain. The three parameters tested here are Vision, Spelling, and Hearing senses. Vision is for writing the word correctly on the screen. Spelling is for checking whether the child is aware of the word. Hearing is for checking whether the child can identify the word accurately or not.

Talking about pronunciation test, the main problem in Dyslexia is **trouble recognizing phonemes (**These are the basic sounds of speech (the "b" sound in "bat" is a phoneme, for example). So, it is a struggle to connect the sound and the letter symbol for that sound and blend sounds into words. The pronunciation Test is designed using phonemes so that we can test the perplexity of the child for pronouncing each word correctly. We are testing the child's motor skills, reading, and phonic awareness. Phonic Awareness is checked by checking the fact that whether the child is aware of the word or not. They might not have seen the word before). Reading skills are tested by quickly identifying the word written on the screen before pronouncing it.

A rapid color naming test is a fluency-based test that aims to evaluate the ability of the child to check the fluency in speech and correctly name the colors in the correct order within a given time limit. Rapid Naming depends on processing speed, i.e., how quickly a person retrieves the desired information. Dyslexic children usually tend to perform slowly on such tasks. This test evaluates the child based on four parameters (Tenets of Reading) which include Phonemic Awareness, Phonics, and Fluency. Phonemic Awareness deals with the ability of the child to see and process the colors on the screen. Phonics is the ability of the child to speak whatever he/she is processing in their brain. Fluency deals with the correctness of the naming of the colors.

Object Classification Test aims to evaluate the child's object recognition and spelling orientation selection of the words. This test directly tests the motor skills of the child. The idea of this test is taken from the above the taken tests. The parameters being tested are the mixture of the above two tests taken. The main parameters tested here are Vision, Spelling, and Phonemic Awareness. Vision and Phonemic Awareness are being tested by checking the correctness of identifying the image. The options are designed, so a child has to work hard to identify the correct choice. Phonemic Awareness is also being tested to determine the right option.

3.2 Proposed Solution

The proposed solution involves hosting a web-based application whose implementation will include four tests. The interface will be child-friendly, easy email log in, and free of cost. It will record each session and maintain a progress tracker, which could be evaluated from time to time to monitor the child's improvement. It will be deployed using the MERN stack and involve the implementation of the modules CNN, ANN, and mediapipe. It will be a completely automated website with no supervision required.

Spelling Orientation Test: In this test, the system will give the word to be written on the screen. Word will be communicated through pronunciation. The system will use a hand tracking module (with the help of a virtual painter) to assist the child in writing the word on the screen. After the word has been successfully written, the system will identify the writing with the help of custom trained CNN Model. Then, the score is generated after matching it with the correct word using a similarity index metric.

Pronunciation Test: Here, a word is written on the screen. The child is supposed to pronounce the word correctly written on the screen. Then, the child is evaluated on the correctness of the pronunciation of the word. This is done through custom trained ANN model. This model created a dataset of different words by considering how a dyslexic patient can pronounce the given word.

Rapid color naming test: The system will show a series of rows of colors on the screen. The child will be asked to name the colors starting from the first row at the top from left till the last row at the bottom to the right. Scoring will be done on time taken to name all the colors and the order in which the colors are named on the screen.

Object Classification Test: The child is required to answer specific questions on the screen where the child is supposed to identify the object displayed on the screen. Four relevant options will be shown to the child, of which one will be correct. Options are designed, so the child will find it harder to identify each word correctly. All the options

displayed might be similar to them because we have mirrored/reversed some alphabets in the displayed options. The child will be scored based on the number of correct answers.

3.3 Work Breakdown Structure

The project has been broken into different modules and sub-modules. In the end, all of them will be interfaced as per the data flow of the project. The work breakdown structure given below defines the division of each module or activity that sums up the project's overall completion. The work breakdown structure of our project is shown in figure 1.

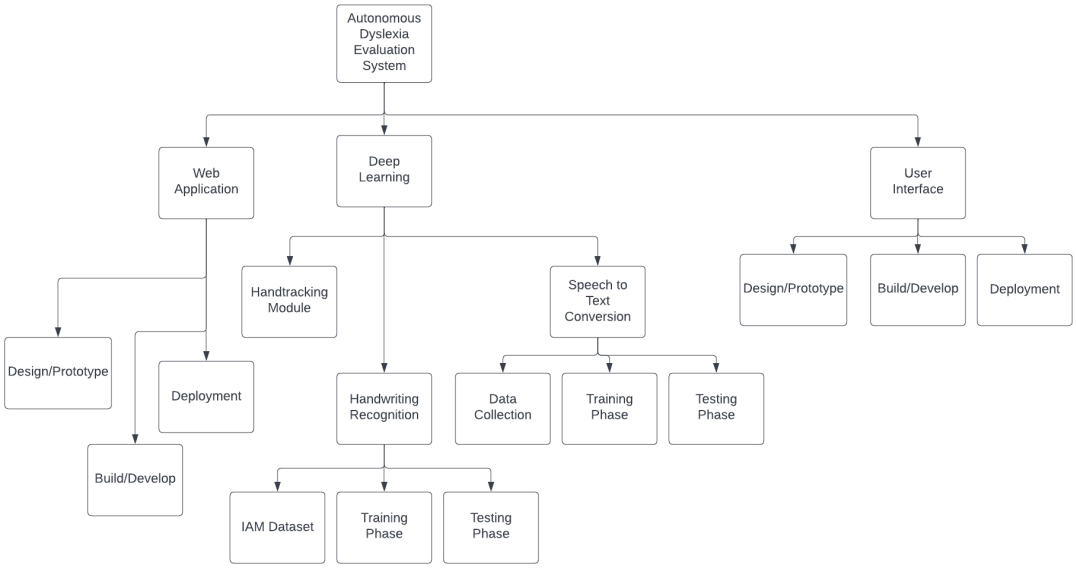

Figure 1: Work Breakdown Structure

3.4 Tools and Technologies

The libraries, languages, and tools used by this system are:

- Languages: HTML, CSS, Python, JavaScript
- Frameworks: Flask Framework, Node JS, React JS
- Libraries: TensorFlow, OpenCV, Mediapipe

The technologies used are described below:

(1) Deep Learning (For Hand Tracking, Handwriting Recognition, and Speech to Text Recognition)

- Hand Tracking (Using Mediapipe Library)

  For Hand Tracking, we are using the Mediapipe library.

  MediaPipe is a Framework for building machine learning pipelines for processing time-series data like video, audio, etc. This cross-platform Framework works in Desktop/Server, Android, iOS, etc. It is a collection of pre-trained neural networks. Some of the Models provided by MediaPipe include Face Detection, Hand Tracking, Box Tracking, etc.

- Speech to Text Conversion

  Artificial neural networks, called neural networks or neural nets, are computing systems inspired by the biological neural networks that constitute animal brains.

  We have trained in a custom Artificial Neural Network with LSTM.

  We created our custom dataset by collecting audio samples of various dyslexic subjects by considering a different set of words.

- Handwriting Recognition (Using Custom Convolution Neural Network)

  A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm that can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image, and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower than in different classification algorithms. While in primitive methods, filters are hand-engineered, ConvNets can learn these filters/characteristics with enough training.

IAM Data, a collection of 10k records of handwritten words, is used for the dataset. Custom Convolution Neural Network is built using TensorFlow Library.

(2) Computer Vision (Using OpenCV-Python module):

- It provides computers the "ability to see." It uses mathematical operations on visual images to break down, store, learn from, and finally operate on them. This enables us to process high-level images and videos.
- We are displaying the word that the user is writing. For this, we have to pre-process the camera's video feed by using the coordinates of the hands provided by hand tracking modules.
- Also, we have provided a method to select different options like font color and eraser. It is done by deciding the orientation of the hand.

(3) Web Application (Using Flask, React JS, Node JS):

- Flask: Flask is a micro web framework written in Python. It is classified as a micro-framework because it does not require particular tools or libraries. It is used for creating suitable API for our deep learning models, which our main web applications use.
- React JS: React is a free and open-source front-end JavaScript library for building user interfaces based on UI components. It is maintained by Meta and a community of individual developers and companies.
- Node JS: Node.js is an open-source, cross-platform, backend JavaScript runtime environment that runs on a JavaScript Engine and executes JavaScript code outside a web browser designed to build scalable network applications. It is the primary backend for our application for maintaining desired databases.

4.1 System Architecture

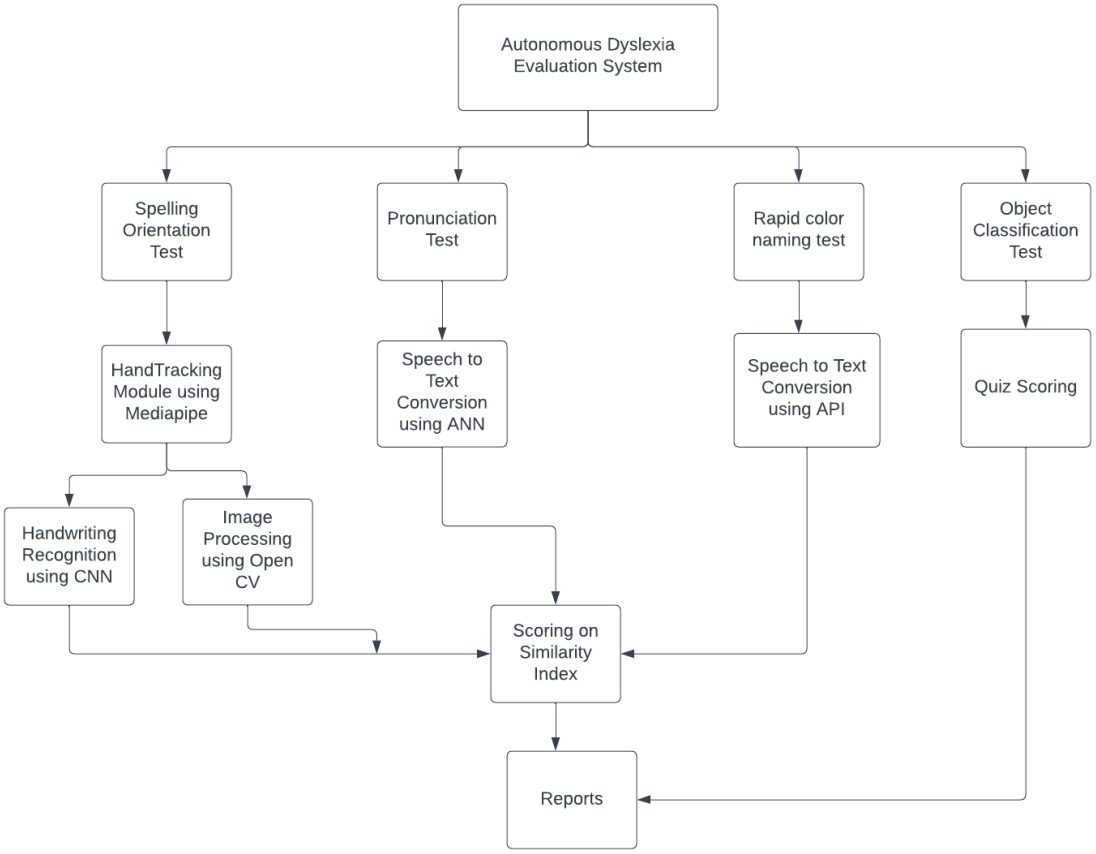

Figure 2: System Architecture

As shown in figure 2, a block diagram is a system diagram in which the principal parts or functions are represented by blocks connected by lines that show the relationships of the blocks.

The Autonomous Dyslexia Evaluation System Comprises four tests. Each of the four tests comprises a mixture of various technologies described in the block diagram given below. Some of the modules use deep learning neural networks to make appropriate predictions. The scoring of 3 out of four modules is based on Similarity Index Metrics.

4.2 Design Level Diagram

a) Activity Diagram:

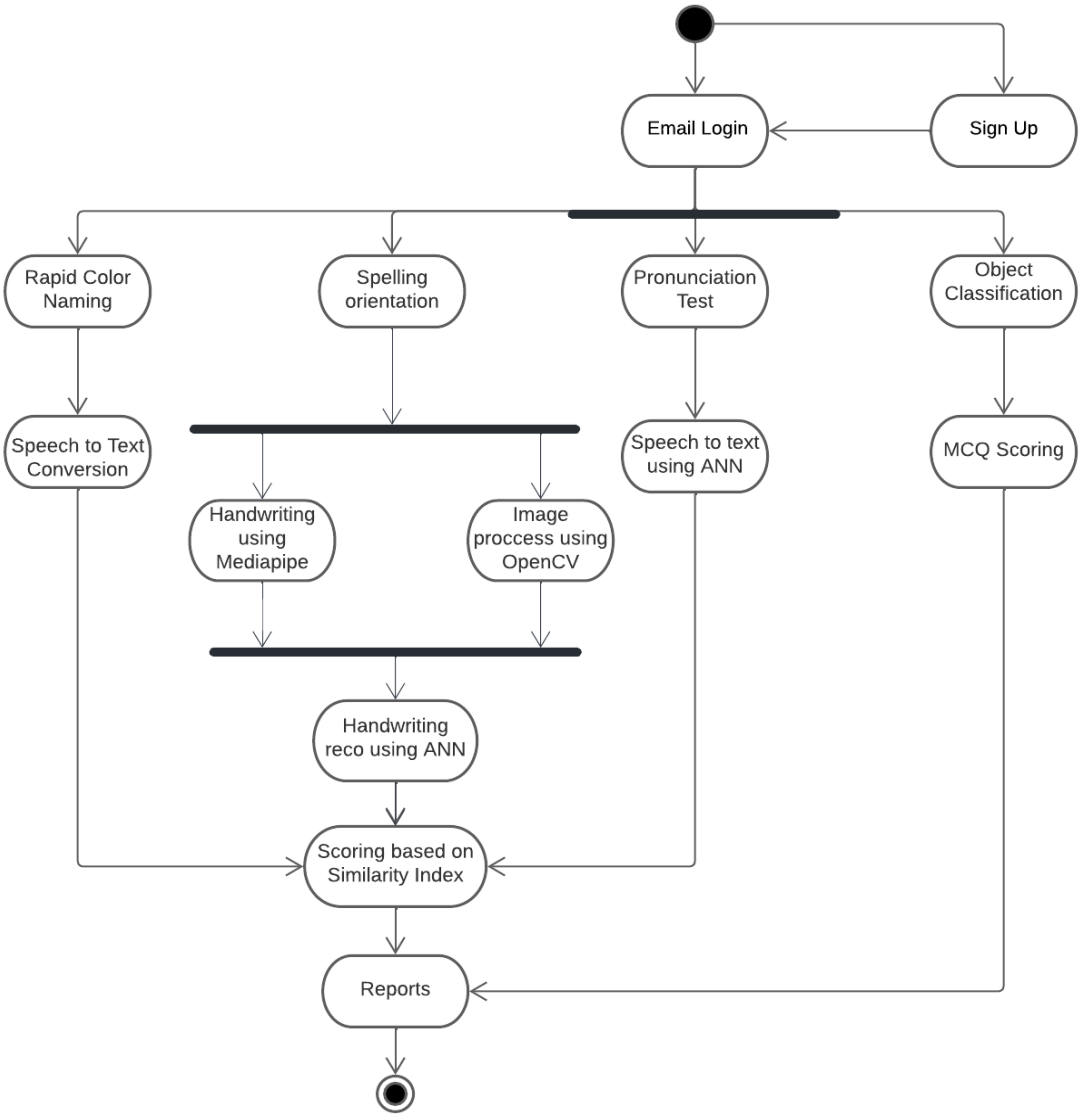

Figure 3: Activity Diagram

An activity Diagram is a flowchart representing the flow from one activity to another. The activity can be described as an operation of the system.

The Autonomous Dyslexia Evaluation System Comprises four tests. Spelling Orientation, Pronunciation, Rapid color naming, and Object Classification Test. Spelling Orientation Tests perform two concurrent tasks, namely hand-tracking and image processing. Each of

the four tests comprises a mixture of various technologies described in the activity diagram above. Some of the modules use deep learning neural networks to make appropriate predictions. The scoring of 3 out of four modules is based on Similarity Index Metrics.

b) Sequence Diagram:

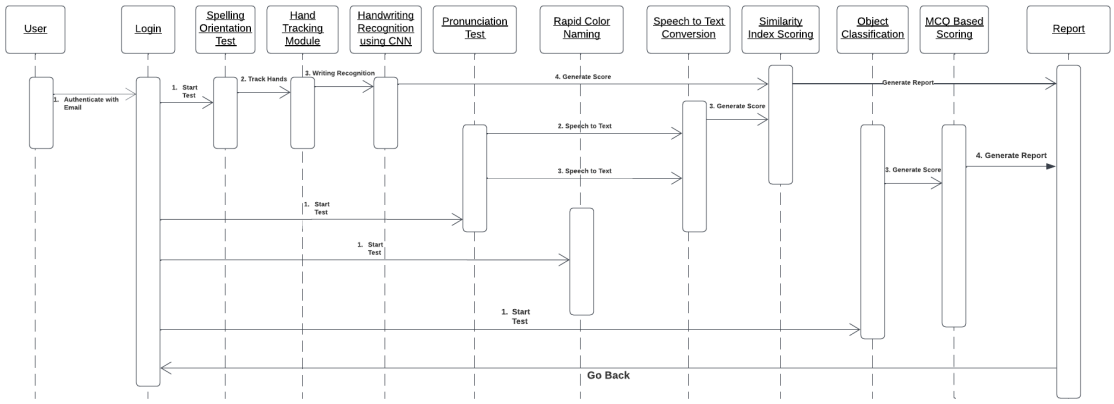

Figure 4: Sequence Diagram

The sequence diagram is temporal focus and shows the system's dynamic behavior. Sequence Diagrams are interaction diagrams that detail how operations are carried out. They capture the interaction between objects in the context of a collaboration. Sequence Diagrams are time-focused, and they visually show the order of the interaction by using the vertical axis of the diagram to represent the time, what messages are sent, and when. Figure 4 shows we are offering when to receive which message. The sequence diagram has two types of messages: synchronous and asynchronous. In the synchronous kind of message, a reply is a must.

c) Data Flow Diagram (DFD):

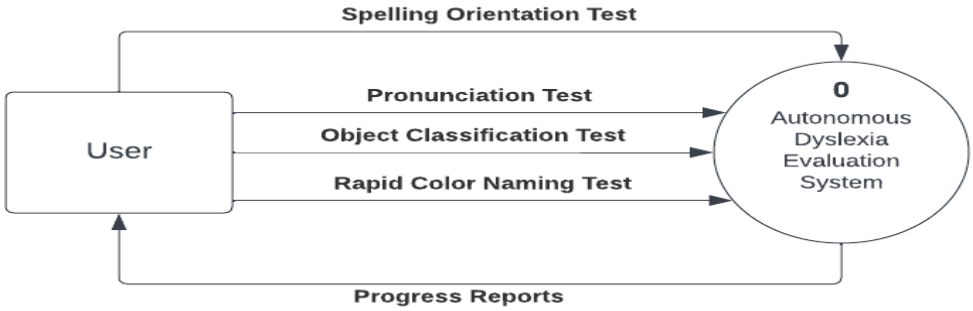

Figure 5: DFD Level 0

DFD

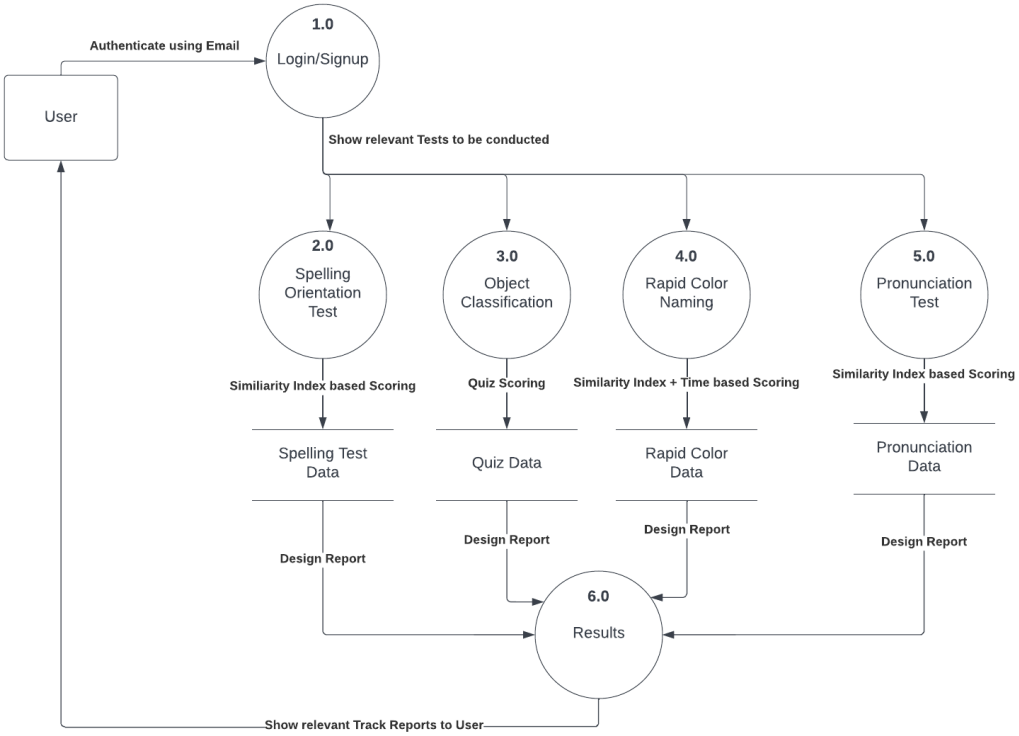

Figure 6: DFD Level 1

graphically represents the functions, or processes, which capture, manipulate, store, and distribute data between a system and its environment and between components of a system. In figure 5, we have one process: the name of our project, Autonomous dyslexia evaluation system. We have one entity named User (student). In figure 6, all the work of processes is explained in detail. The Database is also connected with the required function.

d) **ER Diagram**

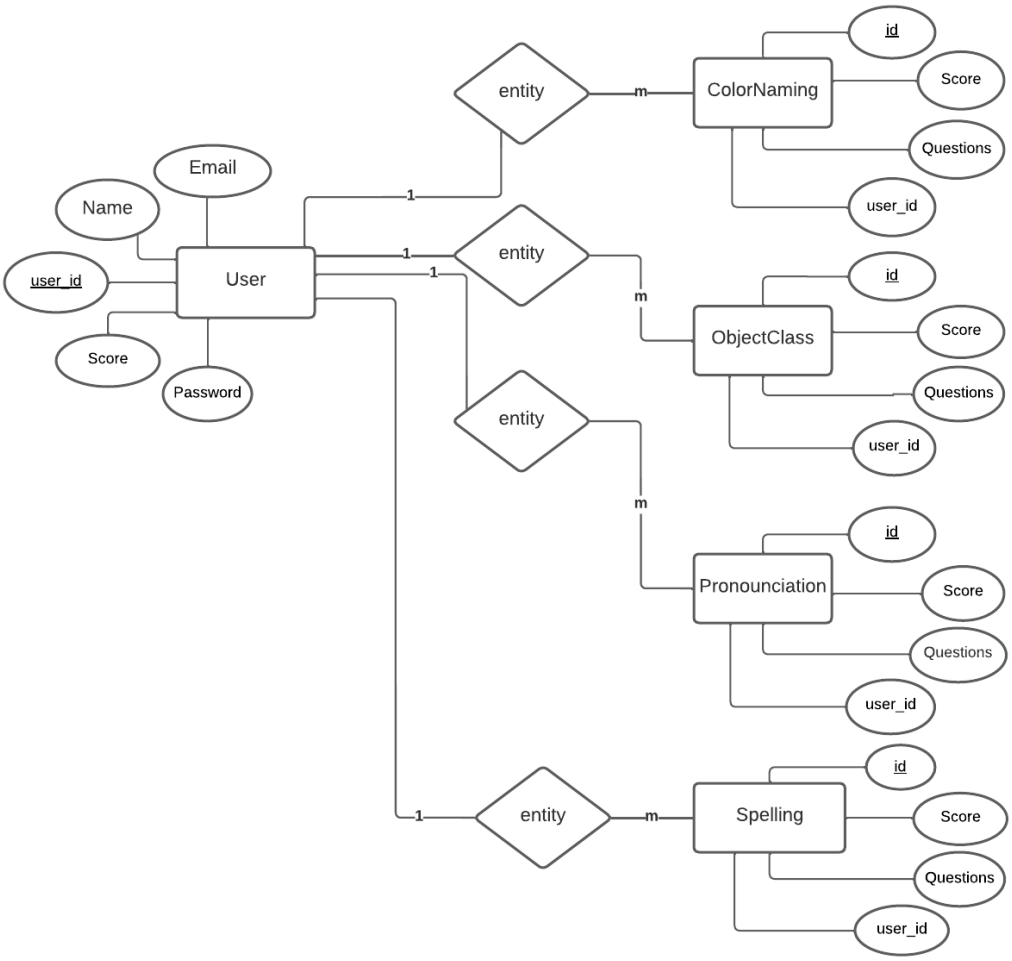

Figure 7: Entity Relationship Diagram

ER diagrams help to explain the logical structure of databases. ER diagrams are created based on three basic concepts: entities, attributes, and relationships. Here are five entities in the ER Diagram: User, Color Naming, Object Class, Pronunciation, and Spelling. Entities refer to tables used in databases.

As shown in figure 7, attributes are properties or characteristics of entities represented by an oval. An ERD attribute can be denoted as a primary key identifying a unique attribute as an underlined attribute that can be assigned to multiple attributes. It can be a derived attribute represented by a dashed oval or a multivalued attribute denoted by a double oval.

e) Class Diagram

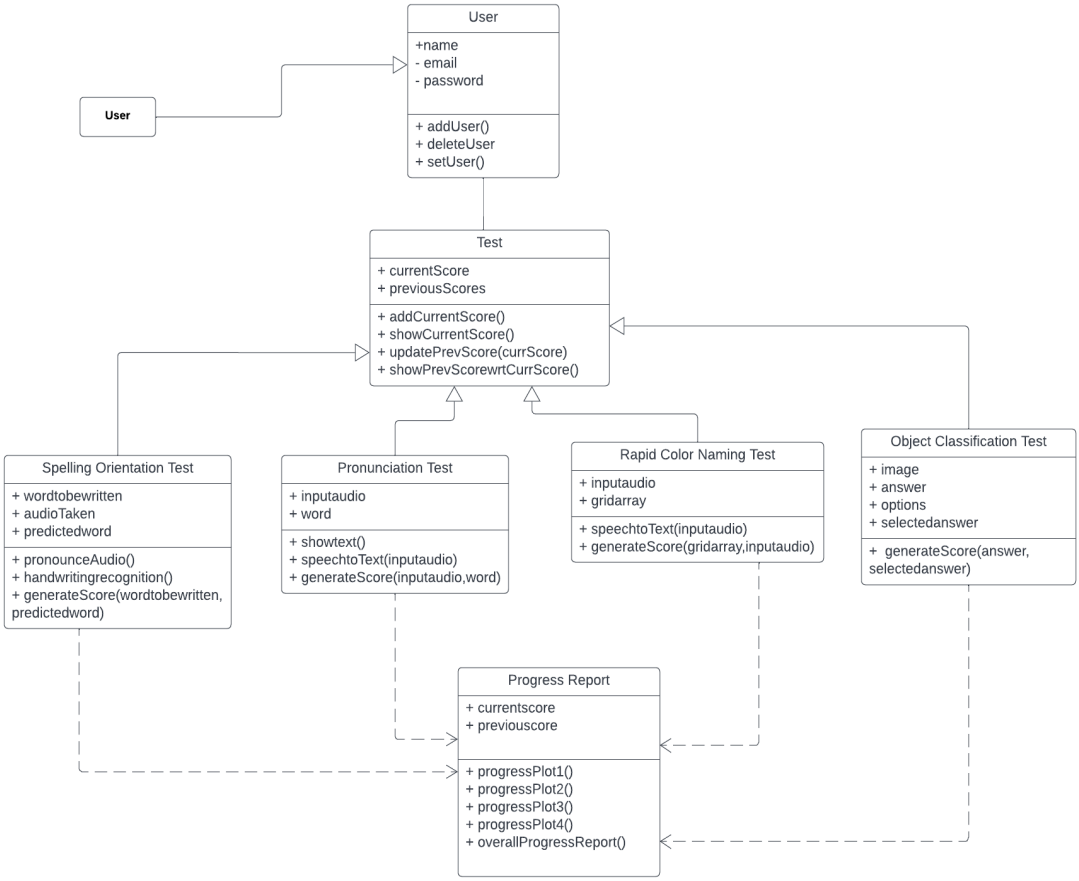

Figure 8: Class Diagram

The class diagram is the primary building block of object-oriented modeling. A class Diagram describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects.

We have seven classes: User, Test, spelling Orientation Test, pronunciation Test, Rapid color naming test, Object Classification Test, and Progress Report class. Four categories are inherited from the test class, and they inherit the data members and member functions of the parent class, i.e., the Test Class. Class Progress Report has a dependency relationship with the four classes, including the Spelling Orientation Test, Pronunciation Test, Rapid color naming test, and Object Classification Test.

f) State Chart Diagram

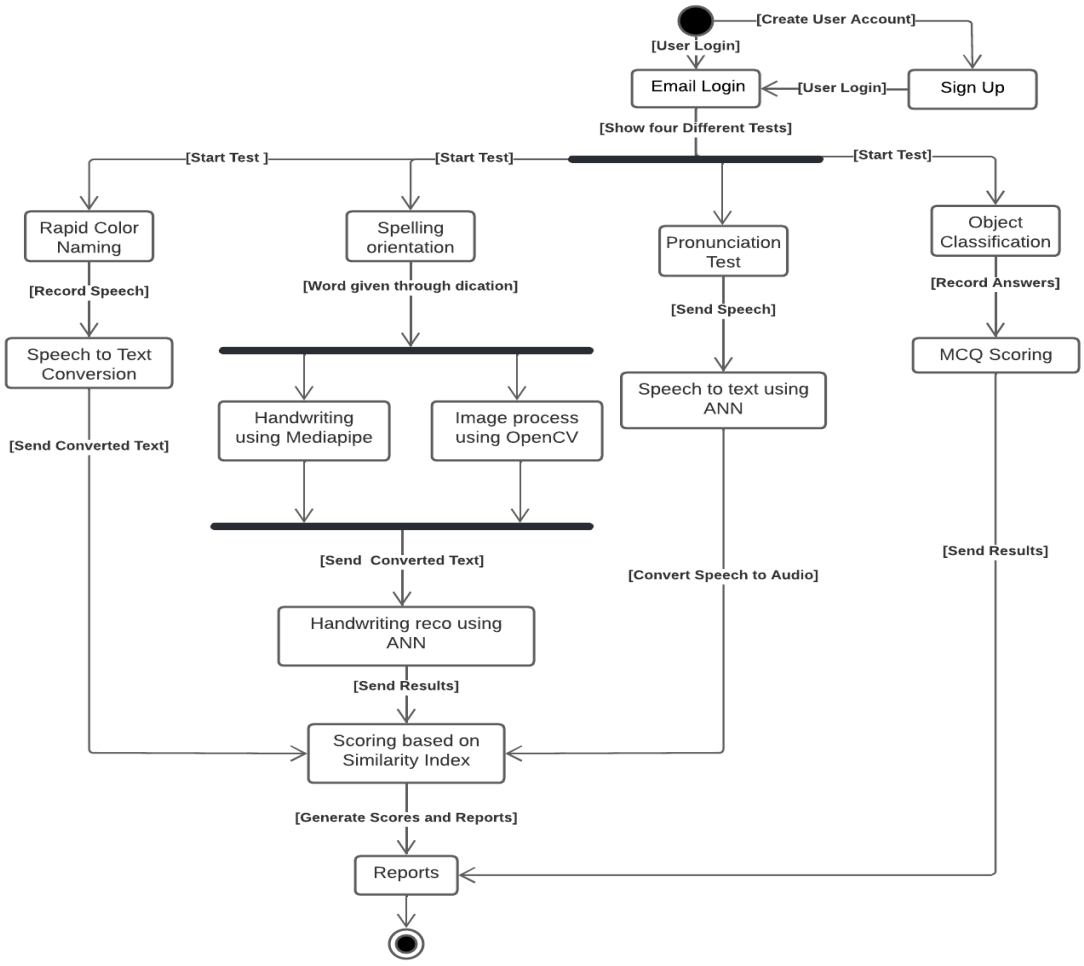

Figure 9: State Chart Diagram

A State Chart diagram describes a state machine. The state machine can be defined as a machine that defines different states of an object, and external or internal events control these states.

In figure x, an event changes its state when there is either a change event, call event, signal event, or elapsed time event.

4.3 User Interface Diagram

Use Case Diagram

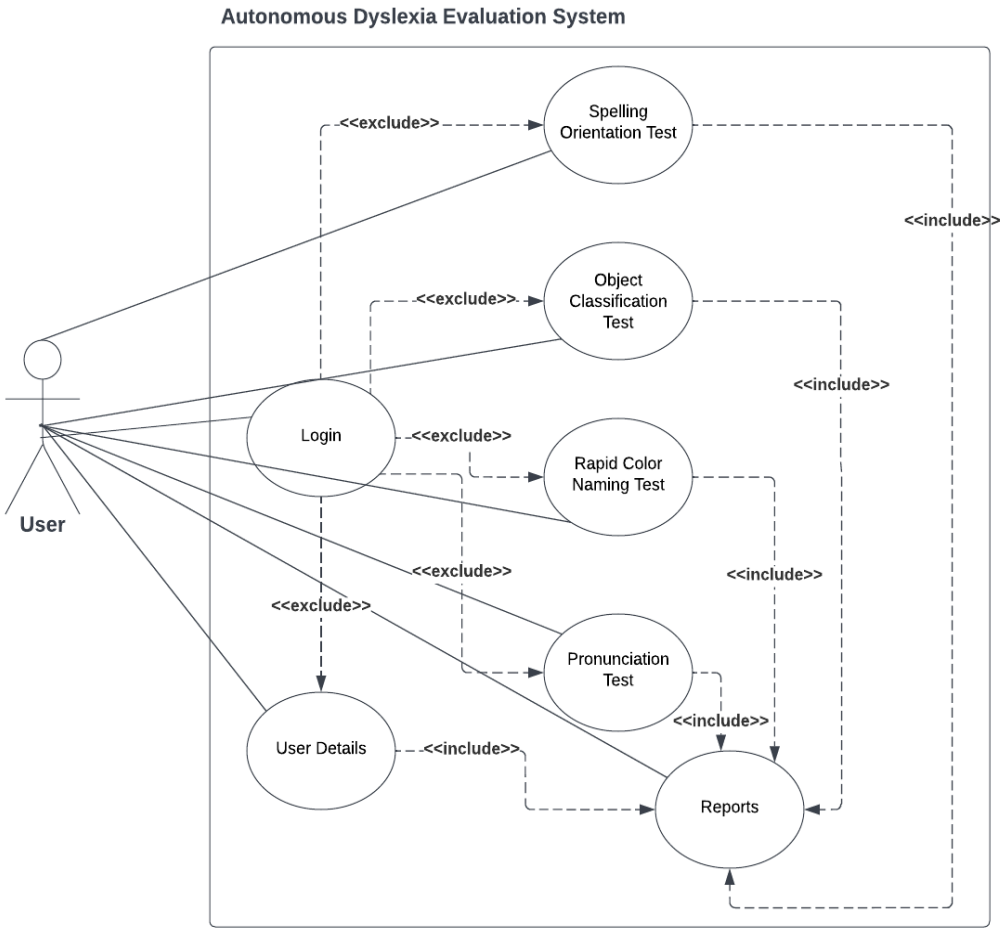

Figure 10: Use Case Diagram

A Use Case Diagram, at its simplest, is a representation of a user's interaction with the system that shows the relationship between the User and the different use cases in which the User is involved.

As shown in figure 10, one user in our case, i.e., Student. In the beginning, the User will log in and can perform the four tests of our evaluation system, i.e., Spelling Orientation Test, Pronunciation Test, Rapid color naming test, and the Object Classification Test. Users can use the website at their places anytime. The final progress report will be shown to the student in its profile.

Use Case Templates:

Table 6: Table describing the Use Case template of Login/Signup

Use Case Title	Login / Signup
Use Case Id	1
Actors	User (Student) (Primary)
Description	The user will authenticate into the system using their email id.
Pre-conditions	It is mandatory to have an email to create a user account. Internet connection is mandatory.
Task Sequence	The user will log in to the system using their email id. The user will create a new account for cases where the user ID does not exist.
Postconditions	Users will be given options to give one out of four tests or check the previous test scores.
Modification History	01-08-2022
Author	Paras Bakshi, Sanidhiya, Shreya Somani, Kashish

Table 7: Table describing the Use Case template of Spelling Orientation Test

Use Case Title	Spelling Orientation Test
Use Case Id	2
Actors	User (Student) (Primary)
Description	The system will pronounce a word. The user is supposed to write the word on the screen using the Virtual Painter Tool
Pre-conditions	It is mandatory to have a webcam and speakers to take this test. Internet Connection of 4 Mbps is mandatory
Task Sequence	The user will be prompted to start the test. For each word, press pronounces button to dictate the word. Then write the word on the screen. Then click next to evaluate the writing.

Postconditions	They will be prompted for the final score of this test and can give other tests. Their progress report will get updated.
Modification History	01-08-2022
Author	Paras Bakshi, Sanidhiya, Shreya Somani, Kashish

Table 8: Table describing the Use Case template of the Pronunciation Test

Use Case Title	Pronunciation Test
Use Case Id	3
Actors	User (Student) (Primary)
Description	The system will display a word on the screen. The user is supposed to pronounce the word correctly.
Pre-conditions	It is mandatory to have a microphone to take this test Internet Connection of 4 Mbps is mandatory
Task Sequence	The user will be prompted to start the test. For each word, press the mic button to record the word. Then click next to evaluate the pronunciation.
Postconditions	They will be prompted for the final score of this test and can give other tests. Their progress report will get updated.
Modification History	01-08-2022
Author	Paras Bakshi, Sanidhiya, Shreya Somani, Kashish

Table 9: Table describing the Use Case template of Rapid Color Naming Test

Use Case Title	Rapid Color Naming Test
Use Case Id	4
Actors	User (Student) (Primary)
Description	The system will display rows of colors on the screen. User is required to name the color in their order of appearance.

Pre-conditions	It is mandatory to have a microphone to take this test Internet Connection of 4 Mbps is mandatory
Task Sequence	The user will be prompted to start the test. Press the mic button to record the order of colors in the correct order. Then click on the finish test button to evaluate the pronunciation.
Postconditions	They will be prompted for the final score of this test and can give other tests. Their progress report will get updated.
Modification History	01-08-2022
Author	Paras Bakshi, Sanidhiya, Shreya Somani, Kashish

Table 10: Table describing the Use Case template of Object Classification Test

Use Case Title	Object Classification Test
Use Case Id	5
Actors	User (Student) (Primary)
Description	The system will show images of various objects and four options, out of which one is correct. The user will select the correct option.
Pre-conditions	Internet Connection of 4 Mbps is mandatory
Task Sequence	The user will be prompted to start the test. The user will select the correct options out of the four options shown. After finishing the test, the user will be shown the correct responses.
Postconditions	They will be prompted for the final score of this test and can give other tests. Their progress report will get updated.
Modification History	01-08-2022
Author	Paras Bakshi, Sanidhiya, Shreya Somani, Kashish

Table 11: Table describing the Use Case template of the report

Use Case Title	Report
Use Case Id	6
Actors	User (Student) (Primary)
Description	The system will show progress reports of each test.
Pre-conditions	Internet Connection of 4 Mbps is mandatory
Task Sequence	Click on the reports section button. Then, select the desired test whose report is to be viewed. The report will be shown to the user.
Postconditions	Users can return to the home screen to choose a desirable test or log out.
Modification History	01-08-2022
Author	Paras Bakshi, Sanidhiya, Shreya Somani, Kashish

4.4 Snapshots of Working Prototype

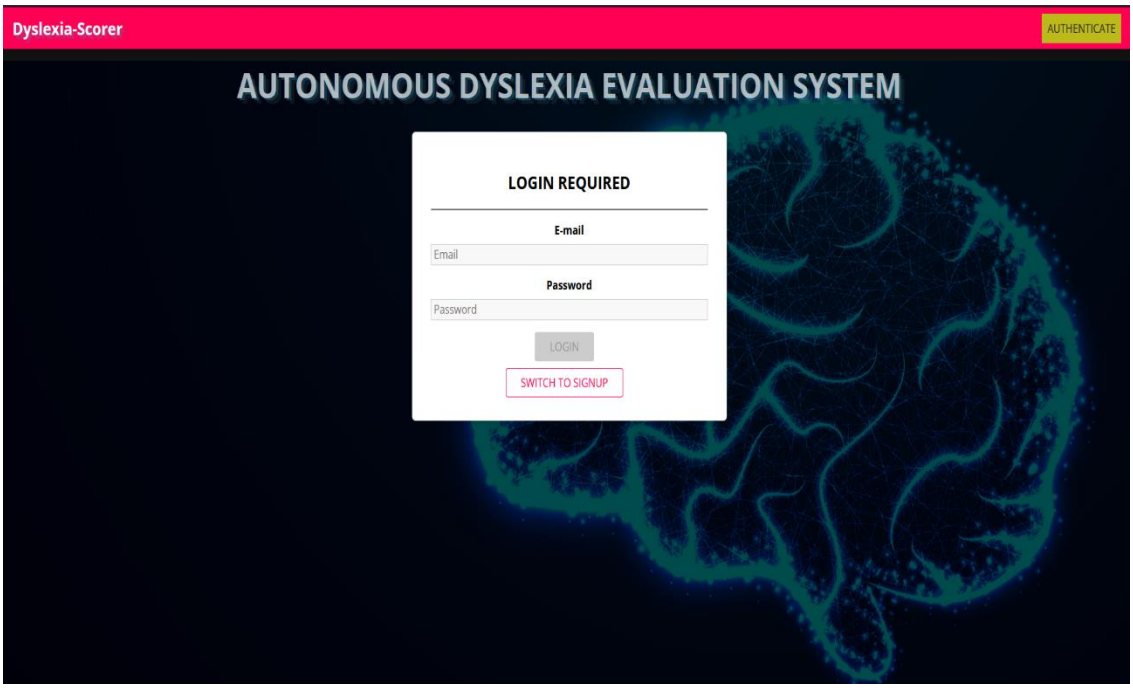

Figure 11: Login/SignUp Page for User Authentication

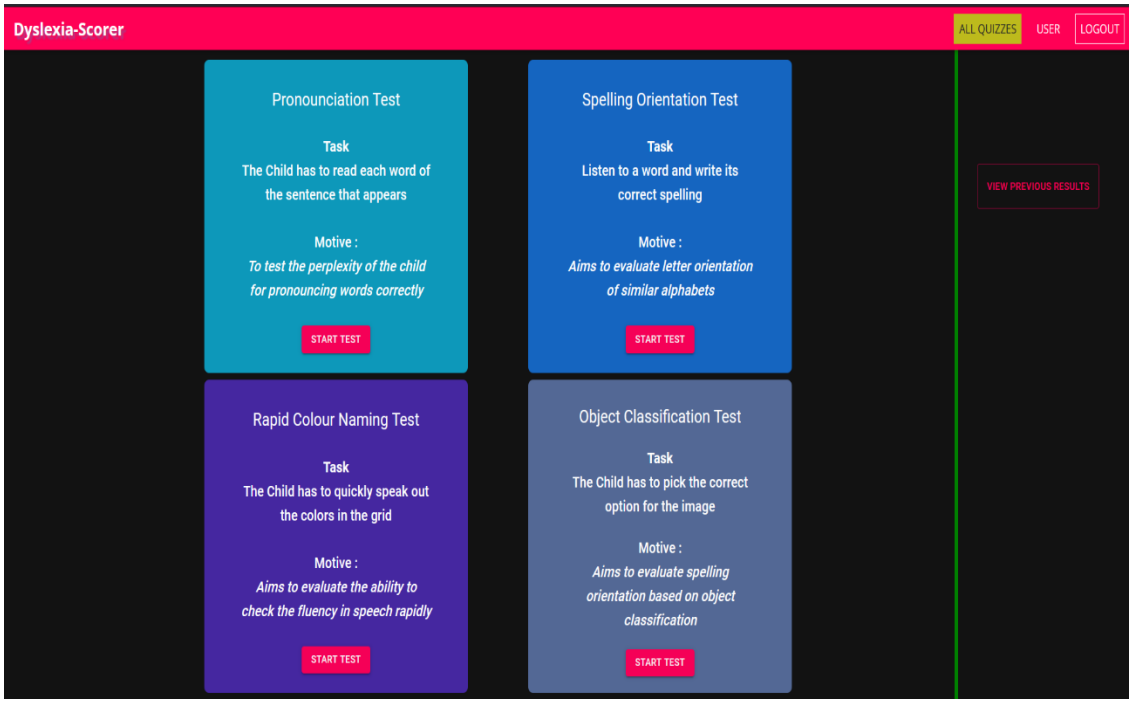

Figure 12: Home Page showing Pronunciation Test, Spelling Orientation Test, Rapid Color Naming Test and Object Classification Test.

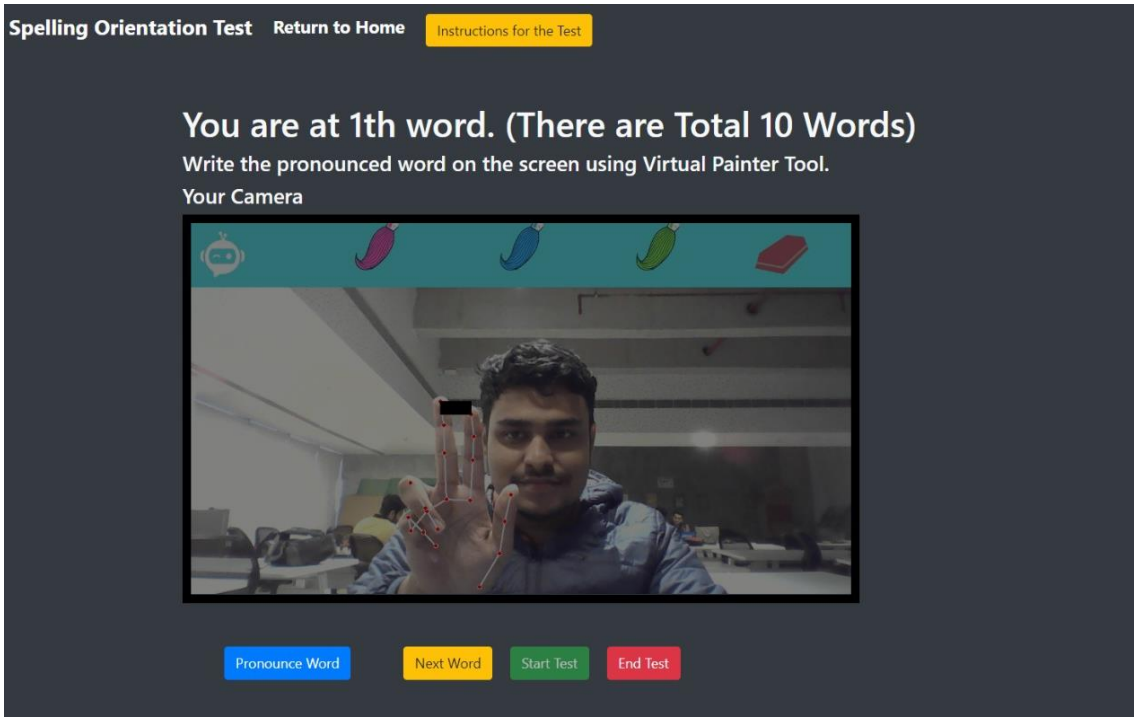

Figure 13: After selecting tool from the selection mode and ready to write after listening

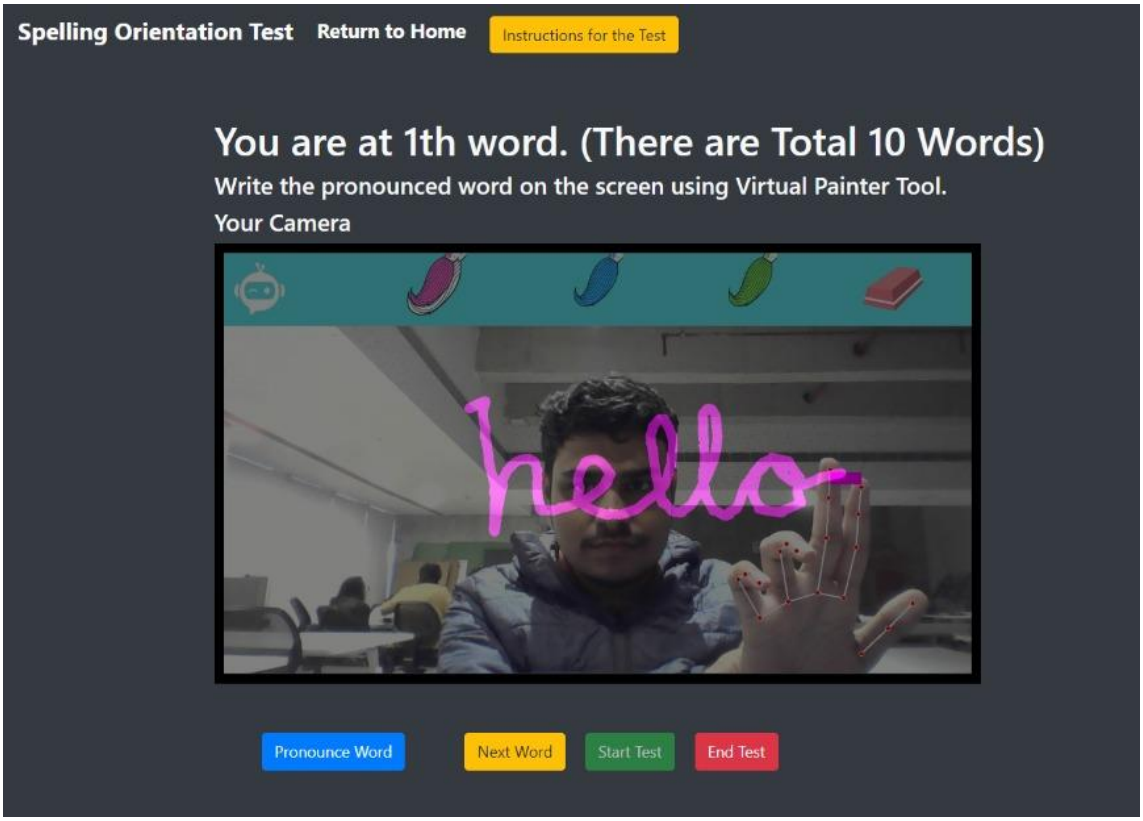

Figure 14: After writing the word, ready for evaluation.

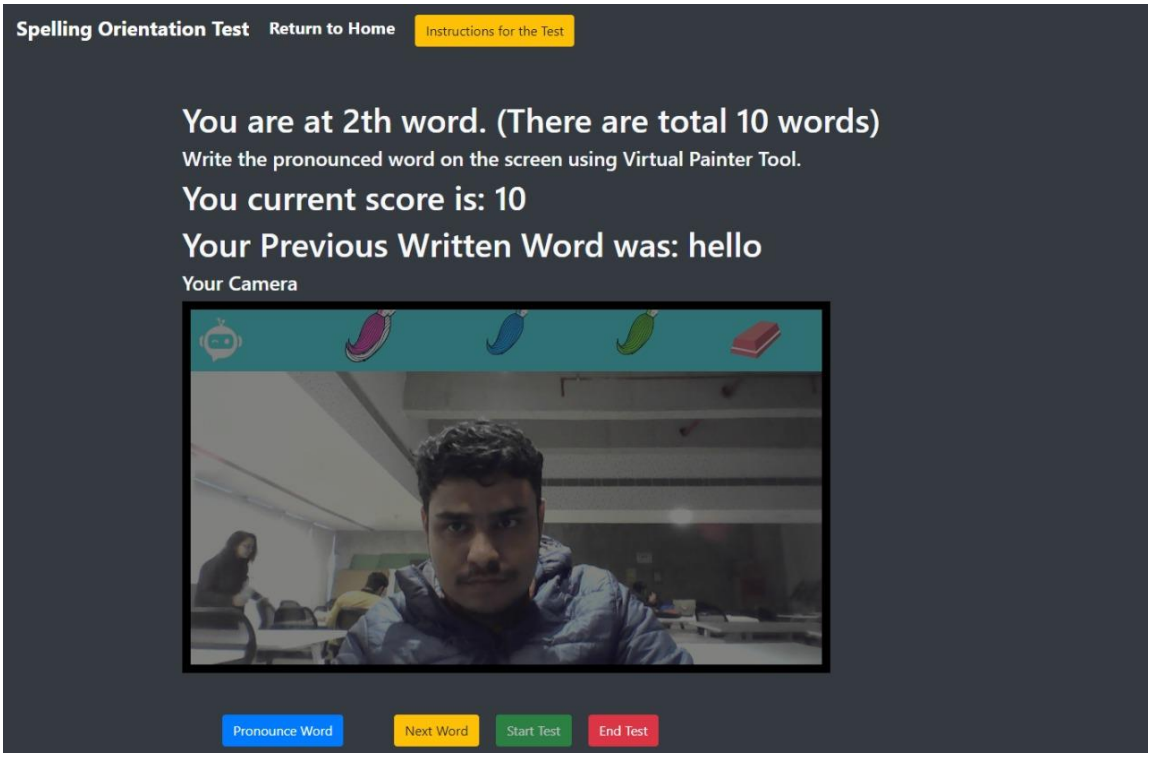

Figure 15: After evaluating the written word

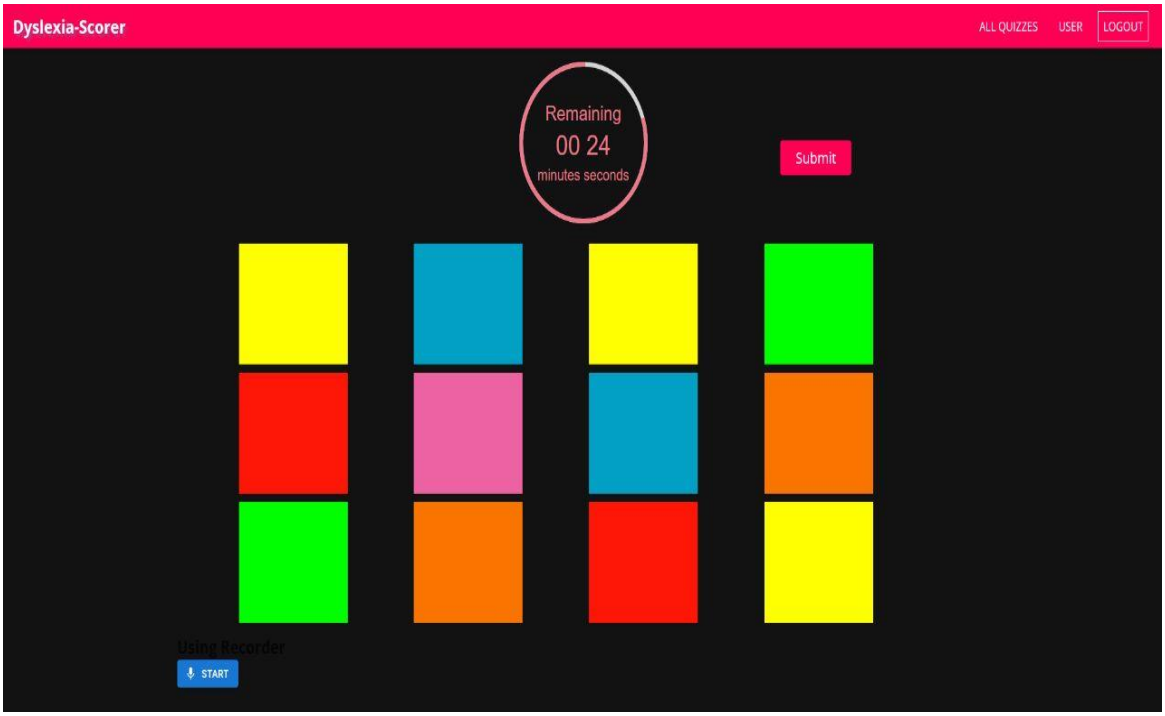

Figure 16: Rapid Color Naming

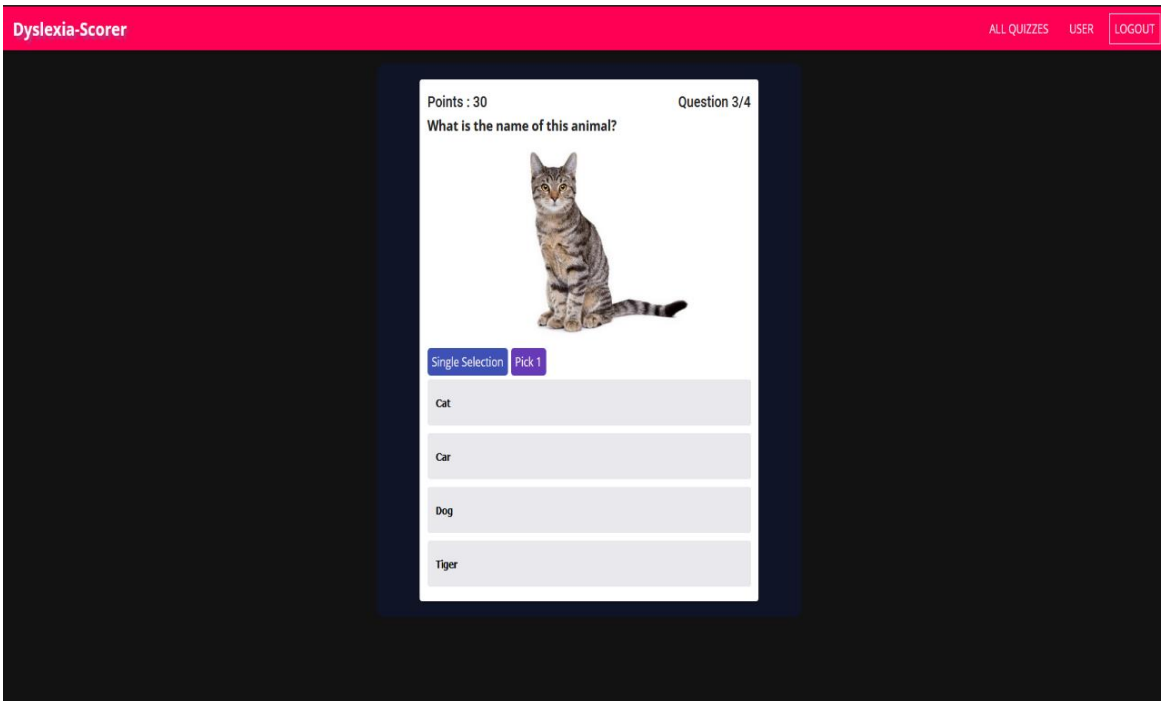

Figure 17: Object Identification Test User Interface

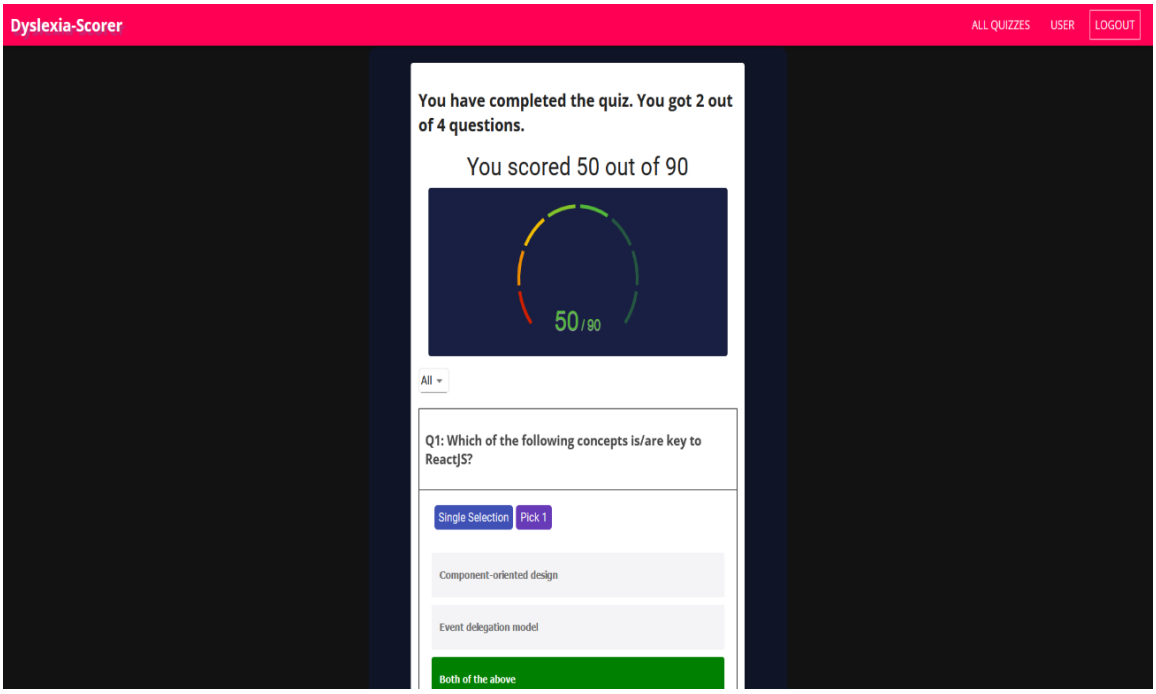

Figure 18: Object Identification Test Score

IMPLEMENTATION & EXPERIMENTAL RESULTS

5.1 Experimental Setup

In the project, the camera is connected to the USB port of the laptop which records the video signals and forwards them to the OpenCV library.

5.1.1 Data

For our model, we have created two kinds of datasets. We have an audio collection that is prepared by recording the different pronunciations of words spoken by dyslexic children. And we have the IAM dataset used for the handwriting recognition module. In our model, we have trained our model both on negative data and positive data to increase the accuracy.

5.2 Performance parameter

- **Efficiency**- We are trying to provide a more efficient platform to help assist dyslexic children on the journey to progress.
- **Time Completion**- of the project is 11 months starting from February 2021 to November 2022. In the given time frame all the deliverables have been achieved.
- **Cost**- It is a cost-efficient prototype till now, if we implement it on a large scale the effectiveness would be good.
- **Quality**- The success of this project would increase the quality of current research going in this field as we are using deep learning. The development of this project would lead to an increase in the progress of dyslexic children. Hence proving quality to children well by reducing the hassle to be physically monitored.

5.3 Working of project

5.3.1 Procedural Workflow

In an object classification test, multiple options are presented in the form of a quiz. The options against each question selected are recorded to compare with correct answers and the score is generated.

Handwriting recognition module involves mediapipe to track hands, an OpenCV virtual painter, and an OpenCV image capture of words drawn. The image is then sent to CNN to recognize the word and compare it with the original word to generate a score

Rapid color naming includes rows of colors shown, given a time frame the child has to speak the name of the color in the correct order, after speaking speech recognition creates a string of colors. We pick the first letter of each word and form a string and match it with the correct answer string using the Jaccard Similarity metric

The pronunciation evaluation test involves audio sample collection, MFCC calculation, RNN model creation, comparison with the correct answer, and score generation.

5.3.2 Algorithmic Approaches Used

Step 1: Web Application Runs on the server with all the required services.

Step 2: The user is presented with the option of giving four types of tests. They can also visualize their results using appropriate graphs.

Step 3: For Object Classification Test: The user is presented with an object on the screen and four options. The user has two select the correct option to get points.

After completing the test, the user will be shown the appropriate score on the screen.

Step 4: For Spelling Orientation Test:The system will pronounce the word to be written on the screen. They will write the word on the screen using their hands through a virtual painter The system will identify the appropriate writing shown on the screen

and will proceed to the next word. The system will generate a final score for the test based on correctness and writing.

Step 5: For Rapid Colour Naming Test: The user will be shown rows of random colors.

They have to say the colors in the correct order, as shown by clicking on the microphone button on the screen within a given time frame. They will be shown the final score of the test based on the proper ordering of colors shown.

Step 6: For Pronunciation Test: The user will be displayed a series of words on the screen. They have to say the words in the same order as shown. They will be evaluated based on fluency and correctness of pronunciation.

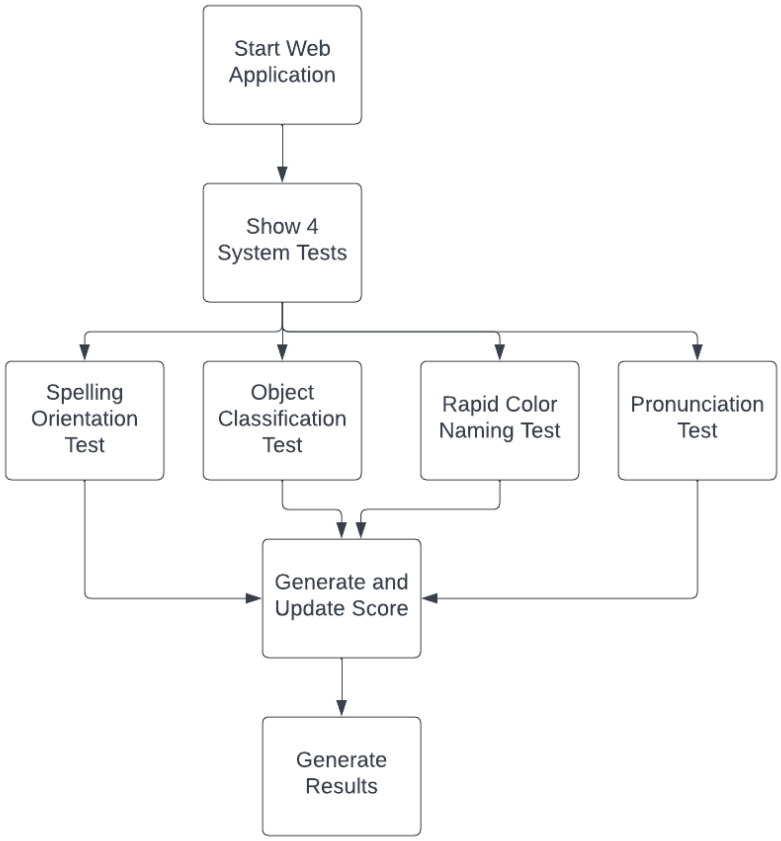

Figure 19: Work Flow

5.4 Testing Process

5.4.1 Test Plan

A test plan for a software project is defined as a document that defines the objective, scope, emphasis, and approach of a software testing effort. Components of the Test plan include Test plan id, features to be tested, test techniques, testing tasks, features pass or fail criteria, test deliverables, responsibilities, and schedule.

5.4.1.1 Features to be tested

- Testing virtual painter which writes in air.
- Checking the accuracy of the CNN model-based handwriting recognition test.
- Checking the accuracy of the RNN model-based pronunciation evaluation test.

5.4.1.2 Test Strategy

A test strategy is a set of guidelines that explains test design and determines how testing needs to be done.
So here we are going to test different modules of the algorithm and check if there are any errors. If any errors are encountered, we will try to correct them with minimal changes that we can do in the project, making sure that these changes won't create any new errors.

5.4.1.3 Test Technique

Unit Testing: Unit testing is a level of software testing where singular modules of the product are verified. The intention is to approve that every unit of the product proceeds as structured. A unit is the littlest testable piece of any product. It as a rule has one or a couple of sources of inputs and normally a singular yield.

The modules to be tested are:

Hardware

- Adjust the camera from how far it can detect.

Software

Pronunciation module - Checking if the word written on the screen is being properly recognized or not.

Spelling orientation module –Checking if the word written is correctly classified by our Handwriting Recognition Model and if our hands are tracked correctly or not.

Rapid color naming module – Checking if the colors named on the screen are in the correct order.

Object classification module - If the object displayed on the screen is displayed correctly with options.

Graphical module – Graphs generated to properly visualize the scores.

Integration Testing: Integration Testing is a level of software testing where singular units are consolidated and verified as a gathering. The motivation behind this degree of testing is to uncover errors in the association between incorporated units. Test pilots and test stubs are utilized to aid Integration Testing.

RNN and CNN models accuracy tested, weights adjusted and learning curve created.

Acceptance Testing: Acceptance Testing is a level of software testing where a system is tested for acceptability. The purpose of this test is to evaluate the system's compliance with the business requirements and assess whether it is acceptable for delivery. All modules are to be tested with real-time user values.

Regression Testing: Regression Testing is a kind of software testing that expects to guarantee that changes (upgrades or imperfection fixes) to the product have not unfavorably influenced it. The probability of any code change affecting functionalities that are not legitimately connected with the code is consistently there and regression testing is directed to ensure that fixing one thing has not broken something else. During this testing, new experiments are not made however recently made experiments are re-executed.

5.4.2 Test Case

In the Spelling Orientation Test, we used a hand-tracking module to assist the child in writing the word on the screen. After the word is successfully written, the system will identify the writing with the help of custom trained CNN Model. Then, the score is generated after matching it with the correct word using a similarity index metric.

In Pronunciation Test, we check the pronunciation of the word written on the screen. Then, the child is evaluated on the correctness of the pronunciation of the word. This is done through custom trained ANN model.

In the Rapid color naming test, we present a series of rows of colors on the screen. The child will be asked to name the colors starting from the first row at the top from left till the last row at the bottom to the right. Scoring will be done on the time taken to name all the colors and the order in which the colors are named on the screen.

In Object Classification Test, the child is required to answer specific questions on the screen where the child is supposed to identify the object displayed on the screen. Four relevant options will be shown to the child, of which one will be correct.

5.4.3 Test Results

We can visualize the results of all 4 tests through the following graphs.

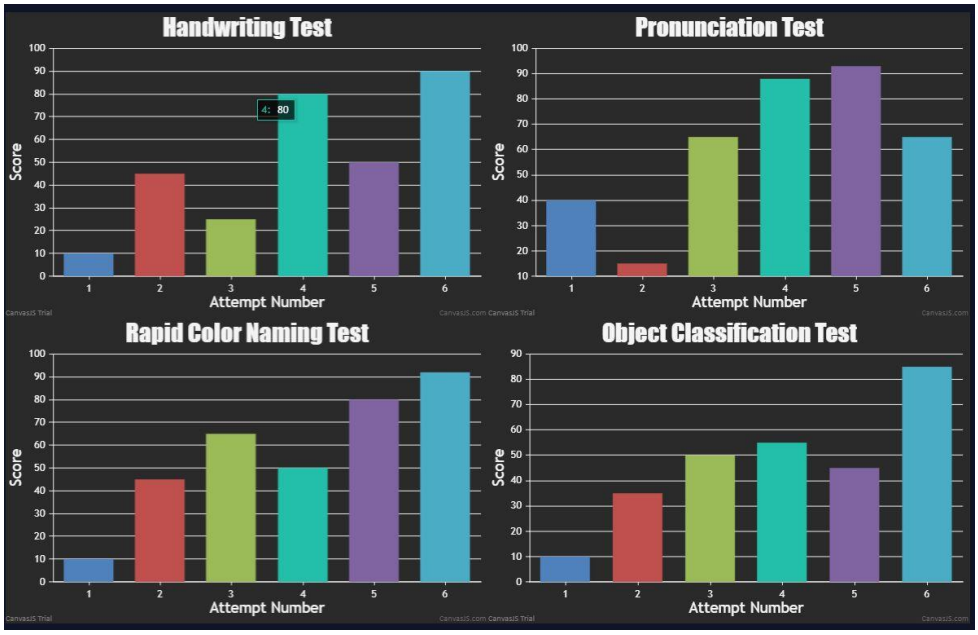

Figure 20: Result Outcome (Histogram)

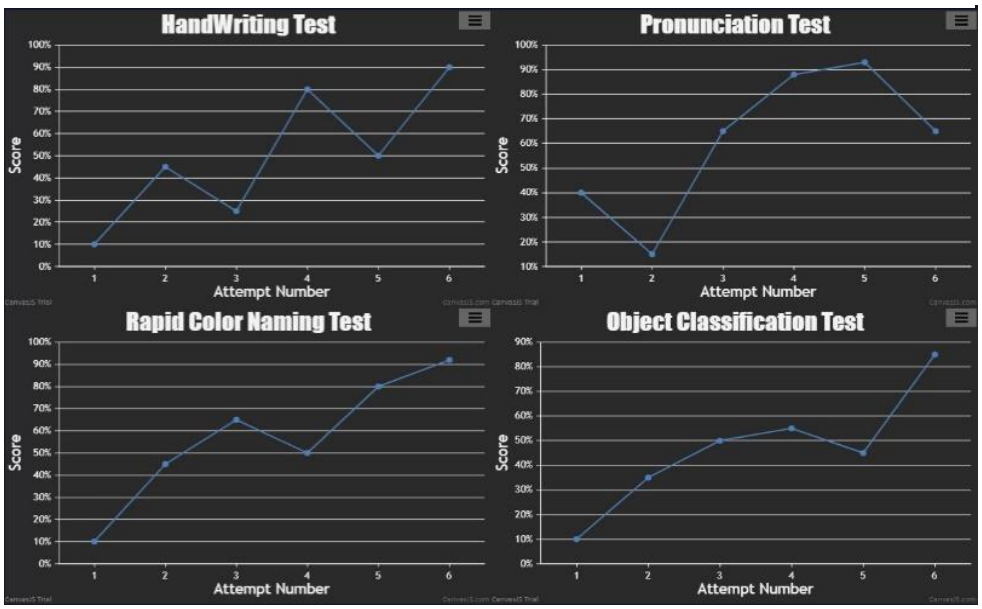

Figure 21: Result Outcome (Line Chart)

5.5 Results and Discussions

The following results are achieved from the project:

- Pronunciation evaluation module is producing accurate results.
- Spelling orientation module is recognizing handwriting correctly.
- Rapid color naming module is recording and identifying accurate order of names of colors spoken.
- Object classification module is producing seamless results based on the options selected.

5.6 Inferences Drawn

The following inferences can be drawn by the working of this project:

- The system can be used by doctors to automate the result.
- Doctors can monitor the progress of the child using appropriate graphs.
- The system can be used in special schools for testing dyslexic children.
- Based on the expected outcomes, the system is working well.

5.7 Validation of Objectives

Table 12: Validation of Objectives

S. No.	Objective	Status
1	To evaluate the spelling of a word.	Done
2	To check the correctness of pronunciation of the word spoken.	Done
3	Record and evaluate the order of color names spoken and the time taken to name them.	Done
4	To generate a score based on the option selected against each picture shown.	Done

CONCLUSION AND FUTURE SCOPE

6.1 Work Accomplished (Discussion w.r.t the Approved Objectives)

The following objectives have been accomplished, which are listed below:

- The main objective of our project is to automate the process of a dyslexic child's evaluation and track the progress of the dyslexic child is accomplished.
- Web Interface for all types of Tests, which includes Spelling orientation, pronunciation, object classification-based spelling orientation test, and color recognition-based fluency test conducted, is completed.
- Statistical Reports generation feature to keep track of dyslexic subjects is completed.
- CNN (Convolution Neural Network) for Handwriting Recognition is trained and ready to be used.
- ANN (Artificial Neural Network) for Speech to text conversion is trained and ready to be used.
- Virtual Painter Module for Spelling Orientation Test which uses Mediapipe for Hand tracking and Open CV for Computer Vision, is ready to be used.
- Object Classification based spelling orientation test is completed.
- To maintain the track record of the dyslexic subject test.
- An autonomous system is a setup that eliminates the requirement of a doctor.
- Increased the efficiency of the dyslexic evaluation process and keep a track record of the progress.
- Provided a personalized remote-based solution that helps evaluate Dyslexia at any time and anywhere free of cost.

6.2 Conclusions

All the objectives listed above have been achieved successfully. All the evaluations consist of tests of spelling orientation, Pronunciation, Object Classification, and Color Recognition will be implemented successfully. The main objective of our project is to automate the process of a dyslexic child's evaluation and track the progress of the dyslexic child is accomplished. We can test a patient for Dyslexia using an autonomous system that eliminates the requirement of a doctor. Maintain a track record of the patient, which helps monitor the patient's progress, and these track records can also be presented to a doctor for proper treatment. Increased the efficiency of the dyslexic evaluation process and optimize the overall cost. Provides solutions to the problem that 20 percent of the population face and a personalized remote-based solution that helps evaluate Dyslexia at any time and anywhere free of cost.

6.3 Environmental (/Economic/Social) Benefits

Dyslexia **affects 20 percent of the population** and represents 80–90 percent of all those with learning disabilities. The project aims to track the progress of a Dyslexic subject and evaluate that person dealing with Dyslexia through a series of tests. The evaluation system will be designed while acknowledging the targeted age group. Hence, it will have a minimal interface and will be child friendly. The system requires only a stable internet connection, and no additional cost will be incurred. We promise to deliver an evaluation system with no financial constraints. Provides a solution to the problem that 20 percent of the population faced. A physical evaluation is not always free of cost, thus depriving children of humble homes a fair opportunity to progress and succeed in overcoming this disorder.

6.4 Future Work Plan

The Autonomous Dyslexia Evaluation system currently consists of four tests to evaluate Dyslexia. Future work intends to introduce more tests related to dyslexia evaluation and improve the accuracy of models and Analyses.

The tests which can be introduced as a future work plan include:

Decoding: The ability to read unfamiliar words using letter-sound knowledge, spelling patterns, and chunking the word into smaller parts, such as syllables. Decoding tests should use nonsense words (words that look like actual words but have no meaning, such as *frut* or *crin*).

Reading comprehension: Typically, children with dyslexia score lower on reading comprehension tests than on listening comprehension because they have difficulty decoding and accurately or fluently reading words.

Automaticity/fluency skills: Children with Dyslexia often have a slow speed of processing information (visual or auditory). Our color naming test can introduce tasks that measure Naming Speed (also called Rapid Automatic Naming) using sets of objects, letters, and numbers.

7.1 Challenges Faced

Finding the solution to the real-life problem of dyslexia: Mapping the problems faced by dyslexic subjects such as difficulty in reading, writing, and fluency skills to be get evaluated by a series of tests that are included in our system was one of the most challenging parts of the project.

Selection of the evaluation metrics: As our project consists of tests of spelling orientation, pronunciation, object classification, and color recognition so to design an evaluation metric that is easily understood by the user was one of our main challenges.

Selection of the Algorithms and Models: In all four tests the selection of the most efficient algorithm in term of time and space complexity and the selection of the model which provide the most accurate result.

Implementation and Data Collection: Implementation of all four tests of spelling orientation, pronunciation, object classification, color recognition, and integration of them together. Collection of data for our deep learning models and arranging the required resources to train them.

7.2 Relevant Subjects

Table 13: Subject Code and Subject Names

Subject Code	Subject name	Description
UCS742	Deep Learning	For Hand Tracking, Handwriting Recognition, and Speech to Text Recognition)
UCS522	Computer Vision	Virtual Painter Module for Spelling Orientation Test which uses Open CV for Computer Vision
UML602	Machine Learning	To implement the machine learning models included in our project
UCS633	Data Analytic and Visualization	It helped us in Data Analysis and Visualization of the scores generated by tests
UCS503	Software Engineering	For making the UML diagrams which includes Use case diagram, class diagram, etc.
UCS310	Database management system	Used for designing schemas of all the different modules in the project.
UCS301	Data Structures and algorithms	For the implementation of the most efficient algorithm in terms of time and space complexity.

7.3 Interdisciplinary Knowledge Sharing

In this project, we have used the principles of different areas of computer science such as Deep Learning, Computer Vision, Machine Learning, Web Development Data Analytics, Visualization, etc. Web Interface for all types of Tests, which includes Spelling orientation, pronunciation, object classification-based spelling orientation test, and color recognition-based fluency test, is implemented by using react for the frontend and Nodejs for the backend. Statistical Reports generation feature to keep track of dyslexic subjects has to be generated. CNN (Convolution Neural Network) for Handwriting Recognition and ANN (Artificial Neural Network) for Speech-to-text conversion are to be trained and deployed. Virtual Painter Module for Spelling Orientation Test which uses Mediapipe for Hand tracking and Open CV for Computer Vision is to be implemented.

7.4 Peer Assessment Matrix

Table 14: Peer assessment matrix

		Evaluation of			
		Kashish	Paras Bakshi	Sanidhiya	Shreya Somani
Evaluation by	Kashish	5	5	5	5
	Paras Bakshi	5	5	5	5
	Sanidhiya	5	5	5	5
	Shreya Somani	5	5	5	5

7.5 Role Playing and Work Schedule

1. **Kashish:** UML Diagram, Front end, Backend, Database, Software Requirements Specification
2. **Paras Bakshi:** Deep Learning Model for Speech Recognition, Documentation, Data Collection, Testing Software
3. **Sanidhiya:** Deep Learning model on handwriting recognition, Documentation, Cost Analysis, Testing Software
4. **Shreya Somani:** UML Diagram, Front end, Literature Survey, Software Requirements Specification

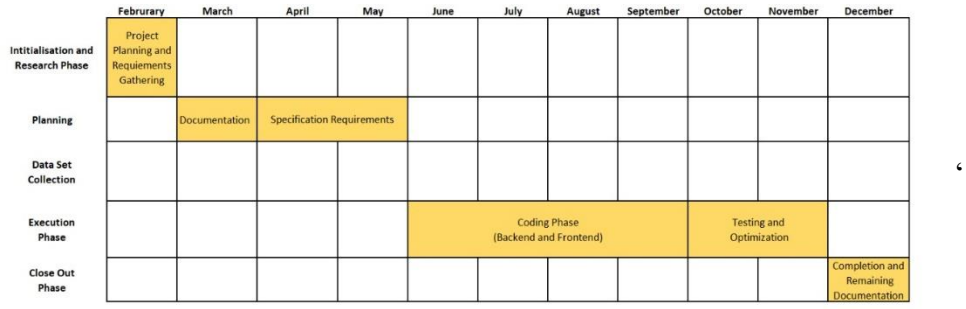

Figure 22: Gantt-Chart of Kashish

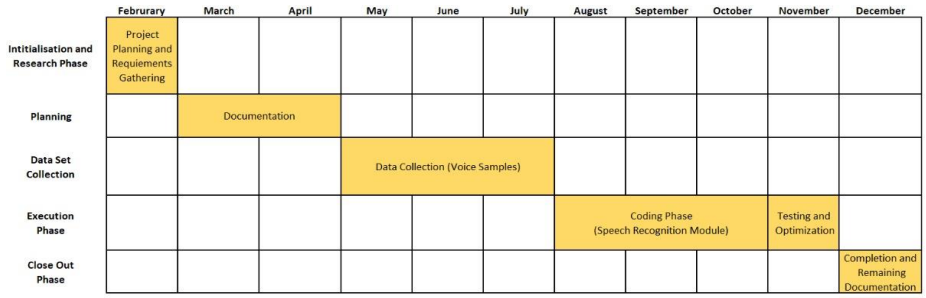

Figure 23: Gantt-Chart of Paras Bakshi

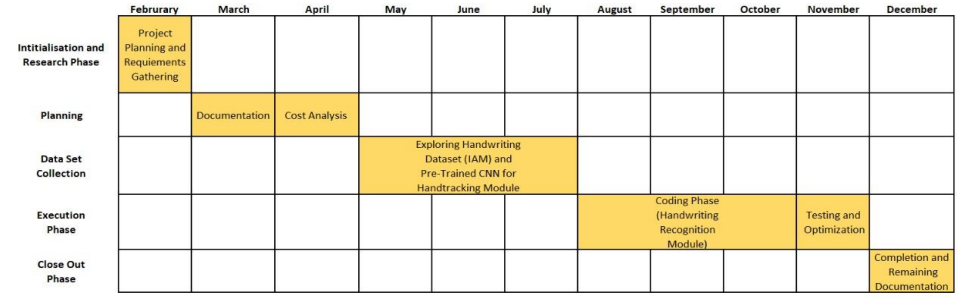

Figure 24: Gantt-Chart of Sanidhiya

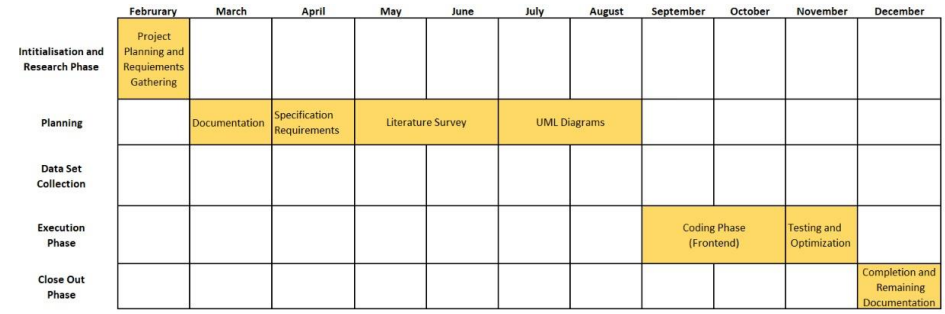

Figure 25: Gantt-Chart of Shreya Somani

7.6 Student Outcomes Description and Performance Indicators

Table 15: Student Outcomes Description and Performance Indicators

SO	DISCRIPTION	OUTCOME
A2.	Applying basic principles of science toward solvingreal-life problems.	Used hand motion in the air to detect it.
B1	Identify the constraints, restrictions, and models for theproblems.	Various restrictions were identified by us which could lead toinaccurate results by our system.
B2	Use tested methods, tools, and techniques for datacollection.	Different and large amounts of data resources are referred to build accurate models.
B3	Analyze and interpret results concerning assumptions, restrictions, and theory.	The person should be in the frame and should know the spelling of the word.
D2	Can play different roles as a team player.	All the team members worked on both, the technical part as well as the documentation part.
E3	Use analytical and computational methods to obtainsolutions.	Used the readings from every dimension to analyze every aspect of the anomaly.
F1	Showcase professional responsibility while interacting with peers and professional communities.	For the data collection, we surveyed a dyslexic school to learn and define real-time problems.
G1	Produce a variety of documents such as laboratory orproject reports using appropriate formats.	All the team members worked on the documentation process andensured the value of time is maintained.
G2	Deliver a clear and effective oral presentation.	Our team delivered PPTs on all mentor as well as el evaluations to show theprogress of our project.
K2.	Apply various codes and algorithmic processes.	Various codes and conversions were used while writing thecode.

7.7 Brief Analytical Assessment

Q1. What sources of information did your team look into to come up with a list of potential project issues?

The team members were aware of the requirements of the project as we spend a good amount of time analyzing our problem statement and mapping it to real-world solutions to evaluate dyslexia by tests of Spelling orientation, Pronunciation, Object Classification, and Color Recognition. We studied various Research papers, visited different websites like dyslexiaida.org, and extract information from various dyslexia blogs. Further, the scope of the project was decided upon by consulting with our mentor and the head of the Dyslexia school.

Q2. What analytical, computational, and/or experimental methodologies did your project team employ to find answers to the project's problems?

Different analytical, computational, and/or experimental methodologies are used we spend a good amount of time analyzing our problem statement and mapping it to real-world solutions to evaluate dyslexia. Meetings were held with the dyslexia school to know the insights of the solution that we came up with for the evaluation of dyslexia. The analytical aspect was to understand the behavior of the model used in the spelling orientation and Pronunciation test.

Q3. Did the project demand demonstration of knowledge of fundamentals, scientific and/or engineering principles? If yes, how did you apply?

Yes, the project did demand a demonstration of knowledge of fundamentals, scientific and/or engineering principles. We have used the fundamentals of various CS subjects deep learning, machine learning, web development, and data analytics and visualization. Also, the principles of software engineering are used in the documentation of our project in a well-defined manner.

Q4. To manage design and production dependencies, how did your teams share responsibilities and communicate scheduling information with others in the team?

The project consists of four different modules namely Spelling orientation, Pronunciation, Object Classification, and Color Recognition. They were broken further into sub-modules and distributed amongst the team members. We maintained the coordination by sharing our research and work during weekly meetups with the other team members. All the objectives were distributed, and team members successfully delivered on their responsibilities thus finishing the work on time.

Q5. For the duration of the project, what resources did you use to learn new materials that were not taught in class?

As in our project we worked with advanced concepts in the field of deep learning, libraries of google, and many other CS advanced fundamentals for building our modules and for evaluation purposes. For that, we use a lot of online content available on youtube, and git hub, and visit various websites like stack-overflow. Our mentor provide support in all doubts that we had regarding the project. For further knowledge, we refer to research papers related to the framework of different libraries of google like mediapipe and advance technology used in our project.

Q6. Is the project making you grasp the need of utilising engineering to address real-world issues, and might the project development be making you skilled with software development tools and environments?

Yes, the project helps us to grasp the need of utilising engineering to address real-world issues, and might the project development be making you skilled with software development tools and environments? From Mapping the problems faced by dyslexic subjects such as difficulty in reading, writing, and fluency skills to be get evaluated by a series of tests that are included in our system which are Spelling orientation, Pronunciation, Object Classification, and Color Recognition. A web-based application to automate the process of Dyslexia evaluation and maintain a track record. Provide a personalized remote-based solution and helps to monitor the progress of the Dyslexic subject.

APPENDIX A: REFERENCES

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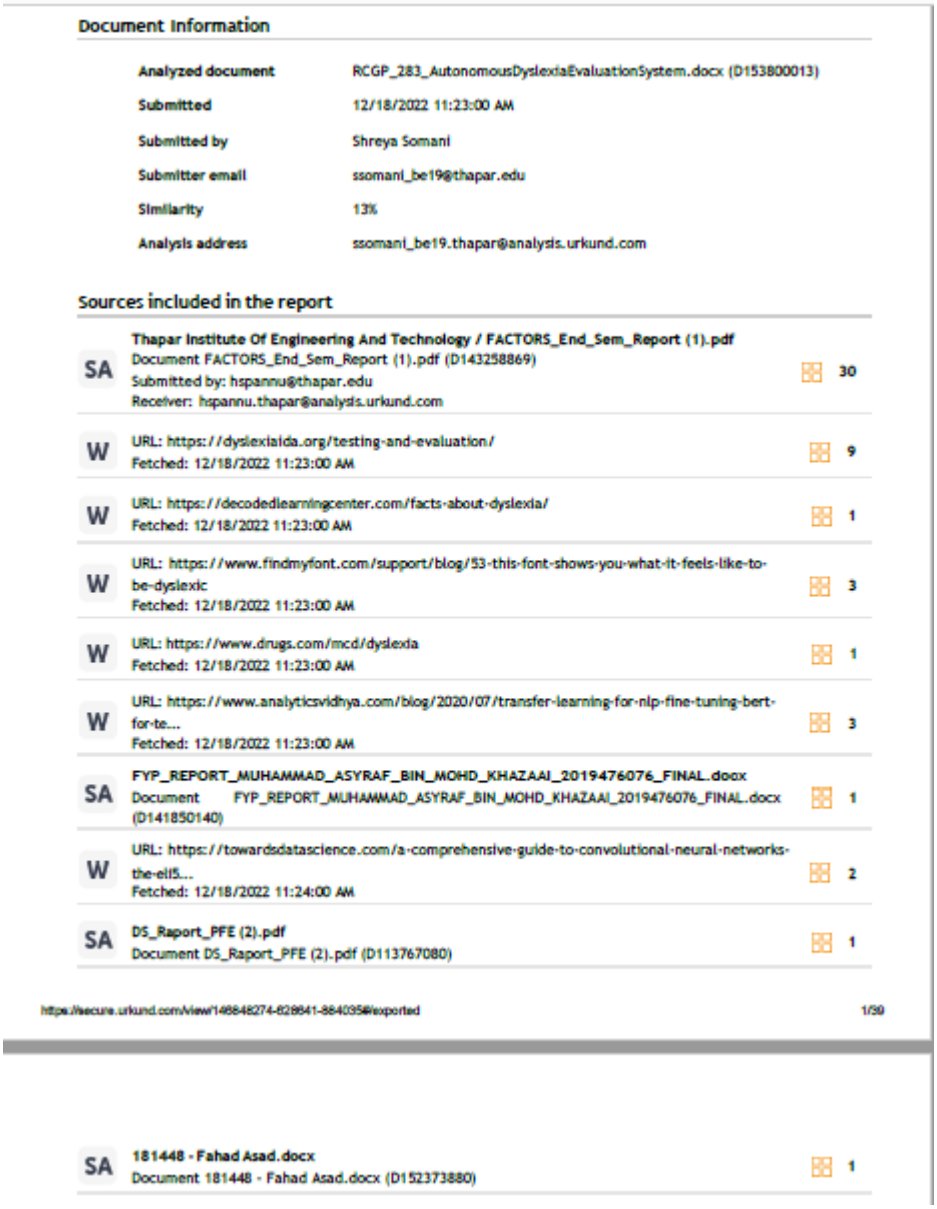
APPENDIX B: PLAGIARISM REPORT



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Submitted	12/18/2022 11:23:00 AM
Submitted by	Shreya Somani
Submitter email	ssomani_be19@thapar.edu
Similarity	13%
Analysis address	ssomani_be19.thapar@analysis.urkund.com

Sources included in the report

SA	Thapar Institute Of Engineering And Technology / FACTORS_End_Sem_Report (1).pdf Document FACTORS_End_Sem_Report (1).pdf (D143258869) Submitted by: hspannu@thapar.edu Receiver: hspannu.thapar@analysis.urkund.com	30
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Figure 26: Plagiarism Report of the Project File