

Ishara: Artificial Intelligence Based Bangla Sign Language E-Learning Application for Deaf-Mute Children.

by

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*Project report (CSE499) submitted in partial fulfillment of the
requirements for the degree of*

Bachelor of Science in Computer Science and Engineering

Under the supervision of

Sabrina Jesmin



**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
UNIVERSITY OF LIBERAL ARTS BANGLADESH**

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DECLARATION

Project Title	Ishara: Artificial Intelligence Based Bangla Sign Language E-Learning Application for Deaf-Mute Children.
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I declare that this project report entitled *Ishara: Artificial Intelligence Based Bangla Sign Language E-Learning Application for Deaf-Mute Children.* is the result of my own work except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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CERTIFICATE

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Dedicated to
my beloved mother
Aleya Parvin Sharma
Father
Shajahan Ahamed
Elder Sister
Sharmin Sultana Kakon
Brother-in-law
Tanvir Hasan
– *Akash Ahamed*

ABSTRACT

Deaf and mute persons may only communicate and study via sign language, but they often face various challenges in achieving education. Due to the lack of sufficient sign language education among the majority of the family and society, it is very difficult to get help from other family members in providing sign language education or to find tutors who are skill in sign language. Although adults learn to associate certain words or symbols with sign language as they grow up, which is difficult for children to do. Therefore, this project's goal is to create an android mobile application with artificial intelligence to help deaf and mute children understand and learn the Bengali alphabet and number sign. The application will contain Bengali alphabet and number sign which will be shown in the form of figure according to the learning content. Also, there will be a multiple-choice quiz process through which students can test the knowledge gained from the application. To provide maximum benefit from the technological side the application will use a sign detector mechanism to detect the Bengali meaning of the sign image which selected by the user. To create this application, I used the waterfall Software Development Life Cycle (SDLC) Model.

Keywords: Bangla Sign Language, BdSL, Sign Language, Sign Language Recognition, Alphabet and numbers, E-Learning, Mobile Applications, Image Recognition, Machine Learning, deaf

Contents

1	Introduction	1
1.1	Problem statement	3
1.2	Aims, objectives and Motivation	4
1.2.1	Aims	4
1.2.2	Objective	4
1.2.3	Motivation	4
1.3	Project Specification	5
2	Literature Review	6
2.1	Analysis of Requirements	8
3	Methodology	10
3.1	Specifications for Requirements	11
3.1.1	Functional Requirements	11
3.1.2	Non-Functional Requirements	11
3.2	Data Acquisition	12
3.2.1	Dataset Properties	12
3.3	Train Data and Model Development	12
3.3.1	Modelling	12
3.3.2	Testing the Model	16
3.4	Conversion of Machine Learning Model	17
3.5	Deployment the Application	18
3.6	Maintenance the Application	18

4	Design and Development	19
4.1	Design of the System	19
4.1.1	Use Case Diagram	19
4.1.2	Level 0 Data Flow Diagram	21
4.1.3	Data Flow Diagram at Level 1	22
4.2	Development	23
4.2.1	Application Development Process	23
4.2.1.1	Android	23
4.2.1.2	Flutter Framework	23
4.2.1.3	Programming Language Dart	24
4.2.1.4	Rive Animation Tool	24
4.2.2	Integrating the Model With the Application	25
4.3	Test the Application	26
5	Result analysis	27
5.1	Machine Learning Model Analysis	27
5.2	Android Application Functionalist Analysis	31
6	Conclusions	37
6.1	Social, Legal, Ethical, and Environmental Issues	37
6.2	Brief Summary	38
6.3	Future works	38
	References	40

List of Figures

3.1	Waterfall Software Development Life Cycle	10
3.2	Google Teachable Machine	13
3.3	Google's Teachable Machine Class Create and Data Uploading Peocess	14
3.4	Google's Teachable Machine Training Parameters Set Process	15
3.5	Testing the Model Prediction Result	17
3.6	Exporting model and download	18
4.1	Diagram of the Application's Use Case	20
4.2	Level 0 Data Flow Diagram of the Application	21
4.3	Level 1 diagram of the Application	22
4.4	Integrating the Machine Learning Model With the Application	25
4.5	TensorFlow Packages Install in the pubspec.yaml Folder.	26
5.1	Model Training Result of Confusion Matrix	29
5.2	Performance Evaluation Accuracy Per Epoch	30
5.3	Performance Evaluation Loss Per Epoch	30
5.4	Application Splash Screen	31
5.5	Application Subject Category Screen	32
5.6	Application Chapter Category Screen	32
5.7	Learning Content Screen of the Application	33
5.8	Application's Option Selection Screen	34
5.9	Application's screen for a multiple-choice test	34
5.10	Feedback Window for the Program	35
5.11	Predict Meaning of Image Containing Sign Language Screen of the Application	36
5.12	Application Searching Process Screen	36

List of Tables

2.1	Comparative Analysis of Related Systems	8
3.1	Property Dataset for Ishara-Lipi	12
3.2	Model Training Paramater	16
5.1	Confusion Matrix	28
5.2	Model Training Paramater	29

Chapter 1

Introduction

We express our feelings to each other by uttering words. But there are many people around us who cannot express their feelings through mouth. They are known as deaf-mutes. By the year 2050, the WHO (World Health Organization) projects that 2.5 billion people, or one in four people, would have disorders related to hearing problems, with 34 million of those people being children *Deafness and hearing loss* (n.d.). The problem is disproportionately greater in the Southeast Asian region. There are no current statistics available on how many deaf and mute persons there are in Bangladesh. However, according to a 2015 report, Bangladesh has 18.6% hearing and 3.9% speech impairments out of about 14 million people with various disabilities. The true amount is higher as of right now.

According to the Disability Information System (DIS) data, Bangladesh has about 2,93,537 deaf-mute children *Dss* (n.d.). Action Aid Bangladesh and Social Assistance and Rehabilitation for the Physically Vulnerable released a joint report, there are about 257,600 hearing and 62,400 speech-impaired children in Bangladesh who are fit to go to school. In Bangladesh, 7 schools for speech and hearing-impaired children are run under government management with only 620 seats, and there are 20 more educational institutions under private management *Dss* (n.d.). which is very insignificant compared to the total number of speech and hearing-impaired children. As a result, only 4 percent of speech and hearing-impaired children are getting a chance to education. But there are many educational institutions in the country for healthy and normal children. People who are backward in society due to a physical disability are deprived of basic rights to education opportunities and become a burden on society and their families. which will hinder the achievement of the desired targets of the Sustainable Development Agenda 2030 targets 4.1,

4.5, and 4.A adopted by Bangladesh to achieve Quality Education is one of the Sustainable Development Goals (SDGs) 4. *Sustainable development goal 4* (n.d.).

Speech-impaired people cannot speak. Because their hearing power is low, they cannot hear the sound with their ears, so they have no idea about the sound. So, they can't even pronounce it. They also have problems in the process of sound formation due to not being able to hear sounds properly. But it is not that they cannot express their feelings at all. They use signs to communicate their emotions. Instead of using spoken words, Sign language is a visual language communicated via bodily gestures *Sign language* (n.d.), and it is commonly used by deaf-mute people. Sign language gained increasing interest and worldwide recognition by linguists and computer scientists in the 20th century because it was considered the native language of the deaf. They could express their needs and ideas using sign language. A collection of facial expressions, stances, and hand gestures known as sign language are used to represent the letters and words of spoken languages. The fact that sign language depends on natural languages means that it has several forms. There is no "universal" sign language, just like there isn't for spoken languages. Sign language follows the same grammar and structural principles as any spoken language.

The sign language used in various nations varies depending on the country, area, and culture. More than 70 million deaf-mute people speak one of the more than 300 sign languages that are now used around the globe *International Day of Sign Languages* (n.d.). For example, Chinese Sign Language (CSL), and Arabic Sign Language (ArSL). BdSL (Bangla Sign Language), also known as Bengali Sign Language or Bangladeshi Sign Language, is the official sign language of Bangladesh. It is thought to have developed in the Calcutta Deaf and Dumb School, which was established in 1893. Later, the CDD (Center for Disability in Development) created an official sign language for the Bangla deaf and mute community with the goal of establishing a common and standardized sign language throughout Bangladesh. This was followed by schools for the speech and hearing impaired across the country.

1.1 Problem statement

Students with deaf and mute often fail to grasp the knowledge and skills they need. As a result, they suffer deprivation in daily activities, sports, and recreation. which hinders the human development of children. This type of problems arises due to various reasons. Such as, Due to the lack of knowledge about proper sign language of the Bangla alphabet and numbers by most of the people in the family and society, it is very difficult to get the help of a family member or find a skilled tutor to provide Sign language education. Additionally, it is much simpler for a deaf and mute child to learn sign language when they have a deaf and mute parent; otherwise, the family must find a specific instructor or enroll the child in sign language institution, which may not be suitable for the family in terms of location, time, and expense. In addition, delaying the introduction of deaf-mute kids to sign language at an early stage may also hinder their ability to learn new skills and provide additional difficulties when it comes to their education, communication, and assimilating into society. Newport (1990)

Although there are a few smartphone apps for learning Bengali alphabet and number sign language, they are currently too few and unfinished to offer efficient sign language instruction. Existing Bangla Sign Language mobile applications not designed for child learners and specific Bengali alphabets and numbers. the applications are designed with emphasis on establishing communication using sign language where Bengali sign language education is deprived. So, to solve this problem, it is necessary to develop the improved version of Bengali Sign Language mobile learning application. Therefore, this project has developed an improved version of Bengali Sign language mobile learning application to solve these problems where students will get an opportunity to learn Bengali alphabet and numbers sign and meanings. The educational material will be organized into various categories to streamline the navigation experience. The students' comprehension of sign language will be evaluated through a multiple-choice quiz and feedback will be given based on their performance. The app will feature a sign recognition feature that will decipher the sign's meaning for the students.

1.2 Aims, objectives and Motivation

1.2.1 Aims

The aim of this project is to develop a mobile application using artificial intelligence as a technological tool. To increase interest in learning Bangla Sign Language for children who are deaf and mute, the alphabet and numbers of Bangla Sign Language can be learned more pleausurably, interestingly, and effectively. To help learners understand how to navigate, the application will have Bangla alphabet and number symbols that will be divided into several scenarios. Also, through the search process, this application will have the facility to complete the desired navigation process in a short time. To provide maximum benefit from the technological side, the application will use a sign detector mechanism that will detect the sign displayed by the user in real time and give feedback to the user. In addition, there will be a quiz module through which students can test the knowledge they have acquired through a selection test on the sign language they have learned while using the application.

1.2.2 Objective

- Reducing the major barriers to providing education to learners in Bengali Sign Language. Such as lack of skilled tutors, cost of education materials, lack of adequate education institutions.
- Eliminating discrimination in the basic rights of education for deaf-mute children.
- Increase the enthusiasm for learning in deaf-mute children as they start to learn Bengali Sign Language.

1.2.3 Motivation

Children's early years are a crucial time for language development. Early immersion in and exposure to sign language are essential for the linguistic development of deaf and mute children. Deaf and mute children are usually first introduced to sign language in school. This can lead to delays in children's language acquisition, which may hinder their capacity to completely grasp the intricacies of their first

language and make it more challenging for them to acquire other languages later in life [10]. The adoption of smart mobile devices for learning is enthusiastically embraced by students of various ages. A paradigm shift in the way that learners connect with one another and communicate with one another has been brought about by the quick development of new technologies like mobile devices. Using this modified technology can play an important role in enhancing cognitive abilities, expanding the knowledge of deaf and mute children.

1.3 Project Specification

The specifications for this project are listed below.

- Student will be able to access and view all the learning content available for a particular subject or a particular chapter within a subject.
- The student will be able to learn the educational content offered by the system.
- The learner can take quizzes to gauge their comprehension of the subject matter
- The student will be able to select one answer from multiple answers.
- According to the results, the student can receive feedback on their performance and understanding of the educational content
- The student will be able to select an image from the gallery.
- The student will be able to predict the Bangla meaning of images containing sign language.
- The student will be able to search for specific educational content within the system.
- The student will be able to see all the learning content when they type their desired word in the search bar.

Chapter 2

Literature Review

A considerable quantity of mobile apps have already been created to make the process of learning sign language easier for deaf and mute children. However, only 6 mobile applications for learning Bangla Sign Language (BdSL) were found on the Google Play Store, such as Bijoy Ishara Vasha-1 [A. Computers \(2020a\)](#), Bijoy Ishara Vasha-2 [A. Computers \(2020b\)](#), Bijoy Ishara Vasha-3 [A. C. Computers \(2020\)](#), Bijoy Ishara Vasha-4 [A. Computers \(2020c\)](#), Bijoy Ishara Vasha-5 [A. Computers \(2020d\)](#), and Bijoy Ishara Vasha-6 [C. Computers \(2020\)](#). This section includes a review of some of the currently available sign language learning applications. These apps are reviewed in terms of language, purpose, target age, sign recognition system, quiz, search engine, videos, cartoon character, numbers, vocabulary, and alphabet. which is shown in Table 2.1.

ASL Kids is a mobile app [media \(2015\)](#) for Android devices that is intended to help children aged 1 to 12 learn American Sign Language. It employs videos to instruct the American Sign Language alphabet and commonly used conversational vocabulary, as well as image matching quizzes and static pictures to illustrate sign language symbols.

SignSchool [SignSchool \(2016\)](#), an Android-based software, provides a self-paced learning platform for students to study American Sign Language. The application's extensive database of sign language signs allows users to search for the sign for any given word. Additionally, it classifies signs into different groups according to subjects. Additionally, it features a multiple-choice quiz to encourage the learning of sign language as well as Sign Builder, a device that uses random sign generators

to increase learners' vocabulary.

Vijoy Ishara Vasha is an application to teach the speech and hearing-impaired people of Bangladesh alphabets, numbers, and conversational vocabulary used in daily life using American and British Sign Language. This application is divided into 6 separate applications: Bijoy Ishara Vasha-1 [A. Computers \(2020a\)](#), Bijoy Ishara Vasha-2 [A. Computers \(2020b\)](#), Bijoy Ishara Vasha-3 [A. C. Computers \(2020\)](#), Bijoy Ishara Vasha-4 [A. Computers \(2020c\)](#), Bijoy Ishara Vasha-5 [A. Computers \(2020d\)](#), and Bijoy Ishara Vasha-6 [C. Computers \(2020\)](#). Vijoy Ishara Vasha-1, the first part of the application, teaches Bengali, American, and British alphabets, numbers, and vocabulary. The rest of the sections teach different conversational vocabulary used in daily life. The app teaches sign language through video tutorials and uses some images.

A smartphone app called Sign Language Education Malaysia allows for self-paced study. [Siong et al. \(2021\)](#). The user interface, Firebase services, Google Cloud services, and an Internet connection make up most of the program. Students can use this application to complete important tasks such as answering questions and viewing sign language symbols, as well as change their information and review their results.

My Sign [Mohammad et al. \(2022\)](#) is an Arabic Sign Language learning tablet application designed primarily for children who are deaf or mute. With the help of the application, a child may learn Arabic sign language (ArSL) through lessons in vocabulary, numbers, and letters. The vocabulary category is divided into six more specific groups. In the vocabulary group, video used to demonstrate how to sign the relevant word; in the number and letter groups, an image is used to demonstrate how to sign the corresponding letter or number. In order to increase the word list, this program enables parents and instructors to shoot videos and upload them. The children can play a game with quizzes after finishing a certain category to assess their newfound knowledge. The testing is divided into two categories: memory-based puzzles and puzzles based on multiple-choice questions.

Table 2.1: Comparative Analysis of Related Systems

	Purpose	OS	Sign Language	Targeted User Age	Number	Alphabet	Words Meaning	Video	Picture	Exercises	Search Engine	Sign Detection
Bijoy Ishara Vasha-1	Education and Communication	Android	BdSL, ASL BSL	-	Yes	Yes	Yes	Yes	Yes	No	No	No
Bijoy Ishara Vasha-2	Communication	Android	BdSL	-	No	No	Yes	Yes	Yes	No	No	No
Bijoy Ishara Vasha-3	Communication	Android	BdSL	-	No	No	Yes	Yes	Yes	No	No	No
Bijoy Ishara Vasha-4	Communication	Android	BdSL	-	No	No	Yes	Yes	Yes	No	No	No
Bijoy Ishara Vasha-5	Communication	Android	BdSL	-	No	No	Yes	Yes	Yes	No	No	No
Bijoy Ishara Vasha-6	Communication	Android	BdSL	-	No	No	Yes	Yes	Yes	No	No	No
ASL Kids	Education	Android	ASL	1-12	No	Yes	Yes	Yes	Yes	Yes	No	No
Sign School	Education	Android	ASL	6-12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
My Sign	Education	Android	ArSL	-	Yes	Yes	Yes	Yes	Yes	Yes	No	No

While reviewing the applications and research papers, I noticed that there are several applications created to teach sign language, mostly aimed at children under 12 years of age. However, the lack of a technological environment for learning the Bengali alphabet and number sign language in the Bengali community is noticeable. Certain limitations are apparent when all the applications reviewed are categorized into specific categories to facilitate student learning.

2.1 Analysis of Requirements

Analysis of Requirements is the process of applying several ways to find and collect needs from different sources, including the project's stakeholders, existing systems, and related literature. In order to ensure that the program being developed satisfies the needs and expectations of its users, gathering requirements is an essential step in the application development process. In the literature review, what needs to be addressed in the existing application was identified, which helped to define the required functionalities of this application. Therefore, we identified some unique features for this project that are missing in existing applications. In this application, students will be able to select the learning content from the subject categories. Signs and Bengali meanings of the selected learning content will be displayed in image form. As a result, students will be familiar with the sign and the meanings of the sign simultaneously. After completing the learning activities, students will be able to participate in multiple-choice exams. Feedback will be given to the students according to the results obtained in the exams. Students can also use the sign detect feature to see the possible Bengali meaning of images containing sign language.

Students can navigate to other parts of the application in a short time using the search function.

Chapter 3

Methodology

A strategy known as methodology gives the process of developing applications structure. It outlines the procedures and duties that must be carried out in order to create the application. Utilizing an application development methodology serves to guarantee that the development process is well-structured, effective, and efficient and that the end result satisfies user needs.

Several well-known application development approaches exist., I followed the waterfall Software Development Life Cycle (SDLC) Model to implement this application. This methodology required some phases.

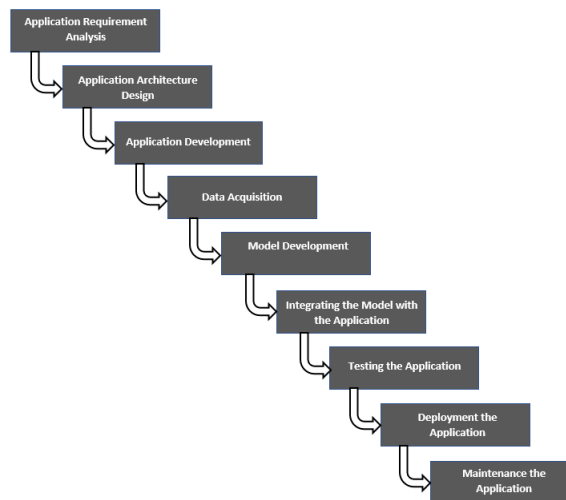


Figure 3.1: Waterfall Software Development Life Cycle

3.1 Specifications for Requirements

3.1.1 Functional Requirements

The system's functional requirements describe what it should be able to achieve. When specific circumstances are fulfilled, a functional requirement will specify how the system will behave or operate. The following requirements for this application's development were identified from the literature and will be implemented in this application:

- Learning by category
Students should be able to select the learning content from the subject categories.
- Learning content
This application should be able to display learning content according to subject categories.
- Searching
This application should be able to provide search items.
- Multiple-choice quiz test
Students should be able to participate in multiple-choice exams.
- Provide feedback
This system should be able to give feedback according to the result.
- Predicting the meaning of a sign
This application should be able to predict the Bengali meaning of images containing sign language.

3.1.2 Non-Functional Requirements

Nonfunctional system requirements provide system attributes such as safety, dependability, performance, maintainability, scalability, and usability. [Leffingwell et al. \(2021a\)](#).

- The application should predict the meaning of images containing sign language for its user in an unnoticeable time.
- To predict the meaning of images containing sign language, the least amount of error should be used.

3.2 Data Acquisition

The important feature of this application is to predict the meaning of images containing sign language. For which Ishara-Lipi: Bangla Sign Language Dataset used [Islam \(2019\)](#).

3.2.1 Dataset Properties

The dataset for Bangla Sign Language (BdSL) recognition is taken from Kaggle, which is Center for Disability in Development (CDD) Standard. This dataset is a collection of Bangla alphabets and number images from Bangla Sign Language. The dataset is organized into 46 classes, and the total number of records is 2800. This dataset is extremely useful for image classification. The detailed properties of the dataset are described in tabular form in **Table 3.1** below.

Table 3.1: Property Dataset for Ishara-Lipi

Type of Data	Class	Classes of sets	Total data
Total Digits	10	100	1000
Vowels	6	50	300
Consonents	30	50	1500

3.3 Train Data and Model Development

3.3.1 Modelling

I utilized "Google's Teachable Machine" for modeling. A web-based tool called "Teachable Machine" makes it simple and quick to build and train a machine learning model. The platform utilizes a drag-and-drop interface to simplify the process of creating machine learning models and Programming is not necessary for the

development or training of the model. The models can be trained using image, audio, or text data, and can be exported for deployment on a range of platforms, including websites and mobile applications.

The primary disadvantage of Teachable Machine is that it does not enable the inclusion of additional Pre-trained, Optimizes, or Loss-Functions. With the aid of Google Teachable Machine, machine learning models can be developed and deployed for usage in a range of industries. The Google Teachable Machine service enables us to define classes for our subject area, develop models for our work, load samples into the classes, and choose and set model parameters. The service is intended to assist us easily and quickly build and deploy machine learning models for a variety of use cases. Accuracy per class, a Confusion Matrix, and a chart of the change in predictive performance throughout the learning period for both the training and test sets are all included in model performance reviews that Teachable Machine can create.[Mizgirev et al. \(2021\)](#).

By default, Google's Teachable Machine divides data into 85% for training data and 15% for test data.

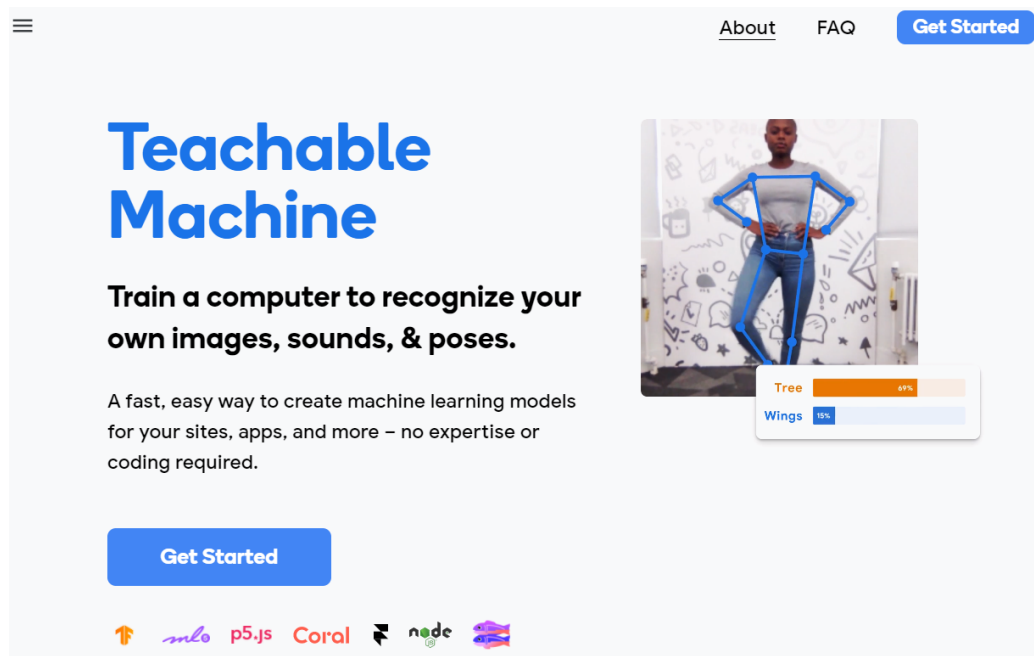


Figure 3.2: Google Teachable Machine

According to our dataset, there are 100 images for each number class (we build the model only for Bangla numbers). So, the total image is 1000. The total training data used is 850, and the remaining 150 are used for testing.

To begin training the model, we will need to create ten classes according to the number data set, which are "Zero", "One", "Two", "Three", "Four", "Five", "Six", "Seven", "Eight", and "Nine" and upload training images to build a model. **Figure 3.3** illustrates the process of creating classes according to the dataset.

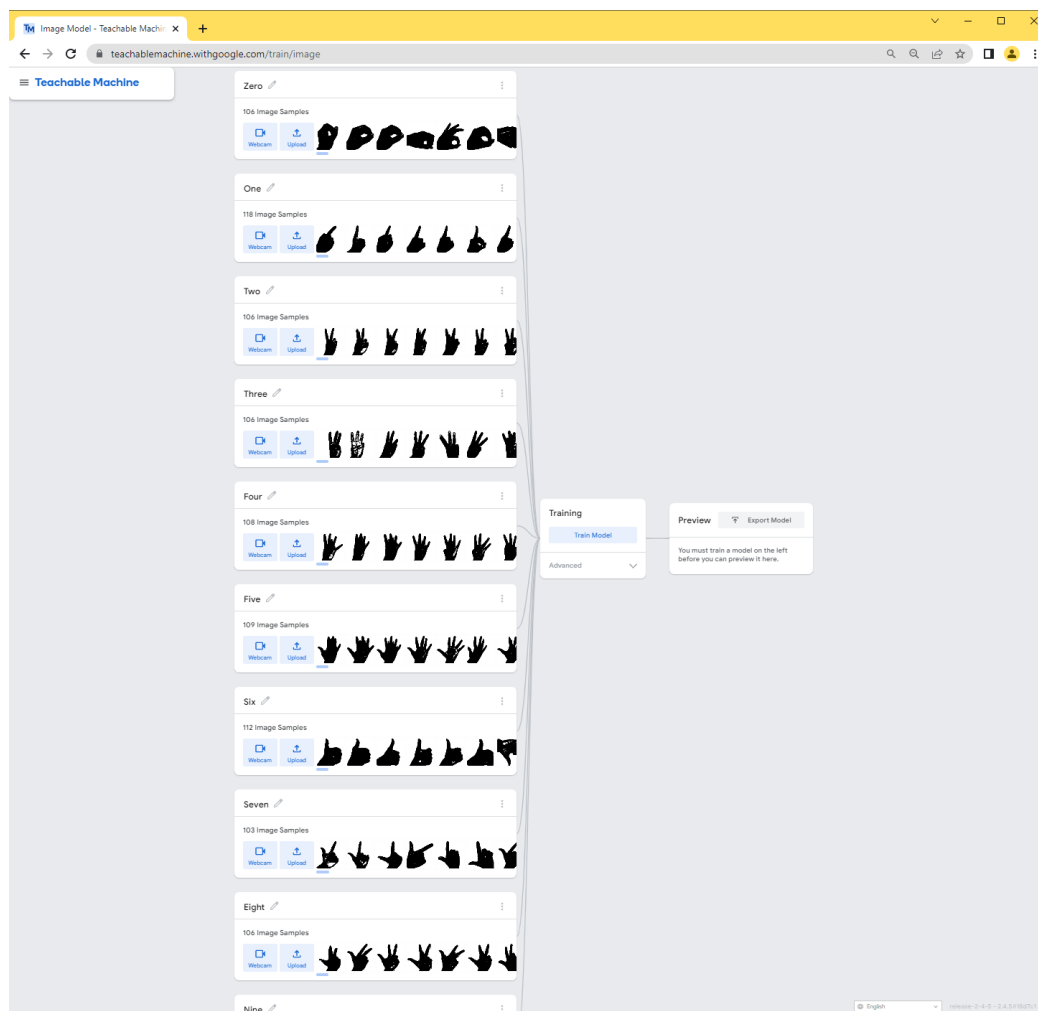


Figure 3.3: Google's Teachable Machine Class Create and Data Uploading Peocess

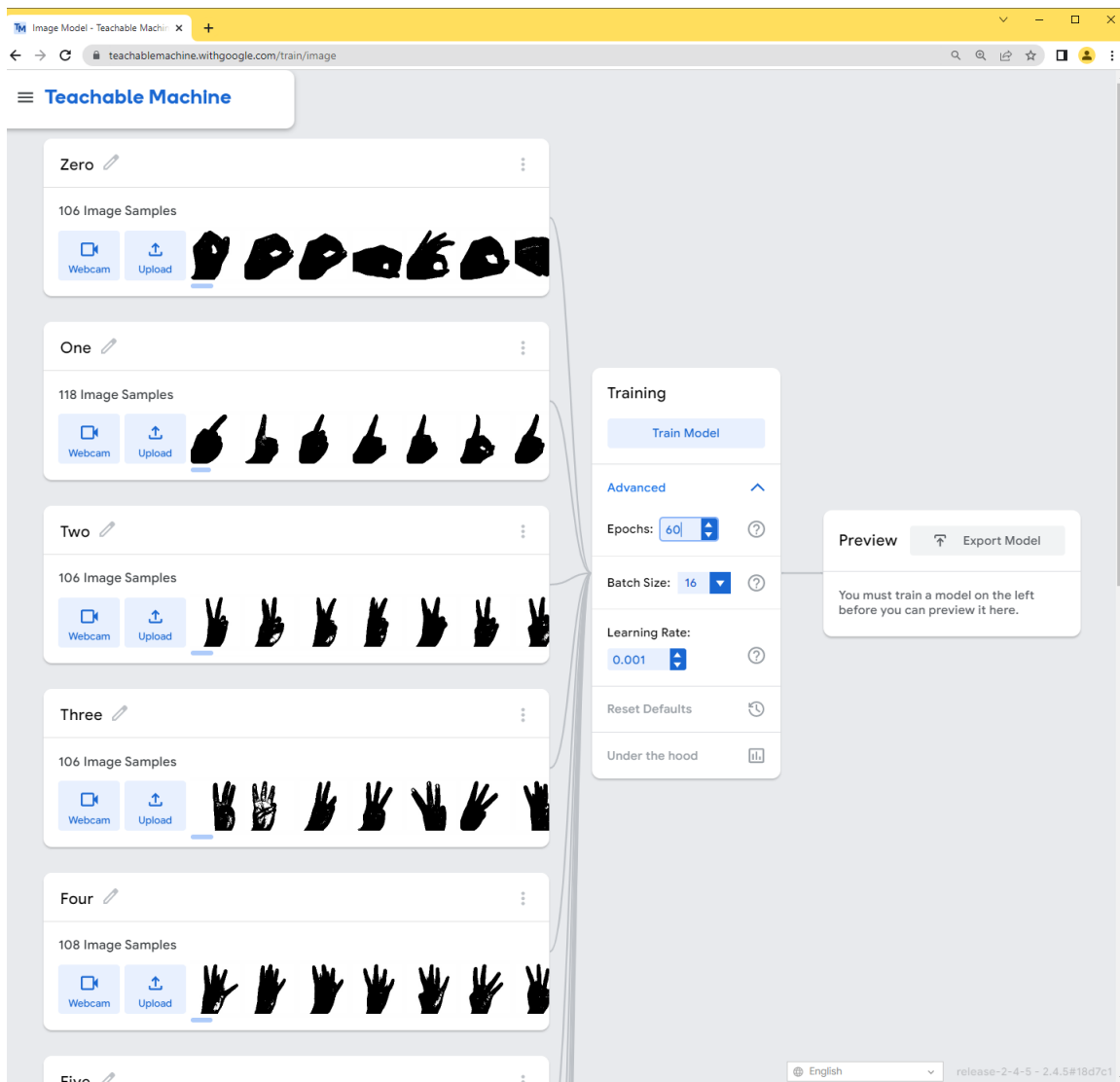


Figure 3.4: Google's Teachable Machine Training Parameters Set Process

In the data training section, as you can see in **Figure: 3.4**, we set some hyperparameters, which are:

Epoch: 60

Batch Size: 16

Rate of learning

Epoch: Every sample in the training dataset has gone through to the training

phase at least once during 1 Epoch.

A batch size is a collection of samples utilized in a single training iteration. We configured the batch size to 16 in accordance with our dataset, which contains 1000 photos. Thus, the data will be divided into 62 batches of size $1000/16$. 1 Epoch will be finished after all 62 batches have been run through the model.

The model is trained three times, and different parameters are used for each training.

For the first training, the batch size is 16, the learning rate is "0.001", and the epoch number is 50.

In Second Training, the batch size is 32, there are 60 epochs, and the learning rate is 0.001.

The third training utilized a learning rate of (0.0001), Size of batch 16, and 60 Epochs.

The data will be re-examined during the pre - processing stage if the model is not optimal for the parameters that have been selected. However, if the model is optimal on the parameters that have been established, the result analysis process can commence. As shown in **Table: 3.2**, some of the hyperparameters used in this study model.

Table 3.2: Model Training Paramater

	epoch	batch-size	learning rate
First Trained	50	16	0.001
Second Trained	60	32	0.001
Third Trained	60	16	0.0001

3.3.2 Testing the Model

When the training is over, we can evaluate the prediction results of the model with other Bangla number sign.

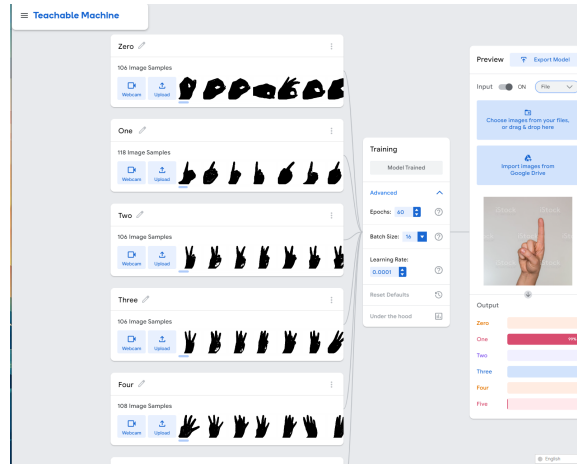


Figure 3.5: Testing the Model Prediction Result

3.4 Conversion of Machine Learning Model

After assessing the predicted outcomes following model training, the trained model should be exported according to our required file format. Since our application is a Flutter mobile application, according to our application, the TensorFlow Lite file format is required.

TensorFlow Lite is a lightweight, high-performance version of TensorFlow specifically designed for mobile deployment. Exporting a Teachable Machine model to TensorFlow Lite involves converting the model from the web-based format to a TensorFlow model, and then compressing and optimizing it for deployment on a device. The TensorFlow Lite translator, which is part of the TensorFlow library, may be used to carry out this procedure. Once the model has been exported to TensorFlow Lite, it can be integrated into a mobile device and run directly on the device, without the need for an internet connection or cloud-based service.

After completing the model conversion process, we get a model file named `converted_tflite.zip`. If we decompress this model file, we get two files, which are:

`labels.txt`

`model_unquant.tflite`

The entire process of connecting these two files to the Flutter application will be discussed in the section on **Integrating the Model with the Application**.

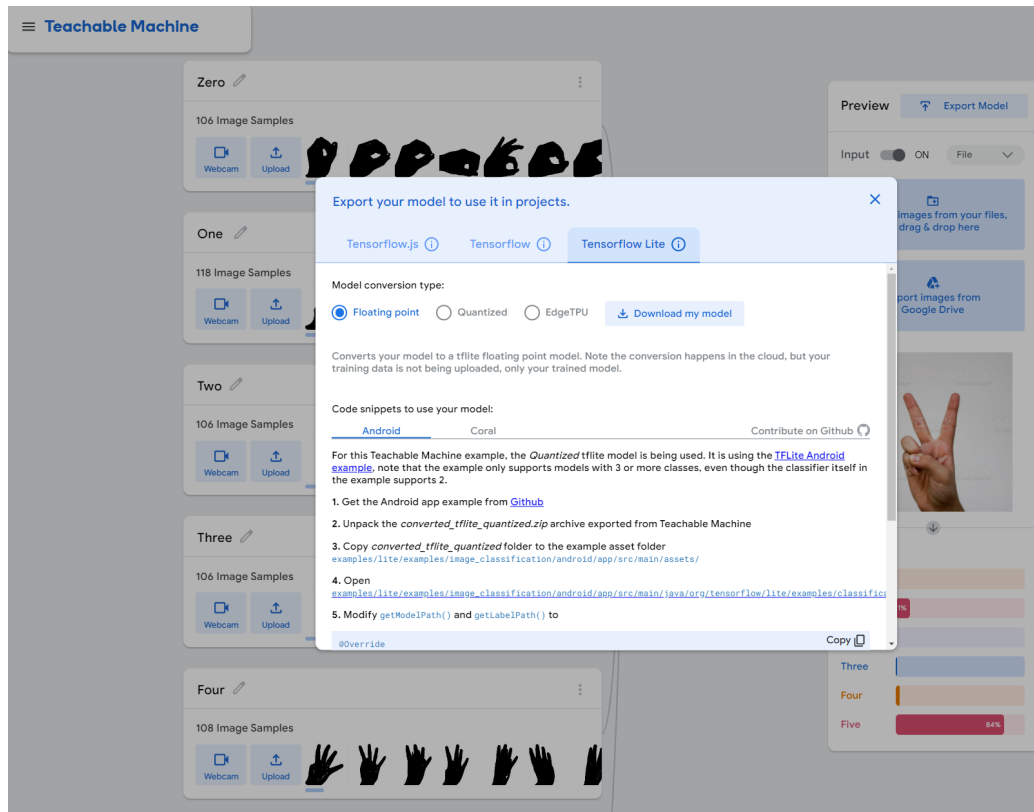


Figure 3.6: Exporting model and download

3.5 Deployment the Application

The application is ready to deploy once all of the necessary processes have been completed. Deployment is the process of making an application available to users. We planned to upload our apps to the Google Play Store so that users could download them. Users can utilize applications after they have been released by downloading and installing them on their devices.

3.6 Maintenance the Application

In order to maintain the functionality of the program and fulfill user expectations, application maintenance is a crucial component of the software development life-cycle. Maintenance activities include bug fixing, security updates, performance optimization, and the introduction of new features and functionality.

Chapter 4

Design and Development

4.1 Design of the System

System design refers to the process of creating a system's architecture, interfaces, and data to adhere to certain specifications. It involves the planning and development of the application structure, components, modules, and their relationships with each other in order to build a cohesive, scalable, and maintainable system. In this section, we will define the overall system architecture using various diagrams.

4.1.1 Use Case Diagram

Figure : 4.1 We can see the use-case diagram in this application. Use-Case shows the actors and the functional requirements of an application graphically. It is a specific sort of UML diagram that is used to represent the boundaries of the system as well as the relationships between its actors and use-cases. Use-case diagram, which also serves to convey the elevated functional requirements of a system, provides a concise and clear overview of the interactions between actors and the system. It is an effective method for gathering requirements, documenting them, and structuring and outlining a system's functionality.

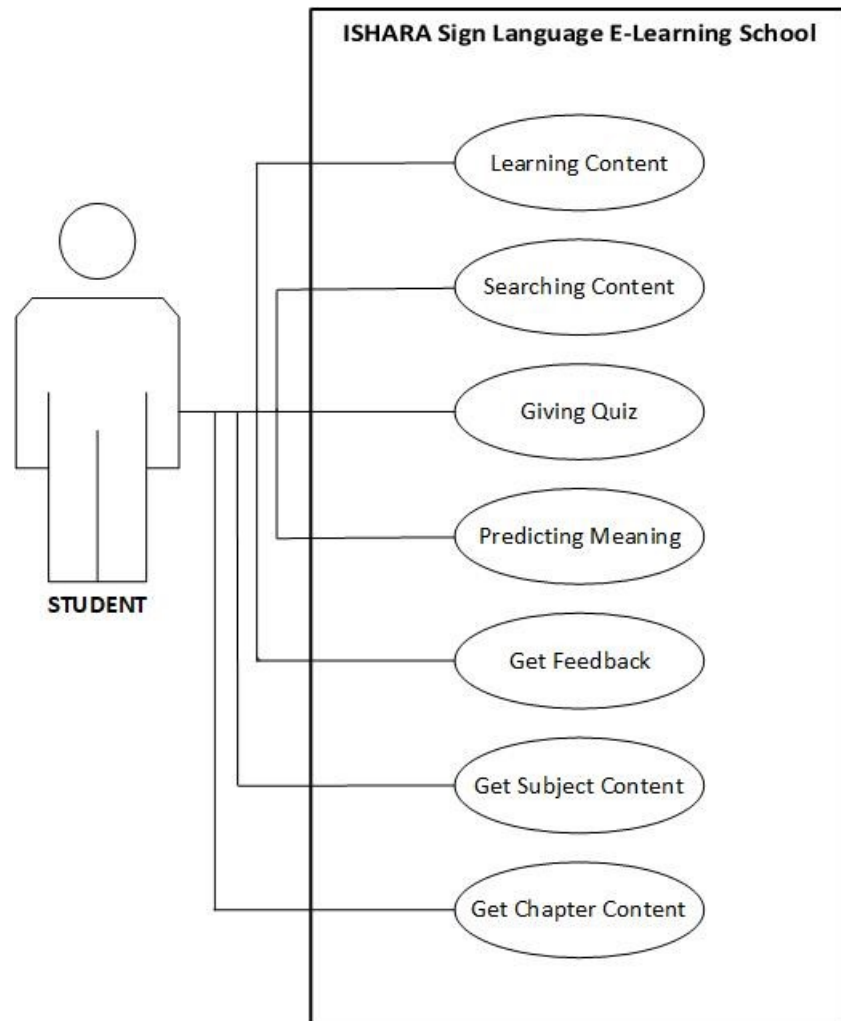


Figure 4.1: Diagram of the Application's Use Case

According to our application requirements, which were identified in the previous section. Use-case diagrams are drawn based on those requirements. In this diagram have an actor which is Student. Student acting 7 activities, which are:

Learning Content, Searching Content, Giving quiz, Predicting meaning, Get feedback, Get Subject Content, Get Chapter Content.

4.1.2 Level 0 Data Flow Diagram

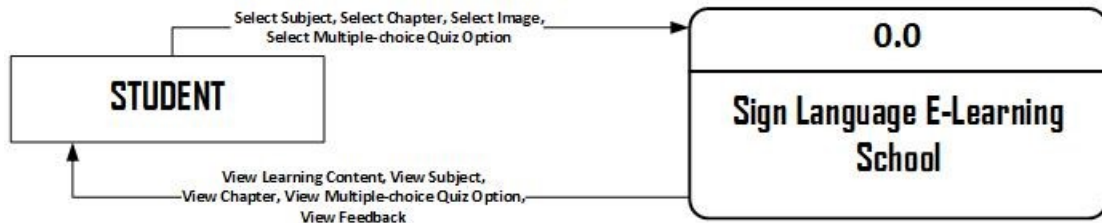


Figure 4.2: Level 0 Data Flow Diagram of the Application

Level 0 diagram, depicts the entire system using just 1 event that is related to all of its constituent parts. The system's inputs, outputs, and the procedures used to convert data from input to output are all seen from above in this report. A Level 0 Data Flow Diagram's primary goal is to provide a high-level overview of the system and list its essential elements.

When using a Level 0 Diagram, application is represented as a single process block that receives inputs, transforms them through internal processes, and produces outputs. This high-level representation is then broken down into more detailed diagrams in subsequent levels.

4.1.3 Data Flow Diagram at Level 1

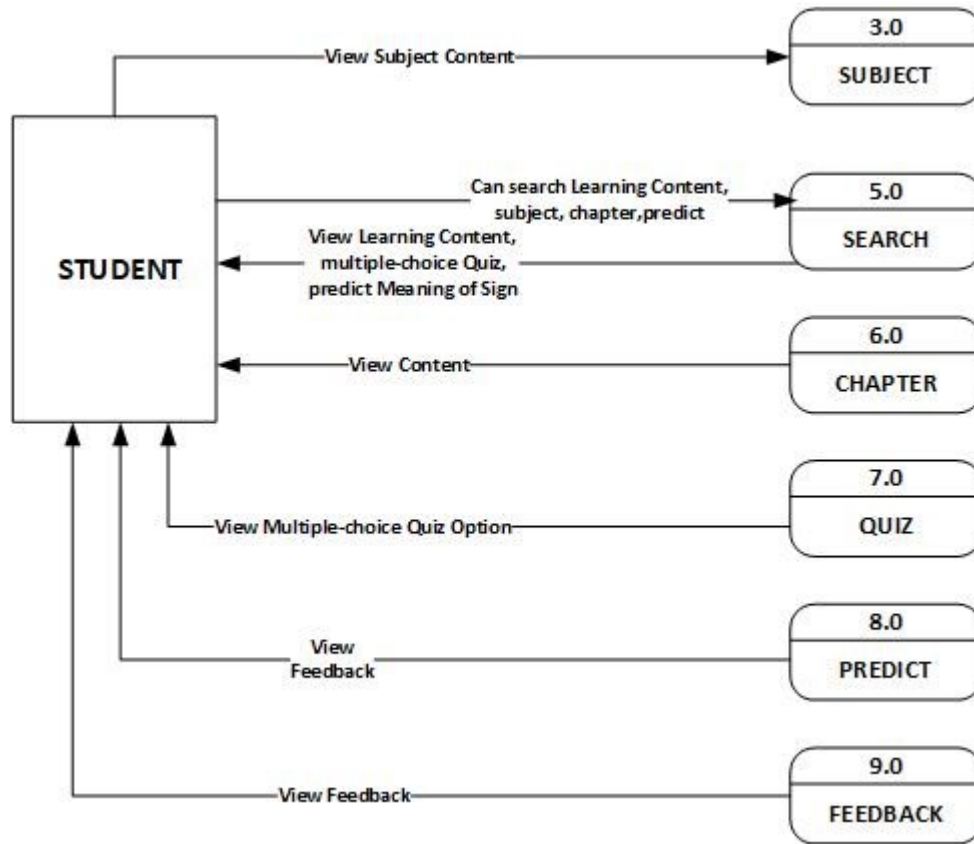


Figure 4.3: Level 1 diagram of the Application

Compared to a Level 0 Diagram, a Level 1 Diagram offers a more thorough picture of a system. It provides a deeper understanding of how data is converted inside of systems as well as the links that exist between the various system components.

The single process block from the Level 0 DFD is divided into a number of smaller processes in a Level 1 DFD, each of which represents a different job in the system. The inputs and outputs of each process are represented by independent process blocks that are coupled by data flows.

The above Level 1 data flow diagram contains 6 processes. which are: Subject, chapter, quiz, search, predict, feedback.

4.2 Development

This section will describe the entire application implementation process. The completed process of application implementation is divided into two parts. One of which is the Application Development Process, and the other is Integrating the Machine Learning Model With the Application.

4.2.1 Application Development Process

In this stage, we design the user interface with the help of the application requirements. Through this interface, students can interact with the application. The system will require the following materials and technological tools to be finished:

- Android Studio
- Flutter Framework
- Dart Programming Language
- Goggle Teachable Machine
- Rive Animation Tool
- Adobe Photoshop

4.2.1.1 Android

The purpose of this project is to create an application for kids who are deaf and mute. So I created the application using Android Studio. The official IDE (Integrated Development Environment) for creating Android apps is called Android Studio [Leffingwell et al. \(2021b\)](#). Android Studio is made to increase productivity and make creating Android applications easier.

4.2.1.2 Flutter Framework

A single codebase may be used to create stunning, natively built, multi-platform applications using Google's Flutter open source framework [Build apps for any screen \(n.d.\)](#). Instead of developing apps especially for each platform, Flutter enables

developers to create native-looking apps from a single codebase, saving time and effort.

Flutter, which offers a contemporary, and leverages the Dart programming language, enables quick and easy app creation. The framework comes with a wide range of tools and widgets that are easily configurable, enabling programmers to quickly create and release attractive, useful apps with little effort. Here is the *Source code* for Ishara: Artificial Intelligence Based Bangla Sign Language E-Learning Application for Deaf-Mute Children.

4.2.1.3 Programming Language Dart

On any platform, Dart is a client-optimized language for creating quick apps. With a configurable execution runtime platform for app frameworks, it aims to provide the most productive programming language for cross-platform development *Dart overview* (n.d.). dart supports asynchronous programming, making it ideal for developing scalable and fast server and web applications. Dart also provides a contemporary, reactive programming approach, which makes it perfect for developing dynamic, responsive user interfaces.

Google's Flutter framework, which offers a quick and simple approach to creating high-performance mobile apps for iOS and Android, uses Dart. Because Flutter automatically converts Dart code to native code, the resulting apps are quick and responsive with no lag or stuttering.

4.2.1.4 Rive Animation Tool

Rive is a powerful tool that helps teams create and run interactive animations for apps, games, and websites *Rive: Flutter package* (2023). Designers and developers may build interactive animations and interfaces for web, mobile, and gaming apps using Rive (formerly known as Flare), a platform and tool for vector animation.

In order to be incorporated into a variety of platforms and technologies, such as mobile and web apps, games, and VR/AR applications, Rive animations may be exported as code or runtime assets. Developers can modify the performance-optimized exported code to match the particular needs of their projects.

4.2.2 Integrating the Model With the Application

In this section, we integrate our machine learning model with the Flutter application to predict Bangla number sign image meaning.

In Section 3.3, “Model Conversion,” we build a machine learning model and download a model file named `converted_tflite.zip`. After we decompress this model file, we get two files, which are:

`labels.txt`

`model_unquant.tflite`

labels.txt: The label of each class of Bangla number sign.

model_unquant.tflite: The machine learning model that has been trained to recognize Bangla number signs.

Copy these two files and paste them in the **assets** folder inside the Flutter project folder. Shown in **figure: 4.4**, and the *Source code*

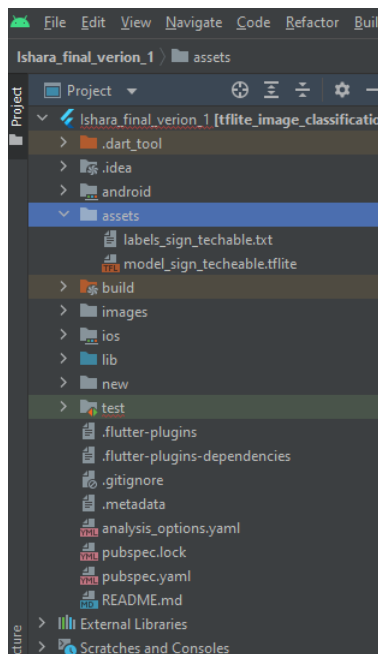


Figure 4.4: Integrating the Machine Learning Model With the Application

To use these two TensorFlow Lite files in our Flutter application, we need to install the following packages in the **pubspec.yaml** folder. This is the *Source code* of the `pubspec.yaml` file.

```
tflite: ^1.1.2  
image_picker: ^0.8.4+11
```

Figure 4.5: TensorFlow Packages Install in the pubspec.yaml Folder.

tflite: ^ 1.1.2 Is a variation of TensorFlow that has been designed with embedded and mobile deployment in mind. A server connection is not necessary for developers to use this small, highly efficient library to execute machine learning models on devices. TensorFlow Lite has an unique version number, 1.1.2, which denotes the upgrades and enhancements done in that specific release.

image_picker: ^ 0.8.4+11 The "image_picker" package is a Flutter plugin that allows user to access the image gallery or camera on device and retrieve the selected image as a File or PNG or JPEG image data. This package is particularly useful for implementing image selection functionality in a Flutter app. "image_picker" version "0.8.4+11" is a specific release of the plugin, which is indicated by the version number

4.3 Test the Application

Application testing is a crucial stage in the creation of application that helps to guarantee the effectiveness and quality of an application. Application are tested to make sure they are high-quality and suitable for their intended usage.

The feasibility and completeness of the requirements for this application's execution are assessed in a number of circumstances, including those involving functionality, usability, performance, infrastructure problems, etc.

To make sure the data in this application is accurate and of high quality, data validation checks have been done. The presence validation was checked to ensure logical consistency of input and stored data. Students, for example, cannot participate in the next question unless they have completed the multiple choice question in the quiz section.

Chapter 5

Result analysis

In the previous two sections **"Methodology"** and **"Design and Development"** showed that the development process of this application. We can see that there are two main aspects to the total development process, which are:

Machine Learning Model Development
Android Application Development Process

In this section, All the application features will be analyzed. Two main parts of the application will be given importance for analysis, which are:

- Machine Learning Model Analysis
- Android Application Functionalist Analysis

5.1 Machine Learning Model Analysis

In this section, we will be analyzing model that was create in the **"Train Data and Model Development"** section.

After training the model, the performance of the model is measured. Using the Confusion Matrix, the model's effectiveness is evaluated.. A confusion matrix aids in visualizing the results of a classification task by providing a table arrangement of the various outcomes of the predictions and findings. The confusion matrix score reflects how well the model was able to anticipate each of the positive predictions.

The confusion matrix shown in **Table: 5.1** can be described as follows:

Table 5.1: Confusion Matrix

		Actual	
		Positive	Negative
Predicted	Positive	True Positive	False Positive
	Negative	False Positive	True Negative

True Positive (TP): A positive value was predicted by our model, and it came true.

False Positive (FP): our model predicted a negative value, and it is actually positive.

True Negative (TN): Our model predicted a negative value, and it is actually negative.

False Negative (FN): Our model predicted a negative value, and it is actually positive.

The confusion matrix classification results have four terms to determine how accurate the model is: **Accuracy, Precision, Recall, and F1-score.**

Accuracy: Accuracy is used to accurately find both positive and negative predictions.

Accuracy is equal to $(\text{True Positive} + \text{True Negative}) / (\text{True Positive} + \text{False Positive} + \text{False Negative} + \text{True Negative})$

precision: The positive observation ratio that was successfully anticipated is measured using precision.

Precision = $TP / (TP + FP)$

The model is trained three times, and different parameters are used for each training.

For the first training, the epoch number is 50, the batch size is 16, and the learning rate is (0.001), and we see the training performance accuracy 92% and the f1-score 90.4%.

With 60 epochs, batch size of 32, and a learning rate of (0.001), Second Training has a training performance accuracy of 92% and a F1-Score of 90.4%..

The third training used 60 epochs, a batch size of 16, and a learning rate of 0.0001, yielding training performance accuracy 92% and an F1-score of 90.4%.

The all training parameters produced high performance accuracy of 92% and f1-score 90.4%. The following settings led to the test set's maximum classification accuracy:

Table 5.2: Model Training Paramater

	epoch	batch-size	learning rate
First Trained	50	16	0.001
Second Trained	60	32	0.001
Third Trained	60	16	0.0001

which has a confusion matrix and accuracy per epoch shown in **figure 5.1** and The findings are displayed in **Figure: 5.2** accuracy per epoch visualization..

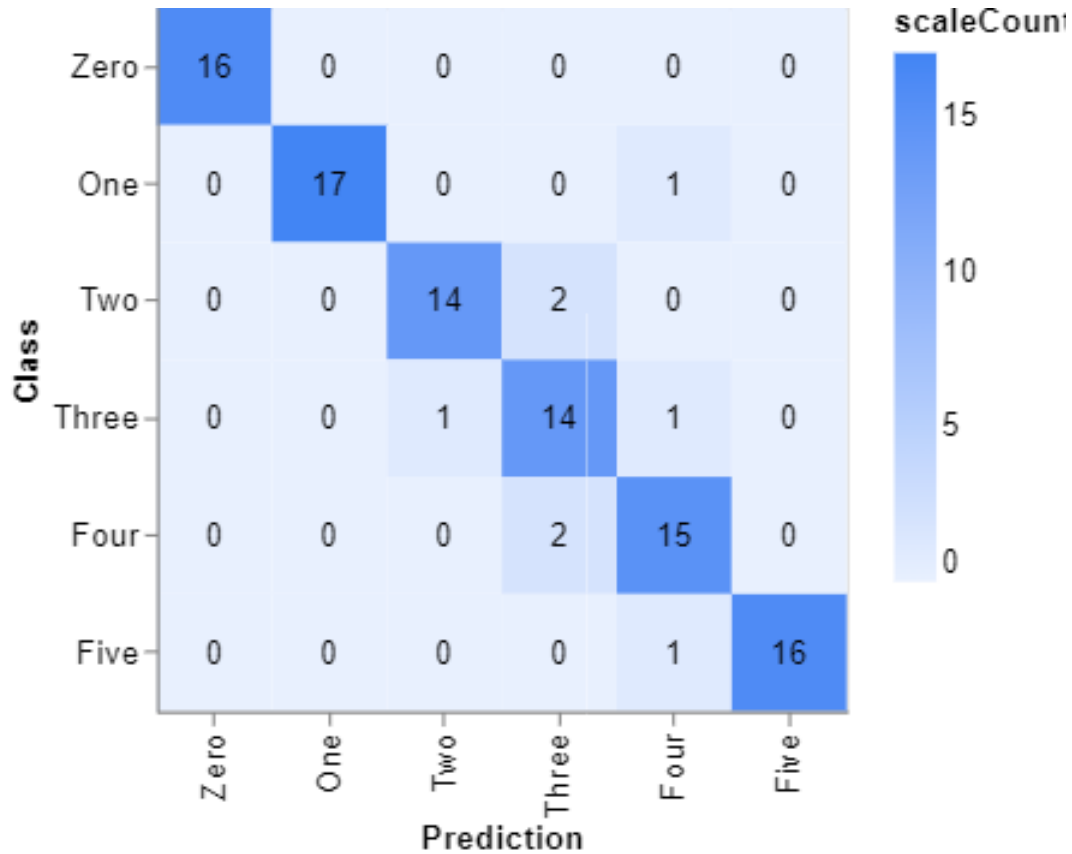


Figure 5.1: Model Training Result of Confusion Matrix

The experiment with the greatest accuracy evaluation performance, **Figure: 5.2**, Accuracy of 92% and a f1-score of 90.4%. Additionally to performance evaluation,

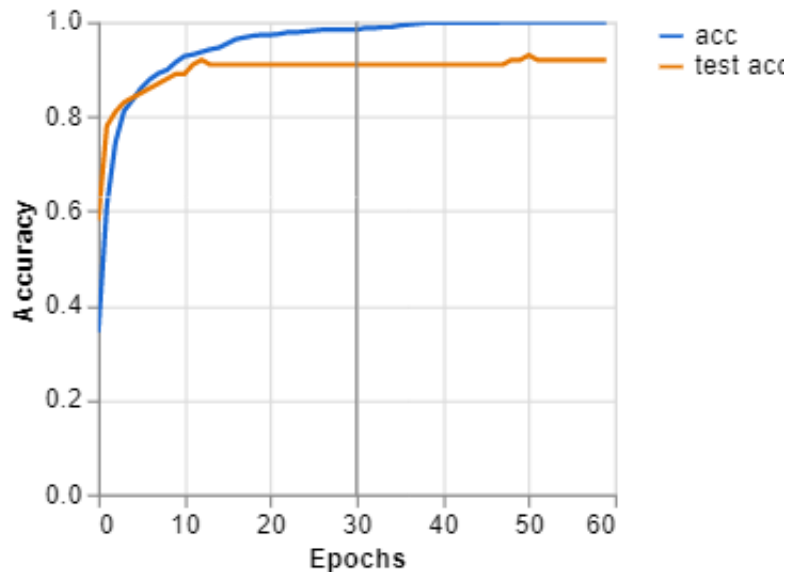


Figure 5.2: Performance Evaluation Accuracy Per Epoch

which is based on accuracy per epoch, performance is also examined based on loss per epoch, as shown in **Figure: 5.3**.

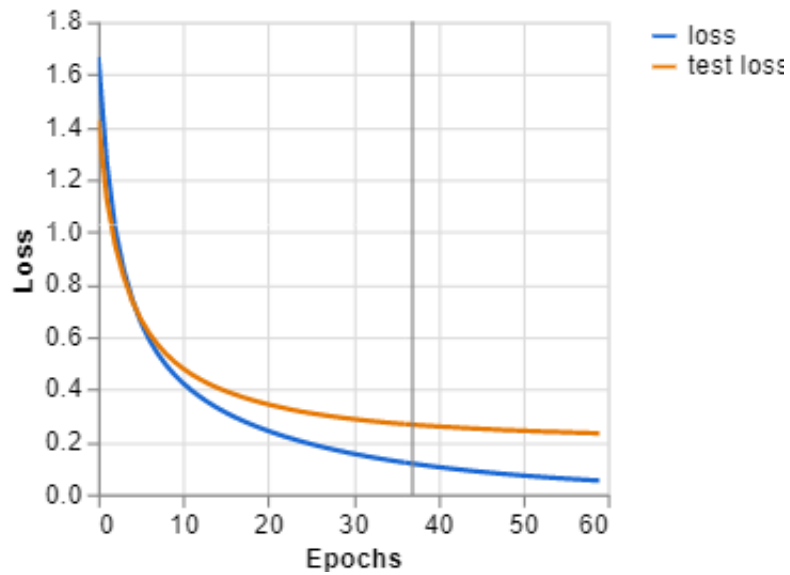


Figure 5.3: Performance Evaluation Loss Per Epoch

5.2 Android Application Functionalist Analysis

The development process is depicted in the Development section. After developing the application, this section describes the student's experience using all the features of the application. This application will be displayed in the landscape view of a mobile device with an Android operating system.

Splash Screen: When an application opens, the splash screen is the initial screen to appear.. **Figure: 5.4** illustrates the splash screen or launch screen of the application. The application logo is displayed by the splash screen. For the implementation of the splash screen, we used a custom splash screen with the help of the Rive animation tool.



Figure 5.4: Application Splash Screen

Subject Category Screen: After 2 seconds, the splash screen will disappear, and then the Subject Category Screen will appear. Figures 5.5 illustrate the learning category screen of the application. The category-wise learning process will provide students with an opportunity to learn Bangla Sign Language according to different subject categories. Subjects are categorized into important subjects such as the Bangla alphabet, mathematics, etc. All the signs used in the application are divided into sub-categories under meaningful categories based on the importance of the subject. Students can scroll to find the category of their choice and begin learning activities for different signs within that category.

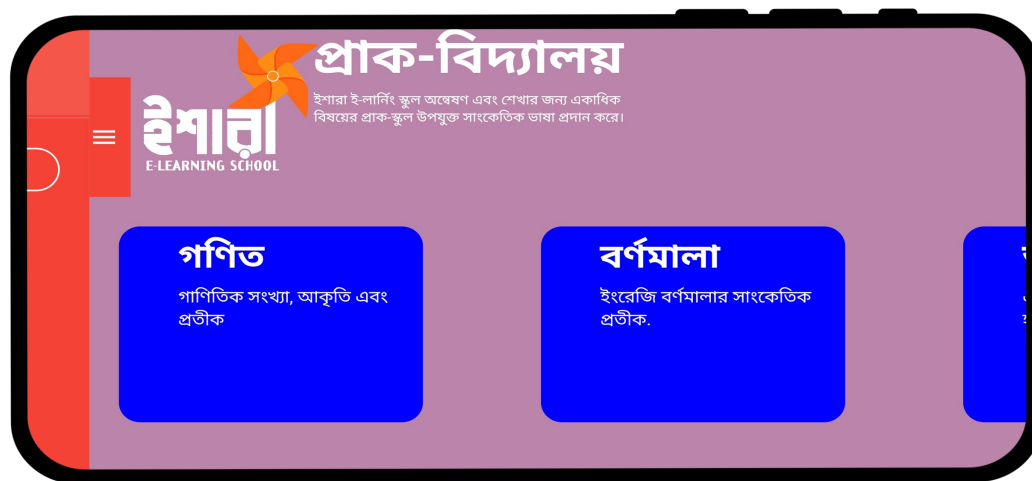


Figure 5.5: Application Subject Category Screen

Chapter Category Screen: When students select a subject on the subject category, the chapter category screen will appear on the screen, and the student can see all chapters of mathematics. **Figure: 5.6** depicts the application's chapter category screen. Students can scroll to find the chapter of their choice and begin learning activities for different signs within that chapter.



Figure 5.6: Application Chapter Category Screen

Learning Content Screen: In figure: 5.7 we can see the learning content. Learning content will be displayed when the student enters a particular sub-section of the subject. The content shown in figure: 5.7 is a sign of number section of mathematics subject. Learning content is shown in the image form and Bengali meaning is also displayed. So that the students get acquainted with Bengali signs and meanings. By using the next icon on the right side, students can see and learn the next sign of this topic. Similarly, students can go to previous signs by using the icon on the left side. Students can return to the main subject categories using the back icon in the top left.



Figure 5.7: Learning Content Screen of the Application

Optional Selection Screen: After completing the learning activity, a multi-activity option facility selection screen will appear for the type of activity that the student would like to participate in next. Multiple activities include re-learning activities, participating in quiz activities, and detecting image signs. which is shown in Figure: 5.8 If students want to participate in the quiz after completing the learning activity, then the option "Participate in Quiz" should be selected. After selecting the option "Participate in Quiz," the quiz screen will appear in front of the students.



Figure 5.8: Application's Option Selection Screen

Quiz Screen: After completing the learning activities, students will be able to participate in multiple-choice exams. **Figure: 5.9** shows one of the multiple-choice questions in the "Mathematics" category. The sign that is being presented to students may be seen, and by tapping on it, students can select from any of the choices provided next to the sign. The correct response will be marked in green if the student selects it, while the erroneous response will be highlighted in red. The screen at the top will show the overall number of questions as well as the current question number. Here on top right edge of the screen, the outcome will be shown as a score.



Figure 5.9: Application's screen for a multiple-choice test

Feedback Screen: Feedback will be given to the students according to the results obtained in the exams. The total result will be displayed in a pop-up box based on the test results, which will highlight in a specific color based on the type of result. Which shows in **figure: 5.10**



Figure 5.10: Feedback Window for the Program

Predict Screen: The sign detection feature is a special feature that helps students identify the Bangla meaning of the sign image. This function aids students in choosing a picture from the image gallery, locating the label within it, choosing the proper name for the image, and displaying it. demonstrates sign recognition using the student-chosen image, which will be compared with the model. This application could only predict Bengali number sign language in tests.

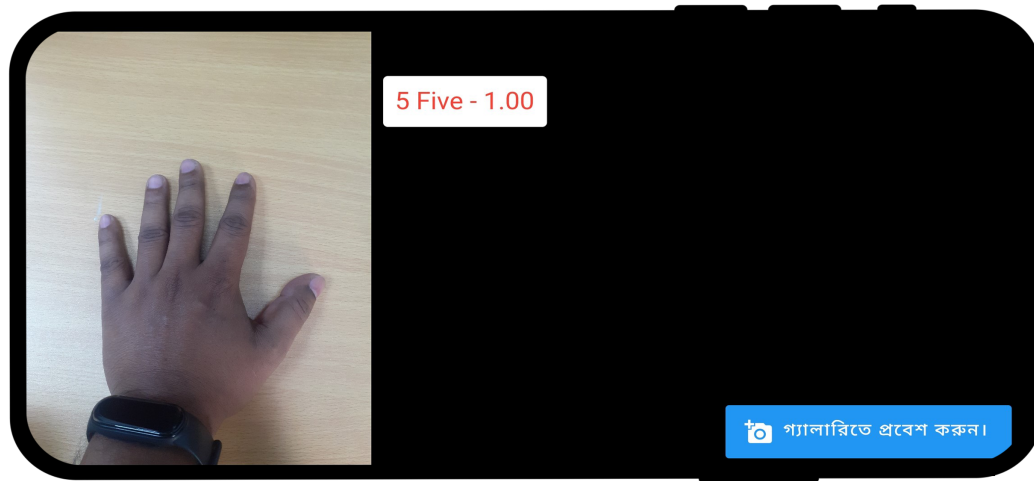


Figure 5.11: Predict Meaning of Image Containing Sign Language Screen of the Application

Search Screen: Figure 5.12 shows the search process screen. The search mechanism helps students quickly find learning content without scrolling through individual subjects for learning content. When students type their desired word in the search bar, a list of all the learning content in the application will be displayed. From the displayed list, students can navigate to the learning content pages very easily and in a short time.



Figure 5.12: Application Searching Process Screen

Chapter 6

Conclusions

Parents, other family members, and teachers face major challenges in learning and teaching sign language to deaf and mute children. The project aims to provide an effective solution to the lack of a Bengali Sign Language learning platform in the Bengali community by developing an e-learning mobile application with four features to teach Bengali alphabet and number sign language to deaf and mute children outside the conventional education system. This application will play an important role in providing a wider environment for the use and learning of Bengali Sign Language among the Bangladeshi community. which can motivate parents, teachers, and ordinary people to learn sign language for deaf and mute children in the family or society in general and in the classroom in particular.

6.1 Social, Legal, Ethical, and Environmental Issues

There are some social, ethical, and legal issues surrounding the use of Bengali Sign Language applications for deaf-mute children. Hence, the application is designed keeping in mind all these social, ethical, and legal concerns. Personal information of all users is protected, including that of deaf-mute children, and the application follows a data privacy policy. User information is not stored in the application and is not shared or transferred with any third party. Primarily, this application won't require any particular device permissions, such as those for phone calls, messaging, or internet connections. It intends to use just the camera's authorization and gallery photographs. All learning content and other materials used in the ISHARA E-Learning application are used with the permission of the appropriate authority. This might also have a significant social impact since it will provide

these underprivileged groups of society a technical advantage to exercise their fundamental rights in history's internet age when everything is digitized. Using digital devices instead of paper for learning reduces the need for paper products, which can bring significant environmental benefits, including reduced deforestation, reduced water use, and reduced carbon emissions.

6.2 Brief Summary

The project's goal is to create an artificial intelligence-powered application that would teach deaf and mute kids the Bengali alphabet and number sign. The app will contain images of the Bengali alphabet and number signs, along with a multiple-choice quiz to test the student's knowledge. The application will also use a sign detector mechanism to detect the Bengali meaning of the sign selected by the user. The development of the application will follow the waterfall Software Development Life Cycle (SDLC) Model. The main goal is to provide education to deaf and mute children who face challenges due to the lack of knowledge of proper sign language in their families and society, and to make it easier for them to learn.

6.3 Future works

The functionality of this application might be further expanded in the future. Some possible areas of future work for an artificial intelligence-based Bangla Sign language e-learning application for deaf-mute children are described below.

Integrating sign recognition technology: A feature can be added to detect hand gestures made by deaf-mute children in real time.

Improving the accuracy of sign recognition technology: The system can be trained on a larger dataset to improve the recognition of signs made by deaf-mute children or to predict the Bangla meaning of the sign image.

Adding learning content: This application can currently only teach the Bengali number system and predict, but the content and lessons offered in the application can be expanded to include subjects like the Bangla alphabet, mathematics, science,

and social studies to expand its functionality.

Integrating communication features: Gesture-to-text features can be added to aid communication between deaf-mute children and systems or normal people.

Creating a personalized learning experience: The system can be modified to adjust to the learning pace and style of certain children in order to deliver a personalized learning experience.

Adding interactive and gamified elements: Gamification elements such as puzzles and interactive games can be added to make the learning experience more engaging and fun for the Children.

References

Build apps for any screen. (n.d.). Retrieved from https://flutter.dev/?gclid=Cj0KCQiA8t2eBhDeARIsAAVEga2Ke-tyieCKDCRp9gUW56_Enwee53kZC_ijvVn-CuHpYZge9DglZH4aAm-eEALw-wcB&gclsrc=aw.ds

Computers, A. (2020a, Feb). *Bijoy ishara vasha -1*. Retrieved from https://play.google.com/store/apps/details?id=com.anandacomputers.bijoyisharavasha_1

Computers, A. (2020b, Feb). *Bijoy ishara vasha -2*. Ananda Computers. Retrieved from <https://play.google.com/store/apps/details?id=com.anandacomputers.bijoyisharavasha2>

Computers, A. (2020c, Mar). *Bijoy ishara vasha - 4*. Ananda Computers. Retrieved from https://play.google.com/store/apps/details?id=com.anandacomputers.bijoyisharavasha_4

Computers, A. (2020d, May). *Bijoy ishara vasha - 5*. Ananda Computers. Retrieved from https://play.google.com/store/apps/details?id=com.anandacomputers.bijoyisharavasha_5

Computers, A. C. (2020, Feb). *Bijoy ishara vasha - 3*. Ananda Computers. Retrieved from https://play.google.com/store/apps/details?id=com.anandacomputers.bijoyisharavasha_3

Computers, C. (2020, Aug). *Bijoy ishara vasha - 6*. Ananda Computers. Retrieved from <https://play.google.com/store/apps/details?id=com.company.anandacomputers>

Dart overview. (n.d.). Retrieved from <https://dart.dev/overview>

Deafness and hearing loss. (n.d.). World Health Organization. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss#>

Dss. (n.d.). *Disability information system*. Retrieved from <https://www.dis.gov.bd/>

- International day of sign languages*. (n.d.). United Nations. Retrieved from <https://www.un.org/en/observances/sign-languages-day>
- Islam, S. (2019, Aug). *Ishara-lipi: Bangla sign language dataset*. Retrieved from <https://www.kaggle.com/datasets/ksanzid/esharalipi-bangla-sign-language-dataset>
- Leffingwell, A. D., D. L., & Leffingwell, D. (2021a, Aug). *Nonfunctional requirements*. Retrieved from <https://www.scaledagileframework.com/nonfunctional-requirements/>
- Leffingwell, A. D., D. L., & Leffingwell, D. (2021b, Aug). *Nonfunctional requirements*. Retrieved from <https://www.scaledagileframework.com/nonfunctional-requirements/>
- media, N. i. (2015, May). New-impulse media. Retrieved from <https://play.google.com/store/apps/details?id=com.basvanderwilk.aslkids>
- Mizgirev, L., Galiaskarov, E., Astrakhantseva, I., Bobkov, S., & Astrakhantsev, R. (2021). Transfer learning for road-based location classification of non-residential property. In *Ceur workshop proceedings* (Vol. 2843).
- Mohammad, H., Tamimi, H., & Abuamara, F. (2022). An educational arabic sign language mobile application for children with hearing impairment. *International Journal of Interactive Mobile Technologies*, 16(20).
- Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science*, 14(1), 11-28. Retrieved from <https://www.sciencedirect.com/science/article/pii/036402139090024Q> doi: [https://doi.org/10.1016/0364-0213\(90\)90024-Q](https://doi.org/10.1016/0364-0213(90)90024-Q)
- Rive: Flutter package*. (2023, Jan). Retrieved from <https://pub.dev/packages/rive>
- Sign language*. (n.d.). Retrieved from <https://education.nationalgeographic.org/resource/sign-language>
- SignSchool. (2016, Oct). Author. Retrieved from <https://play.google.com/store/apps/details?id=com.signschool.signschool>
- Siong, T., Nasir, N., & Salleh, F. (2021). A mobile learning application for malaysian sign language education. In *Journal of physics: Conference series* (Vol. 1860, p. 012004).
- Sustainable development goal 4*. (n.d.). Retrieved from <https://betterbangladeshtomorrow.org/sustainable-development-goal-4/>

Abbreviations

Several symbols and abbreviations that will be used in the document's body are listed in the following list.

Abbreviated	Full Form
WHO	World Health Organization
DIS	Disability Information System
CSL	Chinese Sign Language
ASL	American Sign Language
ArSL	Arabic Sign Language
AI	Artificial Intelligence
FR	Functional Requirements
SDLC	Software Development Life Cycle
FS	Finish to Start