E-LEARNING SYSTEM FOR HEARING IMPAIRED STUDENTS

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Specializing in Software Engineering

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The dissertation was submitted in partial fulfillment of the requirements for the BSc(Hons) in Information Technology Specializing in Software Engineering

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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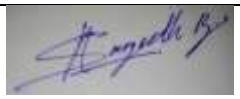
Sangeeth Raj A	IT18152074	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

…….. Date :……

Signature of the supervisor:

(Dr. Kalpani Manathunga)

…….. Date :……

Signature of the co-supervisor:

(Mrs. Samanthi Erang Siriwardene)

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ABSTRACT

Due to the pandemic situation everything is digitalized especially education is transferred to an online but the certain community of people faces lots of difficulties to transferring to the online education, one of them is the hearing impaired students. We explored to provide a solution to them by providing Learning Management System(LMS) which enable the hearing impaired students to learn from the lectures who don't have knowledge or experience in sign language. This will increase the educational quest of the hearing impaired community and help them to get an education through the best educators in their field. The proposed system will generate sign-language for the videos uploaded by the lecturers with the help of Machine Learning(ML) and Natural Language Processing(NPL) technologies. Students are able to upload a video in case of having doubts, and the exact process will happen in vice verse. Further, there is a tutorial segment where students are taught American Sign Language(ASL) and they are tested using motion detection technique so that we can analyzing their learning.

As mentioned above the tutorial segment for the user gives a chance to learn to ASL and check the knowledge whether they are following the instruction correctly using python Convolutional Neural Network we can detect the motion of the user using webcam in real time. If the user followed the instruction and do as the system request he/she can learn sign language easily but in order to reach next level, he/she should pass by following correct instruction.

Keywords: *Machine Learning, Video Processing, Natural Language Processing, Convolutional Neural Network, OpenPose*

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LIST OF ABBREVIATION

Abbreviations	Description
ASL	American Sign Language
LMS	Learning Management System
ML	Machine Learning
CNN	Convolutional Neural Network
NLP	Natural Language Process
WHO	World Health Organization
HCI	Human Computer Interaction
FEMD	Finger Earth Mover Distance
SP-EMD	Super - pixel Earth Mover Distance
CSL	Chinese Sign Language
XML	Extensible Mark-up Language
ReLu	Rectified Linear Unit
ROI	Region of Interest
UI	User Interface
UX	User Experience

1. INTRODUCTION

1.1 Background Study

Nowadays, e-learning has become an essential component of higher education for both teachers and students. According to a study on the effectiveness of e-learning on education, it was found that students nowadays are more satisfied with web enhanced learning when compared to a traditional classroom environment[1]. But there many people who are unable to accept the change of education into online e-learning, one such group of is the hearing-impaired community. We are aware that universities and higher education institutes adopting some form of e-learning to assist their students. Many institutes use their own customized version of a Learning Management System (LMS) to provide online course material. But there is not good source or proper guidance to the hearing-impaired community, even thought people are willing to help but lack of proper knowledge in sign language they are unable to communicate and guide the student, this brings a huge gap being the two communities[17]. According the WHO estimated that approximately 466 million people around the world has disable hearing loss which is a total sum of 6.1% of the world's population. Where 34 million are children and projections of WHO show that the number could rise to 630 million by 2030[20]. There is no 100 percent cure for hearing disability but we can help the community but providing products and service specially designed for them so that we can reduce the gap between them and us. The motivation, goal of the research proposal is to eliminate the difference between both the community by breaking the barriers.

Our suggestion for a hearing-impaired LMS would make a difference and will benefit both students and teachers in a variety of ways. For example, nowadays lecture video are available online so that students are less likely to miss a lecture, and professors can ensure that regardless of location and time all student have accessibility to lecture video and other study material[1]. When lecture videos is recorded and published it helps student with different level of learning and this result in gain a better understanding of the module of the subject. For example, those who are familiar with the work can skip ahead to a section of interest while those that need more time to

understand the concepts can pause and rewind to digest the lecture at their own space [2, 3]. Usually, many LMSs enable lecturers to upload course material such as tutorials, lab sheets, lecture slides, and lecturer's video. Lecture videos are always benefit student with auditory and visual effect so that is more effective and they are not without any drawbacks[4] but in our LMS student can watch the video which are translated to sign language and many students find watching recorded lecture videos tedious due to their length, which typically ranges from 1 to 2 hours long, and student losses interconnection and refer to other or related course content[5] so we will have a time restriction to be effective in the limited time period to avoid conflicts. Although many video-creation and editing platforms exist that enable users to create interactive course materials, these technique is more time consuming user as significant amount of time spent on making the lecture video more interactive so that we are presenting in a simpler way in which the regular lecture video will be uploaded and user will get the translated sign language video and if the student got any doubts on the subject he/she can upload the video of his/her doubt in forum where the lecturer will receive it in a meaningful text format as they only communication using sign language[15,18], once the lecturer answered the question the student will be able to see the answer in a sign language content. All the user may get benefit form the module forum by this functionality. At the time of writing this proposal, to the best of our understanding, there isn't a system which automatically identifies detection of user's motion and analyse for quiz, in the aim of teaching sign language in a few steps[6]. As a result, the primary emphasis will be on two facets of course content: accessibility and interactivity. Our goal is to develop an intelligent system capable of teaching students and improving the interactivity and learner engagement of tutorial material in just a few clicks. Figure 1 who are willing to learn sign language.

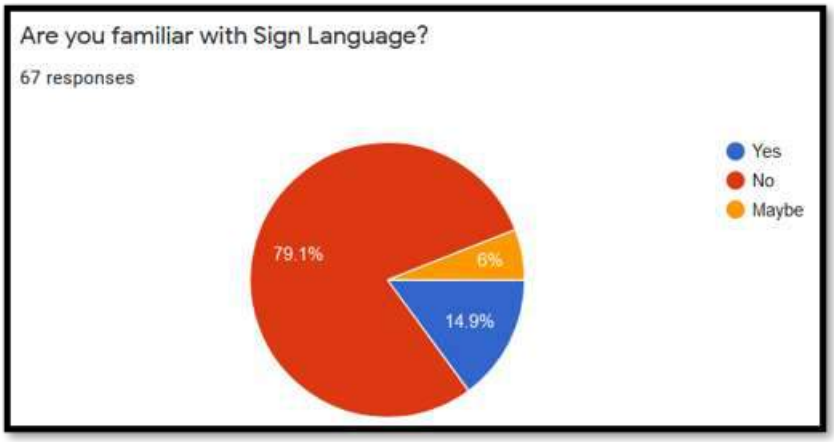


Figure 1- Illustration of Survey result 1

1.2 Literature Survey

For the past two decade there are number of researches have been conducted under motion detection of sign language but all of them do not related one another because the main conflict is existence of different sign languages all over the world[7]. Therefore I have collected and review some of the research papers related to ASL which in the motion detection of hand gesture in sign language for e-learning and algorithm to identify motion of the user.

In the year 2000 Zhao , Karin & Schuler, Liwei , Kipper , William , Christian , Vogler , Norman , Palmer , Badler and Martha in their paper "*Machine Translation System from English to American Sign Language*" [15] has proposed Language-based engineering system with high cost and user friendly natural looking human hand gesture which provide insight for the design principles that has changed over time period in the natural human interaction or communication. Researcher have suggest a machine translator system to convert English to ASL that considers both linguistic and visual and spatial content related with ASL. As a conclusion we can see that research are proposed system to translate English to ASL, this was proposed in earlier 2000 which means it was not possible back then but it is not with significant dataset we can make it possible.

In 2010, Mona M. Nasr, in their paper “Enhanced e-Learning Environment for Deaf/HOH Pupils ” [10] has proposed an e-Learning system to the hard of hearing community, based on the Chinese Sign Language. It includes a variety of learning activities that can assist deaf students in performing on equal level with their fellow students. Students can learn and communicate with others in virtual classrooms using chat rooms and discussion forums provided by the system. There is also a translation feature that allows course materials to be translated into Chinese Sign Language and re-uploaded for use by others. They can be converted into animations or videos. It also has many user positions for system maintenance, including administrator, teacher, and student. As a conclusion the e-Learning system has proven to be useful in locating other LMS components that need to be converted to sign language, such as discussion forms to make communication more effective.

In the year 2013 V. Adithya, U. Gopalakrishnan and P. R. Vinod in their paper "Artificial neural network based method for Indian sign language recognition "[13] proposed an approach for hearing impaired community are unable to communicate along with the general public without a sign language interpreter, deaf people are unable to communicate with the general public. Deaf people become isolated in society as a result of this conflict so that we need sign language recognizing system. By introduction SL recognizing system it will bring a change for the hearing-impaired individuals to communicate with general people with any conflicts or interpreter. The researcher have proposed a SL fingerspelling recognizing in Indian SL in their paper. The dataset collected from hand gesture are used to figure the signs, for extracting the hand area from the photograph, we used skin color based segmentation. Using image distance transform researcher proposed a shape feature technique. The dataset collection of sign image are used to ML model training by forward CNN. Using digital image processing method the proposed component it developed. So that we don’t use any external hardware device to get hand gesture or features. As a conclusion using low computational complexity we can gave high accuracy with only software to implement a system.

In the year 2015 C. Wang, S. Chan and Z. Liu in their paper "Super pixel Based Hand Gesture Recognition with Kinect Depth Camera"[12] proposed an approach for new SL recognition system with the novelty of SP-EMD including `Kinect` depth technology camera which identifies the color of skin and shape of the hand gestures, depths and corresponding textures are representing Super pixel form. The proposed system illustrated by extensive experiment with two third part dataset and with the own research team dataset to experiment whether there was effectiveness in proposed hand recognition algorithm and distance metric. As a the final outcome the system was able to reach higher mean accuracy above 75% also faster hand gesture recogniting speed of average 0.067 second per gesture. As a conclusion this proposed system is very efficient and best fit for HCI application when compared to other SP-EMD and FEMD metric the proposal hand gesture recognition system achieved best performance.

In the year 2016, Goyal, Lalit & Goyal, Vishal, in their paper Text to Sign Language Translation System [14] has proposed that SL user uses facial expression, head notation, body posture, hands and arms to communicate for three dimensions translation of text to SL and translation of spoken or verbal language is totally different as the grammatical order of sentence is not standard in SL, direct translation of SL is complicated. Still, a variety of methods for converting Text to Sign Language have been used, with the input being text and the output being pre-recorded videos or computer-generated animated characters (Avatar). As mention earlier three dimensions translation takes lots of work, to characterize an event, the SL user must takes the 3D space around his user's body which include manual signs, non manual, and also combination of both(2003 Zeshan signs category). Where shapes, location, and movement of hand are known as manual signs and non manual signs considered of head notation, facial expressions, and the user's figure and posture. A sign language symbol or signature have either a manual component nor non manual component, or both combination so that we must consider all the above when has dataset input to train the ML model and to get accurate result from model.

In the year 2016, D . Kelly , C . Markham , and J . Mc Donald in their paper Weakly Supervised Training of a Sign Language Recognition System Using Multiple Instance Learning Density Metrices[17] has proposed an approach using a metric mentioning that not a strong supervised training is need for SL hand gesture recognition system with the help of novel multiple instance learning density technique. Using the metric we can identify isolated SL from a sentence. Our spatiotemporal gesture and hand posture classifiers are then trained using the automatically extracted isolated samples. The research is to evaluate sign language extraction, identify hand gesture and posture classification and spatiotemporal spotting system. This was experimented on a pre-trained model of 48 different vocabulary sign in SL to evaluate overall sign spotting system of 30 sign which resulted in 87% success rate. They suggested a hand posture classification model that can reliably identify hand postures regardless of who is performing the gesture, and a spatiotemporal spotting ML model that can classify gestures on spatiotemporal and detect movement without being specifically trained on a sign. Spatiotemporal ML model and detect posture have be integrated into the framework, using the proposed MIL density algorithm they were able to learn sign language of hand gestures from noisy and weak oversight of translation automatically. The researcher have extending the vocabulary of our automatic training system based on 30 different sign takes only automatic processing of a wider video dataset including accompanying text translations. As a conclusion Proposed system was able to learn using unsupervised training and dataset were from different source and still was able to identify the object, using this method we can conclude efficiency of the unsupervised model.

In the year 2018 M. G. Grif with his colleague A. L. Prikhodko, in their paper "Approach to the Sign Language Gesture Recognition Framework Based on HamNoSys Analysis"[20] BamNoSys analysis and data from the OpenPose program library are used to develop the proposed SL gesture recognition framework. BamNoSys is a transcription system for both manual and non-manual gestures that makes for accurate linguistic transcription. With SL gesture classification based the on BamNoSys linguistic examine a single sign whether it is characterized as a

combination of other SL components in the framework which are Trajectory component, Axis component, Hand Shape component, Rotation component, and Orientation component. The findings of this study will be useful and the development of improved methods and techniques for applied linguistic research, as well as in carrying out educational or research activities related to the Sign Language. As a conclusion we say that the ML can identify both manual and non-manual gestures using BamNoSys transcription system and OpenPose.

In 2020, Tariq Jamil, in his paper “Design and Implementation of an Intelligent System to translate Arabic Text into Arabic Sign Language” [8] has suggested the development of an AI system which transform Arabic written or text to Arabic Sign Language(ArSL). It was created to address the need for the Arabic deaf community to be integrated into society and to be able to communicate with them without difficulty. Text input, parsing, word processing, and ArSL output are the four key steps in the system's implementation. Basically, the sentence that needs to be translated will be passed to the translator user interface and the system will identify each part such as, noun, verb, adjective, and consequently eliminate the words that are meaningless. Then the other meaningful words will be checked with the already updated system’s database full of signs, and hence display the correct output in GIF format. The user interfaces for the translator were created using the ScreenBuilder application and the Java programming language. For quick and accurate text processing, the ‘Farasa' toolkit was used, which also helps to identify the parts of a sentence. Finally, the ArSL signs output was displayed using an animated character supplied by MindRockets, Inc. As a conclusion this research work clearly outlines the implementation process, where the tools and software used for development will be efficient to build an eLearning system and output dataset can be GIF format which mean the GIF can be used as input dataset.

In the year 2020 Xi Hu, Jiayi Zhou, Liming Tan, Shahid Ali, Jun Liao, Zirui Yong, and Li Liu in their paper ″Recognizing Chinese Sign Language Based on Deep Neural Network ″ [9] proposed an approach for hand gesture recognition to identify

complex and complicated sign languages in the HCI with the help of DNN technology algorithm, but the research on CSL recognition remains debate. Researcher gathered dataset and proposed recognition solution to CSL using 2D image. They used a self-created dataset to train the model with excellent classification precision, and they were able to reach a complete sign language recognition with an accuracy rate of 0.9324. As a conclusion this proposed system is very efficient and accurate in analyzing 2D image of sign language of CSL which are really difficult in identify in real, we can use the idea to apply deep neural network in identifying image and analyze motion.

In the year 2020 D. Manoj Kumar, K. Bavanraj, S. Thavananthan, G. M. A. S. Bastiansz, S. M. B. Harshanath and J. Alosious in their paper "EasyTalk, A Translator for Sri-Lankan Sign Language using Machine Learning and Artificial Intelligence"[22] proposed an approach to convert SL text to auditory format, enabling people to communicate more efficiently. This is divided into four sub parts, Hand Gesture Detector, the first component, uses pre-trained models to capture hand gestures. The Image classification component translates hand gesture signs that have been found. The Voice generator component produces a text output or auditory format for the hand gesture signs that have been recognized. Finally, the Text to Sign Converter turns entered English text into animated images based on sign language. Using these tools, EasyTalk can more accurately identify, translate, and produce relevant outputs. As a conclusion The application translated all NLP connected language and SL using an NLP-based API. Ordinary citizens should use the application's reverse engine to translate voice input into sign language of Sri Lanka. They only need a valid dataset to use this API. The Text and Voice Generator aids in the recognition of word segments from alphabet collections, the correction of spelling, and the conversion of word segments to speech. This reverse translator use Semantic Analysis to get GIF images of relevant SL using text input from the user so that it will be an efficient way to use sign language video or gif as a data using RCNN base ML model.

1.3 Research Gap

Even though there are several technologies is already available with similar objectives of motion detection of hand gesture, most of them are not succeed or given efficient and accuracy in the past proposed system. The major goal is involving human intervention to make the content more interactive and increase the user experience with user friendly technology. Our proposed solution aims to increase the amount of human interaction needed for this process by introducing very computationally efficient and best fit for real-world HCI application which will analyze their motion in real-time and LMS gives the content automatically if the user's motion is similar to dataset. Table 1 shows existing system in the market to detect hand gesture.

Table 1 - Illustration of Existing system

Features	FEMD	SP-EMD	Super-pixel Based Hand Gesture Recognition	Recognizing CSL Based on DNN
Achieve accuracy in detection	✔	✔	✔	✔
Fast recognition speed in analyzing	✗	✔	✗	✗
Achieve high mean accuracy in detection	✗	✗	✔	✔

1.4 Research Problem

This research area was proposed in behalf the community and the beginner who are willing to learning ASL Figure 2. There are number of researches that have been

conducted under motion detection of sign language but all of them do not related one another because the main conflict is existence of different sign languages all over the world [7] but when it comes to big picture there only one major issue which the presence of two hand gesture and one hand gesture. The they have used image as the dataset to find the accuracy of the hand gesture and have succeed in their research but previous researches have not achieved the best accuracy level of prediction when the dataset in video format and for a certain point we can get a good accuracy level of prediction[22].

Therefore, the main idea behind this particular component was to implement a best accuracy level of prediction using Kaggle dataset and combine different ML algorithms for classification to improve the accuracy of user motion and prediction good result for user end, and evaluate the accuracy of prediction by applying advanced techniques.

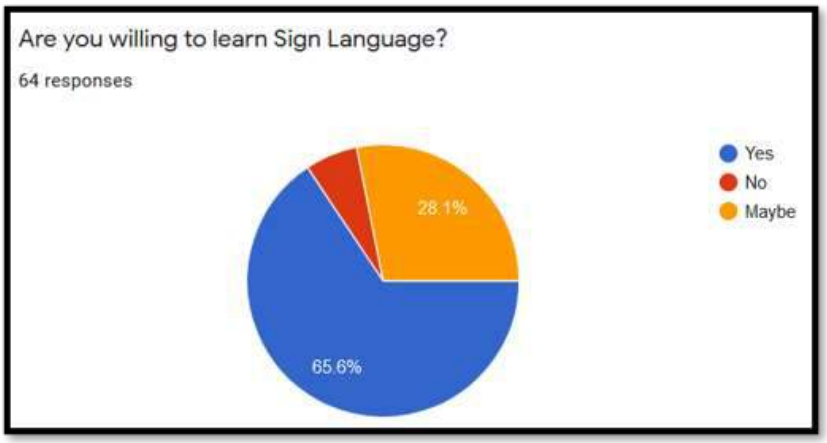


Figure 2 - Illustration of Survey result 2

1.5 Research Question

At the beginning stage of the proposal we had many questions arise from our side those which we uncertain, these were the questions:

- What are the current trending software used for motion detection?
- What design aspects have been considered when designing LMS for hearing impaired community?
- What ML technologies to be used?

- What algorithms to be used to analyze user data?
- What is the source of dataset?
- Will dataset be used effectively in training and testing?
- Will the proposed LMS make an impact in community?

1.6 Research Objective

The proposed LMS is a research study to improve the e-learning method to hearing-impaired students by delivering convert sign language content form lectures video and to increase the level of participation of the hearing-impaired students. The main and sub objectives of the research are as follows.

1.6.1 Main Objective

The motive of this component is to teach ASL who are at elementary level in sign language which are below **Error! Reference source not found.**. We guide the user with a tutorial of the ASL and ask to take test by repeating as per the instruction of the system. The user's motion is analyzed with the help of CNN ML model and if the user successfully completed the task then system will navigate to next level. For instance where the user learning alphabet letter 'A' and succeed the task the system navigates to next task which alphabet letter 'B'.

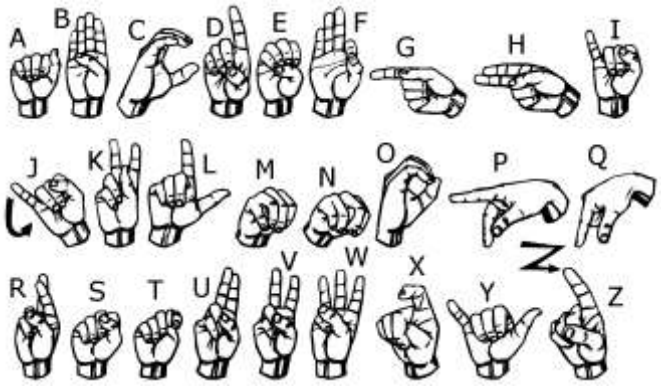


Figure 3 – Illustration of ASL

1.6.2 Specific Objective

- Feeding the system with tutorial of the module.
- *ex: Learn alphabet – feeding database with sign used for alphabet.*
- Providing correct instruction to user and to follow.
- Provide user friendly user interface to navigate.
- Getting optimized/enhanced video from the user.
- Detect the user's motion using Keras and TensorFlow.
- Analyze the video whether the user's motion detected and the motion in ML model is accurate by CNN.

2. METHODOLOGY

This chapter provides the details of methodology used for implementation of the system's relevant functions. We will discuss the methodological approach of requirement gathering, designing, implementation and testing. The suitable tools and technologies were decided based on the literature review of the proposal and some of the technologies were update in the latter part of the development component, only the present tool and technologies will be discussed.

2.1 System Overview

2.1.1 System Overview Diagram

We may see the system diagram is vivid image of the system and it contains separate component and how the interaction take place with supporting documentation. The overall system planning is shown below in the system diagram. The diagram present e-learning system for the hearing-impaired students using four main functionalities. These individual functionalities act as the solutions for some of the problems faced by the hearing-impaired students in e- Learning systems. Each Module in the Figure 4 represents the individual functionalities.

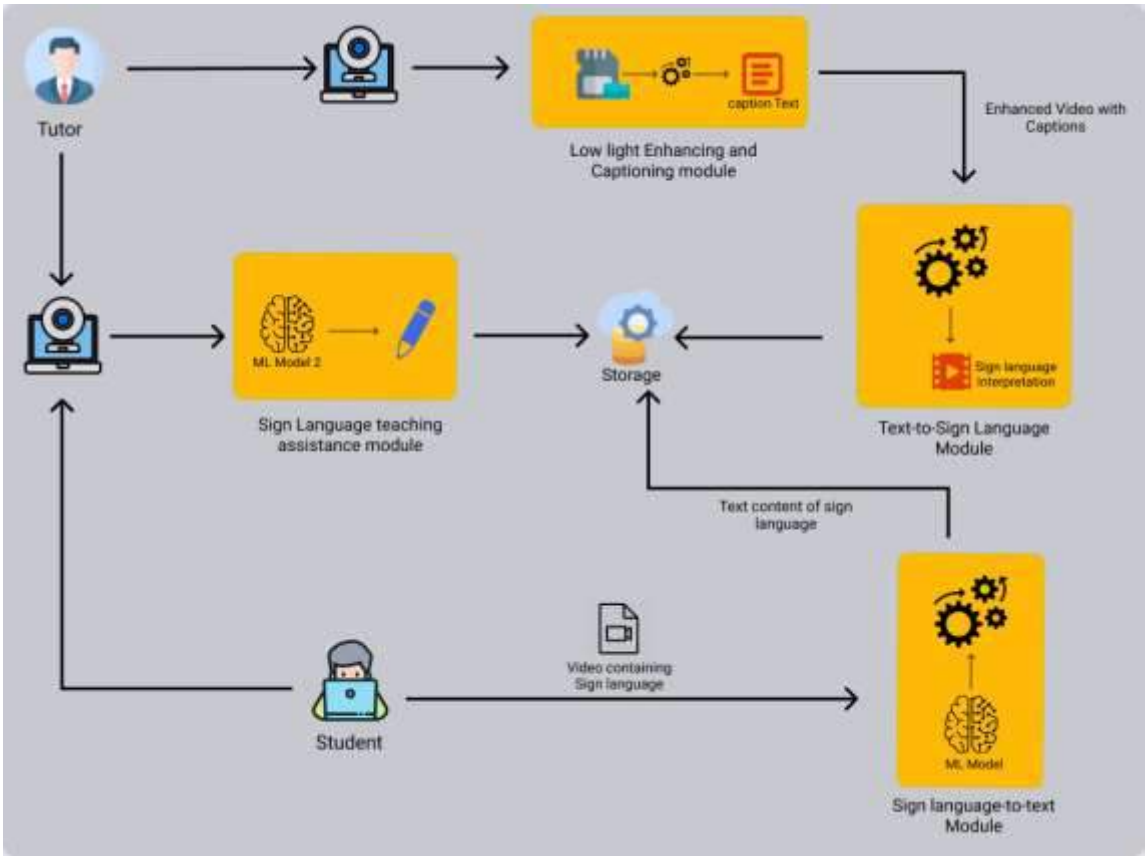


Figure 4 - Illustration of System Overview Diagram

2.1.2 Function Overview Diagram

A Function diagram is a visual diagram of the components which basic functionality is to teach ASL to both hearing-impaired and general user / student and also this can be a great opportunity for both community to learn and improve their knowledge in ASL, this will be an easy mode of learning sign language remotely for their premises. The user will need a personal computer with a webcam and internet connection. We guide the user with a tutorial of the ASL and ask to take test by repeating as per the instruction of the system. The user's motion is analyzed with the help of CNN ML model and if the user successfully completed the task then system will navigate to next level. For instance where the user learning alphabet letter 'A' and succeed the task the system navigates to next task which alphabet letter 'B'. If the motion of the user is correct then it will save and the user will be taken to the next task else if the user is

performing incorrectly then the student is asked to repeat the task from the user. The flow of the functionality is shown in the below Figure 5.

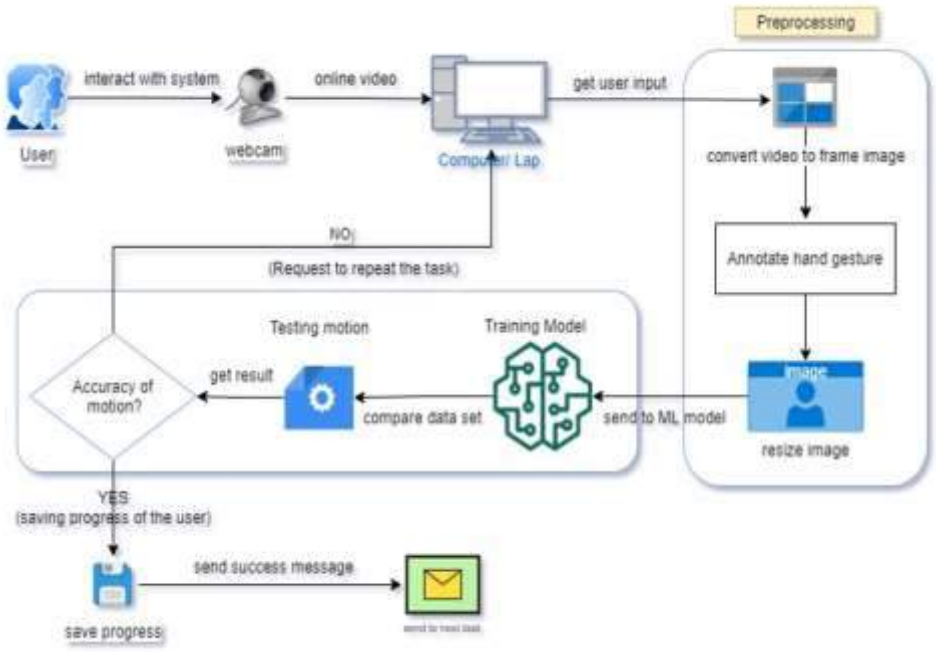


Figure 5 - Illustration of Function Overview Diagram

2.1.2 Function Flow chart

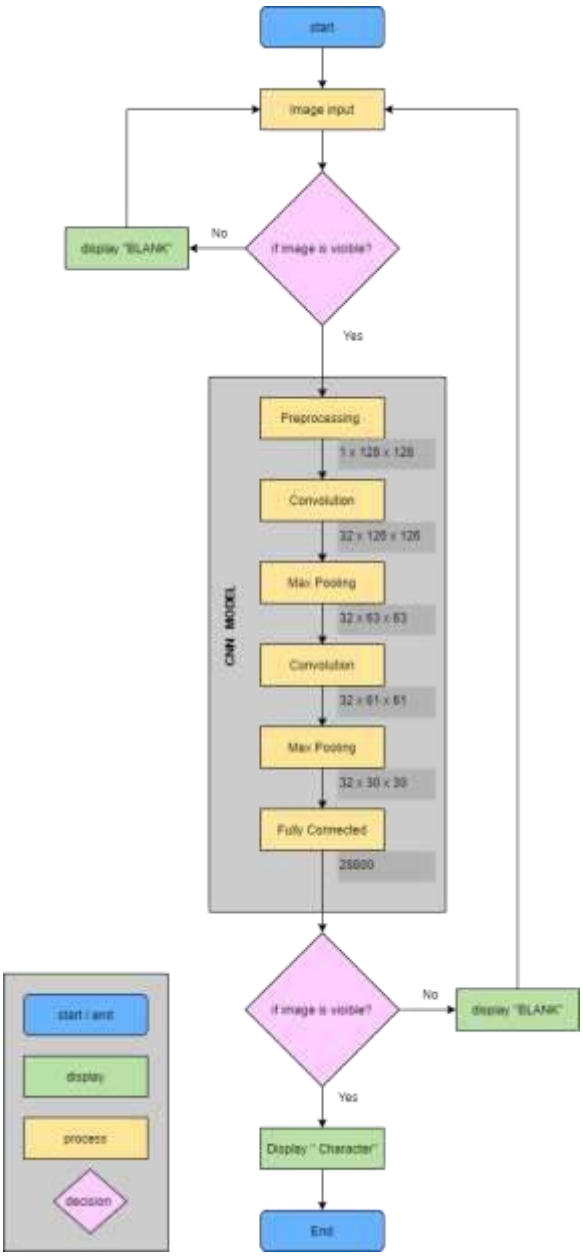


Figure 6 - Illustration of Function Flow chart

2.2 Development Process

2.1.2 Project Management Methodology

At the beginning of a research project requirements may be unclear or undefined due to presence of various sign language and will be subjected to lot of changes throughout

the development cycle. The Agile Scrum model Figure 7 represents the scrum process is an ideal methodology for this kind of a project because it adds more flexibility to the software development life cycle and encourages requirement changes throughout the process of development. Agile follows an incremental and iterative development approach, and each iteration will focus on delivering a working product by adding more dataset. As our team consists of four members, having daily scrum meetings will allow each member to have a general understanding of the whole project and be aware of problems faced by other members as all the functionalities depend on one another. Also, this will improve the collaboration between team members encouraging better team work.

Figure 7 - Illustration of Agile Scrum Process

2.1.2 Work Breakdown Structure

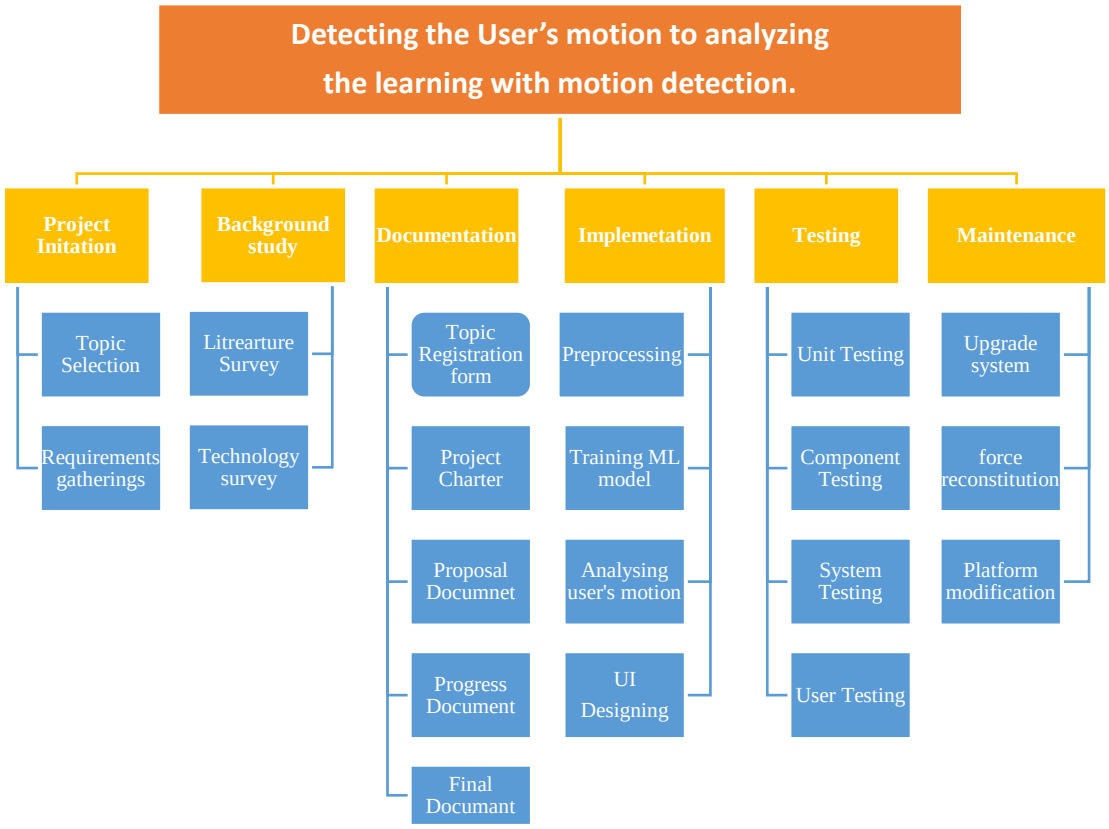


Figure 8 - Illustration of Work Breakdown Structure

2.3 Feasibility Study

Feasibility study means the technological resources needed for the project should be identified and discussed. The technologies like Faster RCNN (RegionBased Convolutional Neural Networks) configuration used for implementation, this feature on TensorFlow and Keras library even more easy by quick build and test of CNN. OpenCV is used for real time computer vision as the video captured in real time in web camera.

The following tools and technologies listed below are used to implement this system,

1. **Designing tools :** Wireframes - Balsamiq
   Diagram - Draw.io

2. **Implementation :** Database - Firebase
   Backend - PyCharm Community Edition(flask)
   Machine Learning – TensorFlow, Keras, OpenCV
   User Interface - Visual Studio 2019
   Version Control - GitLab
   Task Planning - Microsoft Planner

3. **Documentation :** Research Paper/ Final Report - MS Word 2019
   Presentation - MS PowerPoint 2019

2.4 Requirements and Commercialization

2.4.1 Requirement Gathering

This phase is one of the important steps that need to be done before implementing any system. It is a must to analyze and read a lot of previous research works related to this project, to know what kind of implementations to be done, what are the technologies used in the previous researches, and what are the research gaps in those existing works.

1. **Literature Review**

   Under the supervision of our former supervisor we discussed the research project idea and she guided us in collection information from online conference paper and article which gave us a knowledge on what we are going to work on and the current trending technologies which supports the project.

2. **Survey Results**

   We prepared a set of questionnaire to hearing impaired community to find out the difficulties they face in learning and if the are willing to switch to e learning platform with the guidance of our supervisor. We visited a special school Senkadagala Deaf & Blind School, Kandy and the survey was given to students in the school and few teacher as well with the help of few voluntaries we were able to complete the survey, you can find the survey in

APPENDICES.

3. **Dataset**

   To training the ML model we referred resource from Kaggle, Microsoft Research Open Data and eventually ended up in training own dataset which can be found in Figure 9.

Other than the above mentioned requirement there are mainly functional, non functional and user requirements for the functionality those are;

Functional Requirements

a) Analyse user hand gestures effectively and efficiently.
b) Generate proper guidance to user with tutorials.

Non-Functional Requirements

a) Giving accurate result of user's hand gestures without further ado.
b) Accuracy of analysis.
c) Better user experience with user friendly features

User Requirements

a) PC or Laptop
b) Webcam
c) Internet connection

2.4.2 Commercialization aspect of the product

The web-based nature of the platform we propose has several advantages when considering its potential LMS value. The main reason to implement a learning management system for the deaf community students was to make them feel confident in the education field and to achieve success. It absolutely is very helpful for them as they never got to experience an LMS same as the other students (non-hearing impaired). Therefore, they won't be having the feeling of missing out in a community.

The proposed system is very reliable, highly accurate and rapid enough to follow the tutorials, simple and user-friendly application. These aspects will influence very much

in making the application a highly demanded one for the whole deaf community people. Thus it will also increase the user count. Along with that, we can ensure that the students who benefit from this, will come out and shine in the society as they will have no more hurdles in gaining knowledge or skills.

Gradually, there will be expectations for other fields other than education, like IT industries, banking industry, finance industry, advertising industry, etc. to make use of this application, just to convey important information to the hearing impaired users,

The following feature can be considered as the main commercialization aspects

- It can be hosted on a cloud platform and provided as a *Software as a Service* (SaaS) product, where the customer will pay a one-time fee or a subscription to use it.
- It can be developed as a website and advertisements can be incorporated into the system.
- It can be developed as a Freemium model, where services are provided free of charge and certain premium services can be provided for a fee such downloading feature, certification and etc.

2.6 Implementation

This chapter we will discusses the how the functionalities were implement in the system, the implementation has the below functionalities,

a) Image Classifier
b) Web application
c) Database

2.6.1 Image Classifier

2.6.1.1 Dataset

ML model implemented using Convolutional Neural Networks. Using CNN classifier we can process different image then we can categorize them accordingly[22]. Keras

library and TensorFlow was used to implement CNN ML model this will be discussed in discussion chapter below. Dataset of ASL alphabet is used, each letter will be class.

Figure 9 - Illustration of Dataset for Class A

There will be 26 classes and each with minimum 100-150 images per class to train. The above Figure 9 used to show the dataset used to train the ML model.

2.6.1.2 Preprocessing

Here we have used vision based approach which eliminate the cost of sensory device, this approach focus on webcam input to gain data from user end.

Gaussian blur filter : is used to extract data from the user which save preprocessing time, there are other method but in extraction of data arithmetic mean and Gaussian mean are most recommend. The Gaussian mean, pixel values farther away from the (x, y)-coordinate center of the region contribute less to the overall calculation of threshold value, here is the general formula to compute threshold value, T.

$$\boldsymbol{T = \ mean(I_L) - C} \qquad \textbf{(1)}$$

Equation 1 - Gaussian mean

where $(\boldsymbol{I_L})$ is the local sub-region of the image, I, and C is some constant which we can use to fine tune the threshold value T. The code implementation of image preprocessing shown in Figure 10.

```python
import numpy as np
import cv2
minValue = 70

def func(path):
    frame = cv2.imread(path)

    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    blur = cv2.GaussianBlur(gray, (5, 5), 2)

    th3 = cv2.adaptiveThreshold(blur, 255, cv2.ADAPTIVE_THRESH_GAUSSIAN_C, cv2.THRESH_BINARY_INV, 11, 2)
    ret, res = cv2.threshold(th3, minValue, 255, cv2.THRESH_BINARY_INV + cv2.THRESH_OTSU)
    return res
```

Figure 10 - Illustration of Code for Image Processing

2.6.1.1 Image Classification

Once the filter is applied the image going through different stage in CNN classifier layer which are listed below,

1. **Convolutional Layer (1)**

   Image from the webcam has low quality which is 128x128 pixels. It will be passing through 3x3 convolution filter which is smaller filter size (3x3 + 3x3) with smaller kernel value we get more layers and less weight that lead to it learn more complex non-linear features, Figure 11 shows how filtering is done. Finally result with 126x126 pixels for each Filter-weights.

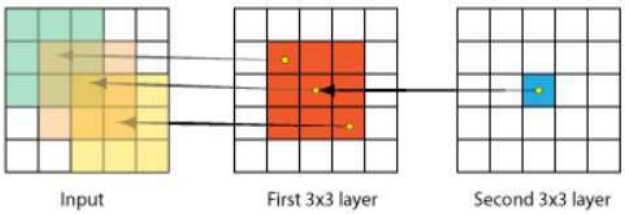


Figure 11 - Illustration of Convolution 3x3 filter

2. **Pooling Layer**

   Once the image pass convolution filter the image are down sampled with the help of max pooling which get the maximum value of the feature map and give the summarized value of the feature detected of the image, down sampling of feature map can be seen in Figure 12. We use 2x2 so that the final result will be 63x63 pixels in the end.

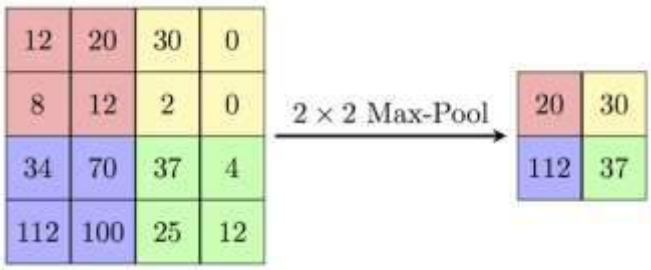


Figure 12 - Illustration of Maximum Pooling (2x2)

3. **Convolutional Layer (2)**

   Now the image value is 63x63 pixels and this will be filtered again with 3x3 filter and result in 60x60 pixels.

4. **Pooling Layer(2)**

   Here the image with 60x60 pixels is down sampled again with 2x2 so that the final result will be 30x30 pixels.

5. **Densely Layer**

   The layer connected with preceding layer deeply which means it is connects every neurons and here 128 neurons hence it is used for simple neural network. Densely layer perform matrix-vector multiplication where column vectors and row vectors must have equal number of columns in Figure 13 where A is a (M x N) matrix and x is a (1 x N) matrix and pooling layer result 30x30 so we take 32 column value and input of the layer is array of 28800 value. To avoid overfitting 0.5 is used as a drop out value.

$$\mathbf{A}\mathbf{x} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$
$$= \begin{bmatrix} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \\ \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n \end{bmatrix}.$$

Figure 13 - Illustration of General formula for a matrix-vector

6. **Densely Layer (2)**

   Result of densely layer (1) used as input to fully connect layer 96 neurons to keep it simple neural network.

Rectified Linear Unit : also known as ReLu is been used in the layers of both convolutional and densely fully connected neurons as Activation Function. Here for each input max(x,0) function is used by ReLu, this helps to learn more features of input and add nonlinearity. So that it results in speeding up training process and reduce computation time.

Max Pooling Layer : there are different types of pooling layers such as Average Pooling Layers, Max Pooling Layers and Global Pooling Layers. We have used Max pooling with pool size of (2, 2) with combination of ReLu activation function. This will reduce computation cost and overfitting.

Dropout Layers : here the layer will drop out activation function which doesn't perform well by setting them to zero, the selection of the activation is one specific but random set is picked. Providing correct output for defined set even if some of the activation function are dropped out, dropout is simply a way to prevent neural network from overfitting in Figure 14 we can see the functionality of applying dropout.

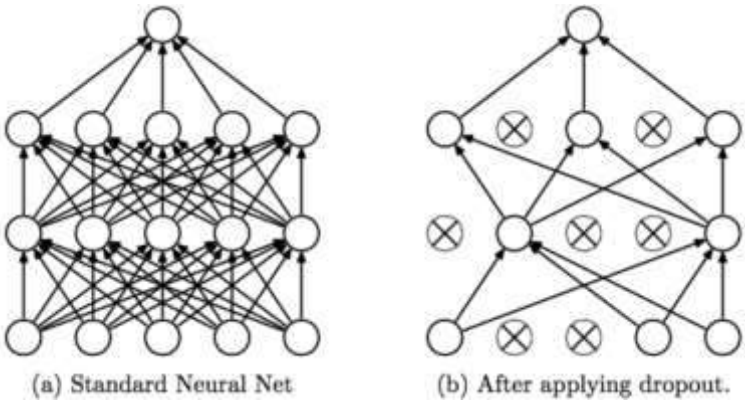


Figure 14 - Illustration of Dropout Layer process

Adam Optimizer : is used for update ML model in response to the output of the loss function. Adam's optimizer has the advantages of two gradient algorithms which are Root Mean Square Propagation(RMSProp) and Adaptive Gradient Algorithm(ADA GRAD).

The code implementation of image preprocessing shown in Figure 15.

train.py > ...

```python
# Importing the Keras libraries and packages
from keras.models import Sequential
from keras.layers import Convolution2D
from keras.layers import MaxPooling2D
from keras.layers import Flatten
from keras.layers import Dense , Dropout
import os
os.environ["CUDA_VISIBLE_DEVICES"] = "1"
sz = 128
# Step 1 - Building the CNN

# Initializing the CNN
classifier = Sequential()

# First convolution layer and pooling
classifier.add(Convolution2D(32, (3, 3), input_shape=(sz, sz, 1), activation='relu'))
classifier.add(MaxPooling2D(pool_size=(2, 2)))
# Second convolution layer and pooling
classifier.add(Convolution2D(32, (3, 3), activation='relu'))
# input_shape is going to be the pooled feature maps from the previous convolution layer
classifier.add(MaxPooling2D(pool_size=(2, 2)))
#classifier.add(Convolution2D(32, (3, 3), activation='relu'))
# input_shape is going to be the pooled feature maps from the previous convolution layer
#classifier.add(MaxPooling2D(pool_size=(2, 2)))

# Flattening the layers
classifier.add(Flatten())

# Adding a fully connected layer
classifier.add(Dense(units=128, activation='relu'))
classifier.add(Dropout(0.40))
classifier.add(Dense(units=96, activation='relu'))
classifier.add(Dropout(0.40))
classifier.add(Dense(units=64, activation='relu'))
classifier.add(Dense(units=27, activation='softmax')) # softmax for more than 2
```

Figure 15 - Illustration of Code to build the CNN

2.6.2 Web application

The functionality needs to be implement in the web application for the user to test themselves but our primary user will hearing impaired student so that we must focus on HCI when designing the user interface(UI) to give better user experience(UX). So that we select React JavaScript framework to implement the frontend. As mentioned above the UI should be simpler and user friendly for the user, the Figure 16 show how the UI planned initially, on the left hand side instruction in words will be displayed, on the right hand side will connect to the backend for the user to test and in the center

there will the video instruction which the user needs to flow. The user can navigate to other functionalities use the nav bar. Buttons are designed in large so that user can navigate easily.

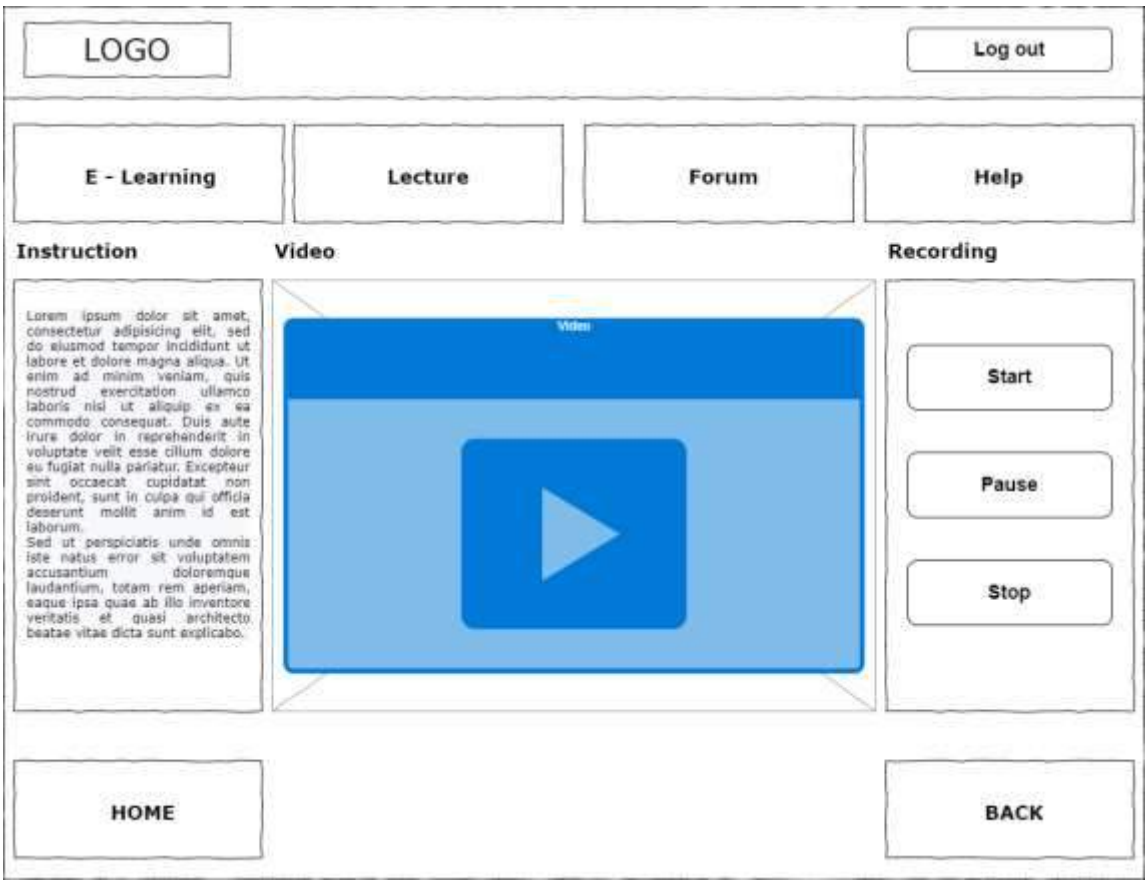


Figure 16- Illustration of Teach ASL wireframe

2.6.1 Database

The complete system will have thousands of data, for highly scalable and large number of data the best practice to use in NoSQL database than relation database so that we choose Firebase as the primary storage unit. In this function the tutorial video are uploaded in the server and progress of user is also stored in database. The UI of system where tutorial video of high quality are stored.

2.7 Testing

This chapter discusses the test results obtained from the development of the application, as the system implementation is done using agile methodology the testing

also done in different sprints. We focused on Unit testing and System, these tests help to identify any weak points of the system. Testing is both a complex and critical component of the development of the application. Application testing includes usability, performance, security, functional and non-functional aspects. The testing will enhance the quality of the product.

2.7.1 Unit Testing

Unit test was when completion of each sprint, training model, test with user skin tone, video test after integrating with UI. Primarily focused on getting correct prediction of the module. Webcam videos tested with different lightings and with both complex and clear background. Below listed are unit test cases.

Table 2 - Illustration of Test Case 01

TEST CASE 01	
Pre-requirements	PC or laptop and webcam.
Description	Detection of user's skin tone to train the ML model by Developer
Test Procedure	Step 1: execute function switch on the web cam. Step 2: place the hand in the region of interest(ROI) Step 3: execute capture function.
Input & Output	
Expected Output	Detection of user's skin tone and omit background
Result of test case	Pass

Table 3 - Illustration of Test Case 02

TEST CASE 02

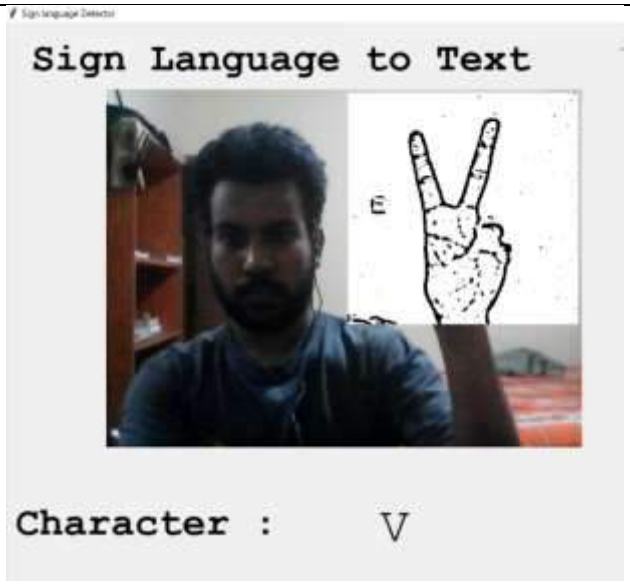
Pre-requirements	PC or laptop and webcam.
Description	Test the trained model by Developer
Test Procedure	Step 1: execute function switch on the web cam. Step 2: place the hand in the ROI. Step 3: system automatically detect the ASL. Step 4: quit from the window.
Input & Output	
Expected Output	Detection of letter ‘C’
Result of test case	Pass

2.7.2 Integration Testing

After integration frontend and backend of teach sign language module the testing was done to get functional and non function aspect of the module.

Table 4 - Illustration of Test Case 03

TEST CASE 03	
Pre-requirements	PC or laptop and webcam.
Description	Test the system after UI update – by Developer
Test Procedure	Step 1: execute function switch on the web cam. Step 2: place the hand in the ROI(gaussian filter) Step 3: system automatically detect the ASL. Step 4: quit from the window.

Input	
Expected Output	Detection of letter ‘V’ and display result next to character
Result of test case	Pass

2.7.3 System Testing

It is done after all the components are integrated and the system does not need to know the inner design of the component. Here, the system is checked with actual outputs and expected outputs. These tests are done with trained users with different age group people and who are taught alphabet in elementary level of ASL. These testing are done with different testing environment,

a) low lighting background
b) balance lighting background
c) dark lighting background
d) balanced lighting background with multiple object

Table 5 - Illustration of Test Case 04

TEST CASE 04	
Pre-requirements	PC or laptop and webcam.
Description	Test system after the integration in **low lighting background**
Test Procedure	Step 1: execute function switch on the web cam.

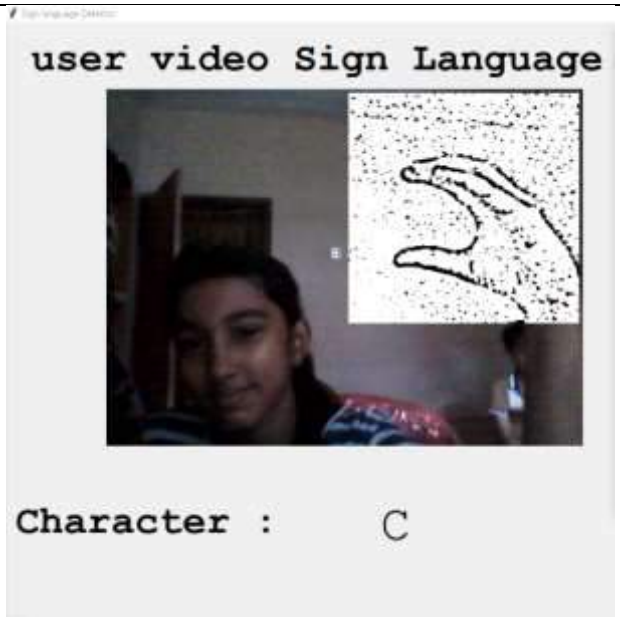
	Step 2: place the hand in the ROI(gaussian filter) Step 3: system automatically detect the ASL. Step 4: quit from the window.
Input	
Expected Output	Detection of letter 'C' and display result next to character
Result of test case	Pass

Table 6 - Illustration of Test Case 05

TEST CASE 05	
Pre-requirements	PC or laptop and webcam.
Description	Test system after the integration in **balance lighting background**
Test Procedure	Step 1: execute function switch on the web cam. Step 2: place the hand in the ROI(gaussian filter) Step 3: system automatically detect the ASL. Step 4: quit from the window.

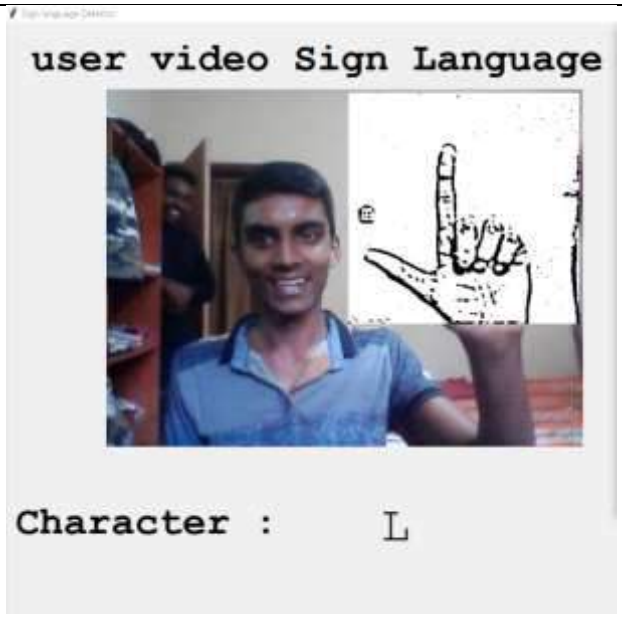
Input	
Expected Output	Detection of letter ‘L’ and display result next to character
Result of test case	Pass

Table 7 - Illustration of Test Case 06

TEST CASE 06	
Pre-requirements	PC or laptop and webcam.
Description	Test system after the integration in **dark lighting background**
Test Procedure	Step 1: execute function switch on the web cam. Step 2: place the hand in the ROI(gaussian filter) Step 3: system automatically detect the ASL. Step 4: quit from the window.

Input	
Expected Output	Detection of letter ‘O’ and display result next to character
Result of test case	Pass

Table 8 - Illustration of Test Case 07

TEST CASE 07	
Pre-requirements	PC or laptop and webcam.
Description	Test system after the integration in **balanced lighting background with multiple object**
Test Procedure	Step 1: execute function switch on the web cam. Step 2: place the hand in the ROI(gaussian filter) Step 3: system automatically detect the ASL. Step 4: quit from the window.

Input	
Expected Output	Detection of letter ‘K’ and display result next to character
Result of test case	Pass

3. RESULTS & DISCUSSION

3.1 Result

The motive of this research study was to provide a functionality that will enable the hearing impaired and general students to learn ASL from the online platforms on their own, without any difficulties or others' assistance. The evident from the test result proves that have reached our goal, here are some technical aspect to prove the function is at its acme.

3.1.1 Confusion Matrix Results

Below is the confusion matrices of ML model in Figure 17 **Error! Reference source not found.**where the true positives are given in the diagonal and have very few false positive values, this indicates the model less negative value and able to prediction sign without any failure.

		A	B	C	D	P E	r F	e G	d H	i I	c J	t K	e L	d M	N	V O	a P	l Q	u R	e S	s T	U	V	W	X	Y
	A	147	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	2	0	0
	B	0	139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0
	C	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	0	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	135	0	0	0	0	0	4	0	0	0	0	0	0	0	0	3	10	0	0	0
C	G	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
o	H	1	0	0	0	0	0	7	143	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
r	I	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
r	J	0	0	0	0	0	0	0	0	0	153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
e	K	0	0	0	0	0	0	0	0	0	0	153	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c	L	0	0	0	0	0	0	0	0	0	0	0	153	0	0	0	0	0	0	0	0	0	0	0	0	0
t	M	0	0	0	0	0	0	0	0	0	0	2	0	152	0	0	0	0	0	0	0	0	0	0	0	0
	N	0	0	0	0	0	0	0	0	0	0	0	0	0	152	0	0	0	0	0	0	0	0	0	0	0
V	O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	154	0	0	0	0	0	0	0	0	0	0
a	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	153	0	0	0	0	0	0	0	0	0
l	Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	147	1	0	0	0	0	0	0	0
u	R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0
e	S	0	0	0	0	1	0	0	0	0	0	0	0	0	0	10	0	0	0	133	0	0	0	0	8	0
s	T	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	151	0	0	0	0	0
	U	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0
	V	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151	1	0	0
	W	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	149	0	0
	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	148	0
	Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151
	Z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 17 - Illustration of Confusion Matrix

3.1.2 Model Test Results

The functionality is tested in different testing circumstance such as in complex background, bright light environment and dark light environment, and we got expected out from the system. Table 9 shows the result of test the functionality.

Table 9 - Illustration of Model test result

Test no.	Test Scenario	No. of test runs	Accuracy (%)
1	Low light background	15	84
2	Dark light environment	15	84
3	Complex environment	15	82

3.2 Research Findings

3.2.1 Convolutional Filters Size

A kernel, convolution matrix, or mask is a small matrix used in image processing. It's utilized for a variety of things, including blurring, sharpening, embossing, and edge detection. A convolution between a kernel and an image is used to achieve this. The Table 10 shows between filter size,

Table 10 - Illustration of Convolutional Filters Comparison

Smaller Filter Sizes	Larger Filter Sizes
We really utilized (3x3) weights if we used the 3 kernel twice to reach a final result. As a result, with decreasing kernel sizes, we obtain fewer weights and more layers.	We utilized 25 (5x5) weights when we applied the 5x5 kernel once. As a result, bigger kernel sizes result in a greater number of weights but fewer layers.
Due to the lower number of weights, this is computationally efficient.	Due to the higher number of weights, this is computationally expensive.
This is computationally efficient due to the smaller number of weights..	This is computationally costly due to the larger amount of weights.

To execute backpropagation, it will need to retain each of the layers in memory as the number of layers increases. This demands the use of more memory storage.	It will require less storage memory for backpropagation with fewer layers.

Based on the above facts smaller kernel filter sizes is used in implementation.

3.2.2 Pooling

In neural networks, pooling is used to reduce variance and processing complexity. Beginners frequently employ a pooling strategy without understanding why they are doing so. Here is a comparison of three basic pooling methods that are widely used.
The three types of pooling operations are:

1. Max pooling: maximum pixel value of feature map.
2. Min pooling: minimum pixel value of feature map.
3. Average pooling: average value of all the pixels in the feature map is selected.

A feature map is a collection of pixels with the same size as the filter size, which is determined by the image size. When using the average pooling method, the image is smoothed out, and so the sharp features may not be visible. Max pooling chooses the image's brightest pixels. It's handy when the image's background is dark and we're just interested in the image's lighter pixels Figure 18. Min pooling, on the other hand, vice versa of max pooling where photos with a white background and a black item, min pooling produces a better outcome.

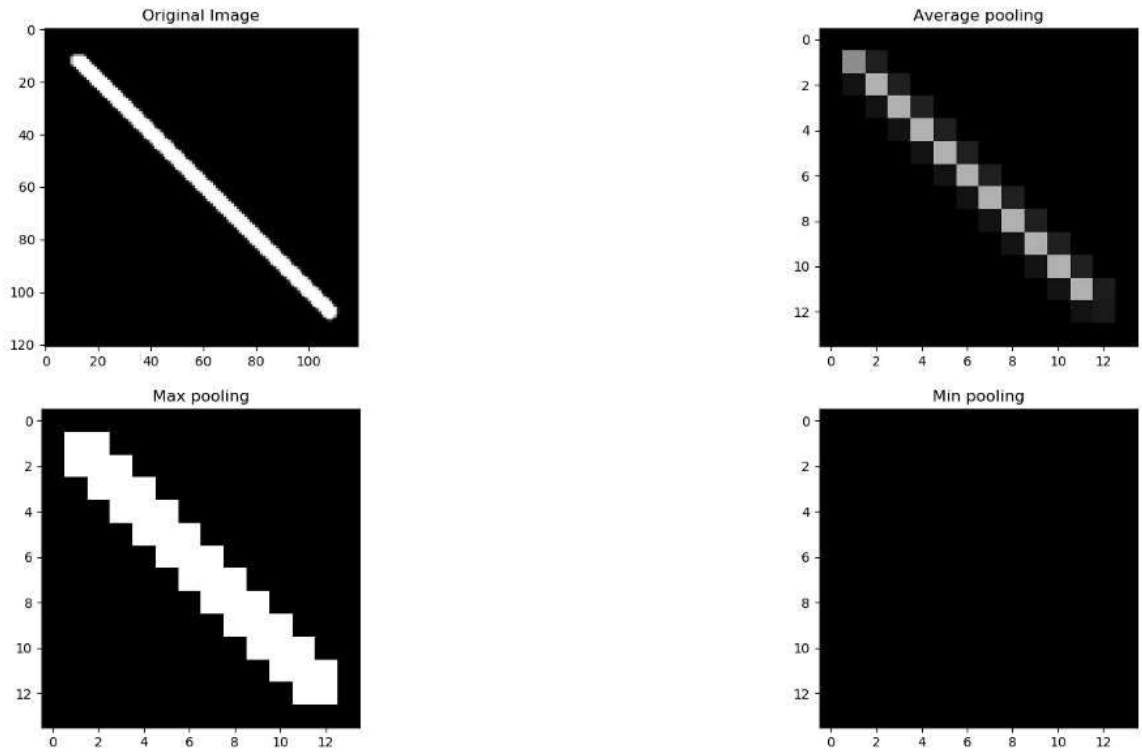


Figure 18 – Illustrate the effects of pooling in dark image

Because max pooling produces better results for photos with a black background and a white object, it is used in this approach.

3.3 Discussion

This chapter discusses the results obtained from the development of the application. We have achieved an accuracy of 84% accuracy for the system. We have used ReLu but earlier there was sigmoid which was replaced but tanh activation function so that in future there might be an activation function to replace ReLu and it can be used in an optimal way to train ML model, if model accuracy increase prediction of ASL can reach it acme.

3.4 Future Works

Many features and experiments have been left for future works. Currently the system is developed based on ASL and it is possible to develop the system to support other sign language as well. This can help more target users to get maximum use out of this

system. This kind of features can be developed in future to provide more advantage to the hearing impaired students. And also Future research should consider the accuracy of the system more carefully. Because here accuracy level is less than 85%. It is better to increase the accuracy level by over 90% in the future, if model accuracy increase prediction of ASL can reach it acme. There are restriction when it comes to multiple objects in the background so that the user is request to work in a clear environment but as future we train the model to omit the background and focus more on user hand gesture. For this we should train the model with more data with different complex background in different lightings so that the accuracy of the model can be increased and get accuracy output.

4. CONCLUSION

To summarize everything, this research work is about developing an e-learning management system for hearing impaired students since the new normal learning became e-learning everything are learning from household without attending school and this must me common everyone which include the hearing impaired community people as well. As time moves on fast the technology also develop parallelly with time and everything sector is online basis where the e-learning is one of the primary sector. Common mistake done but developing team their target audience is ordinary people but we must consider all community which HCI plays a major role but it not an easy task. The hearing impaired community face and differently able community faces difficulties in learning online basis but we can provide them a user friendly system which is how our system could help them and break the communication barriers between different communities. An ordinary tutor or lecturer can use the system to teach a hearing impaired student where the tutor doesn't need a knowledge in ASL, he or she can upload the video and the system translates it for you. Also hearing impaired student can clarify his/her doubt via uploading a video and the tutor will get a translate script from the video where he/ she response to them. Our system's teach sign language part where both hearing impaired and general people can learn ASL from the system. The teach ASL module in the research area is been designed, implemented and tested successfully, anyone can learn ASL using this module and eliminate struggles in learning sign language in e-learning platform. The functionality is developed using vision based approach to eliminate the cost of extra gadgets and device. The ML model is currently trained only with ASL alphabets and it works in the chronological order with an accuracy of 84% where the ML model is able to predict signs on different lighting setup and background with multiple objects with the help of Keras library with ReLu and TensorFlow made training model easier. Therefore, it is hoped that they benefit from this and more users will find this enlightening for their studies in the near future.

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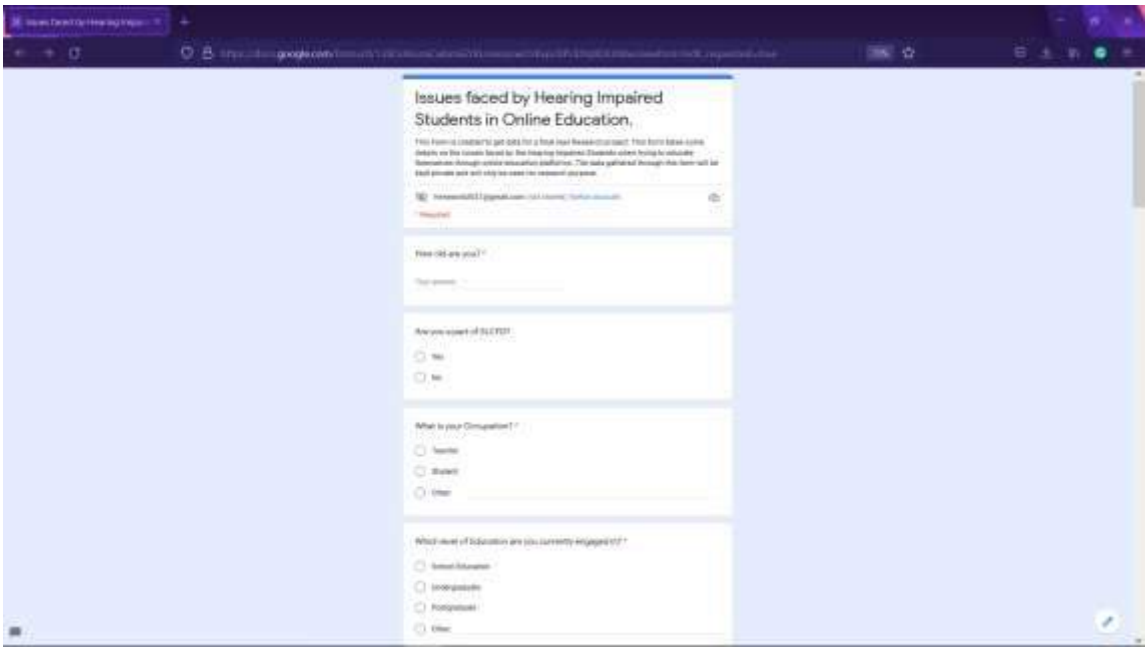
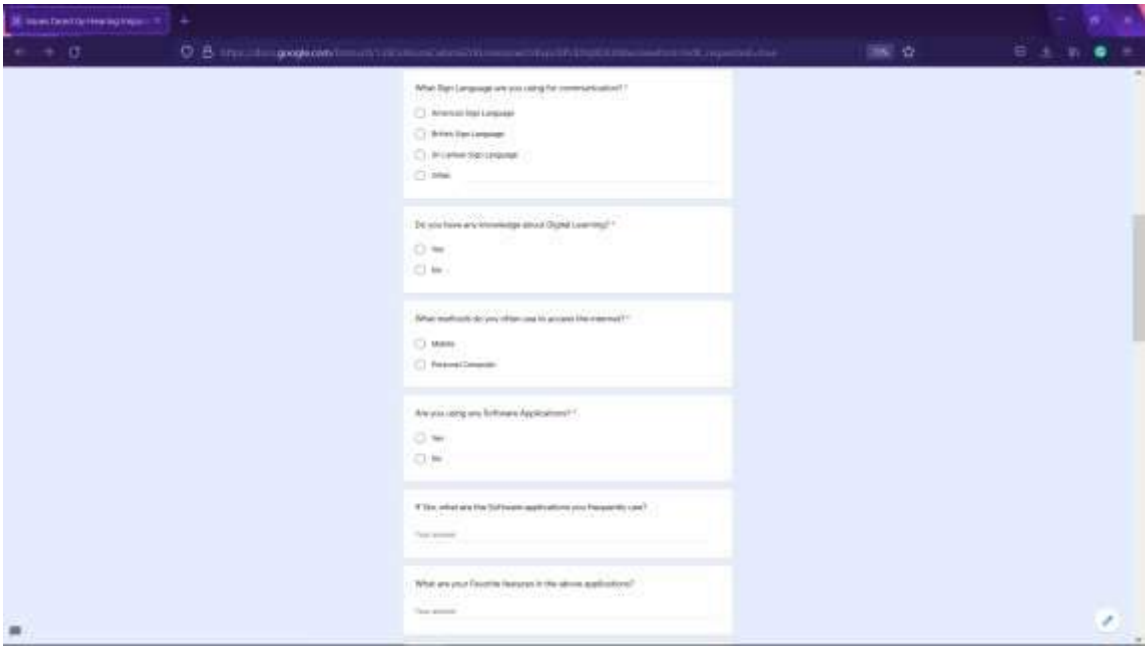
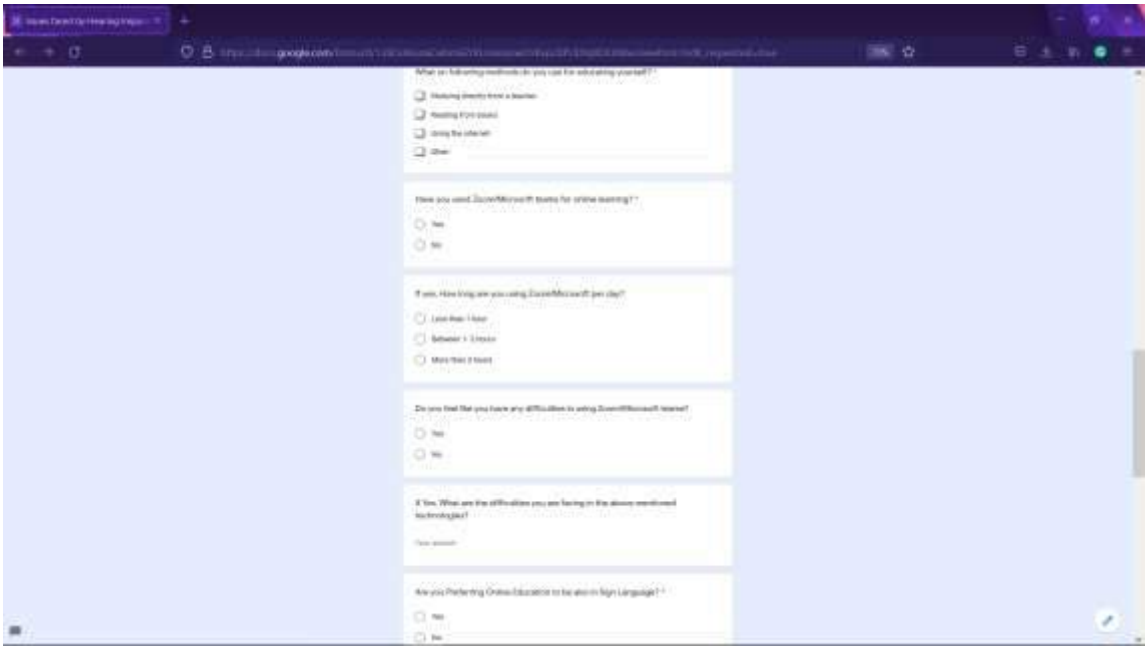
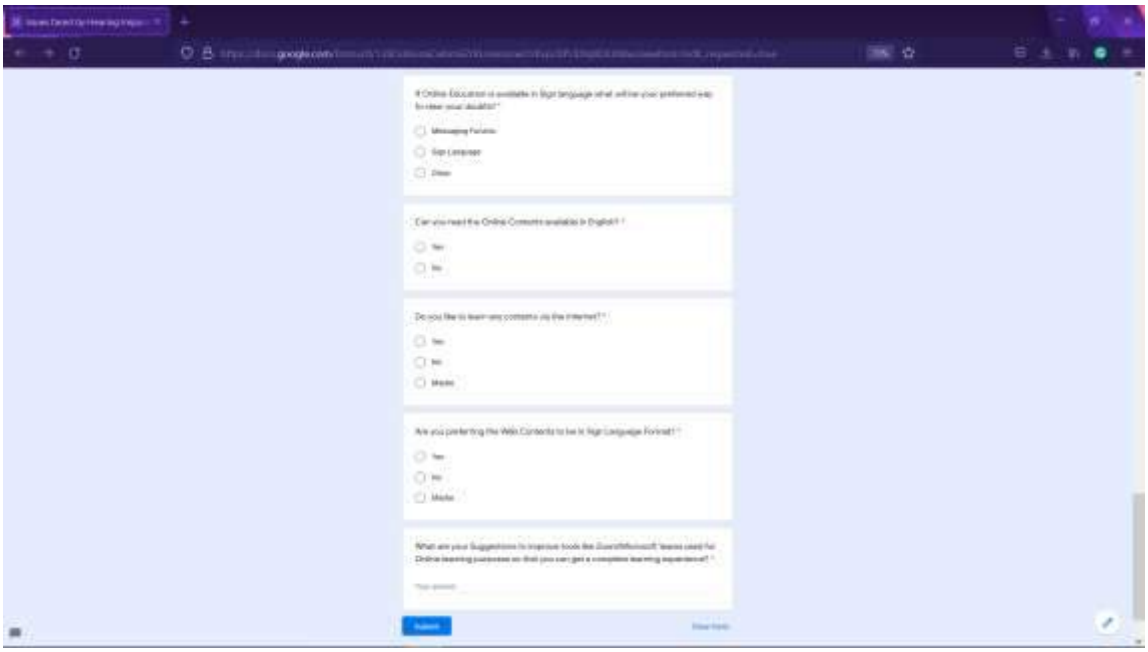
APPENDICES

Survey form









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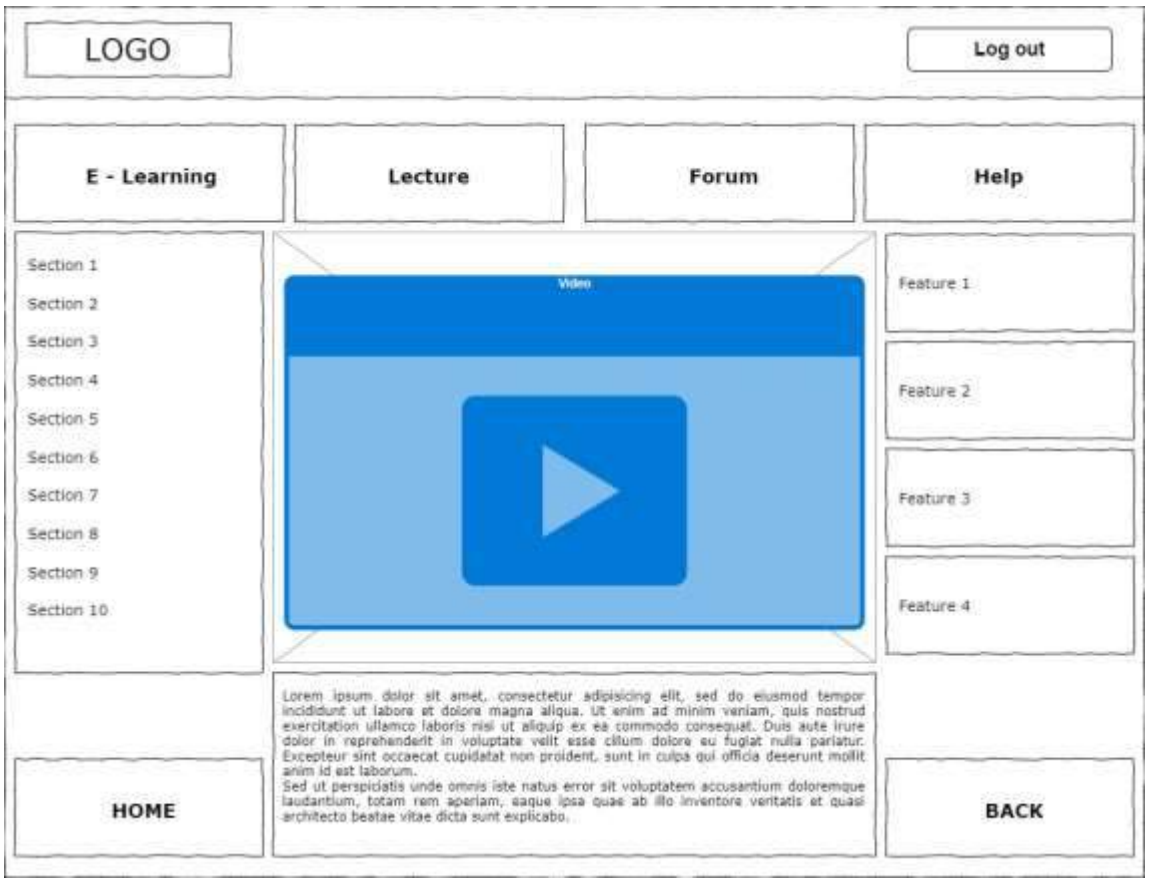
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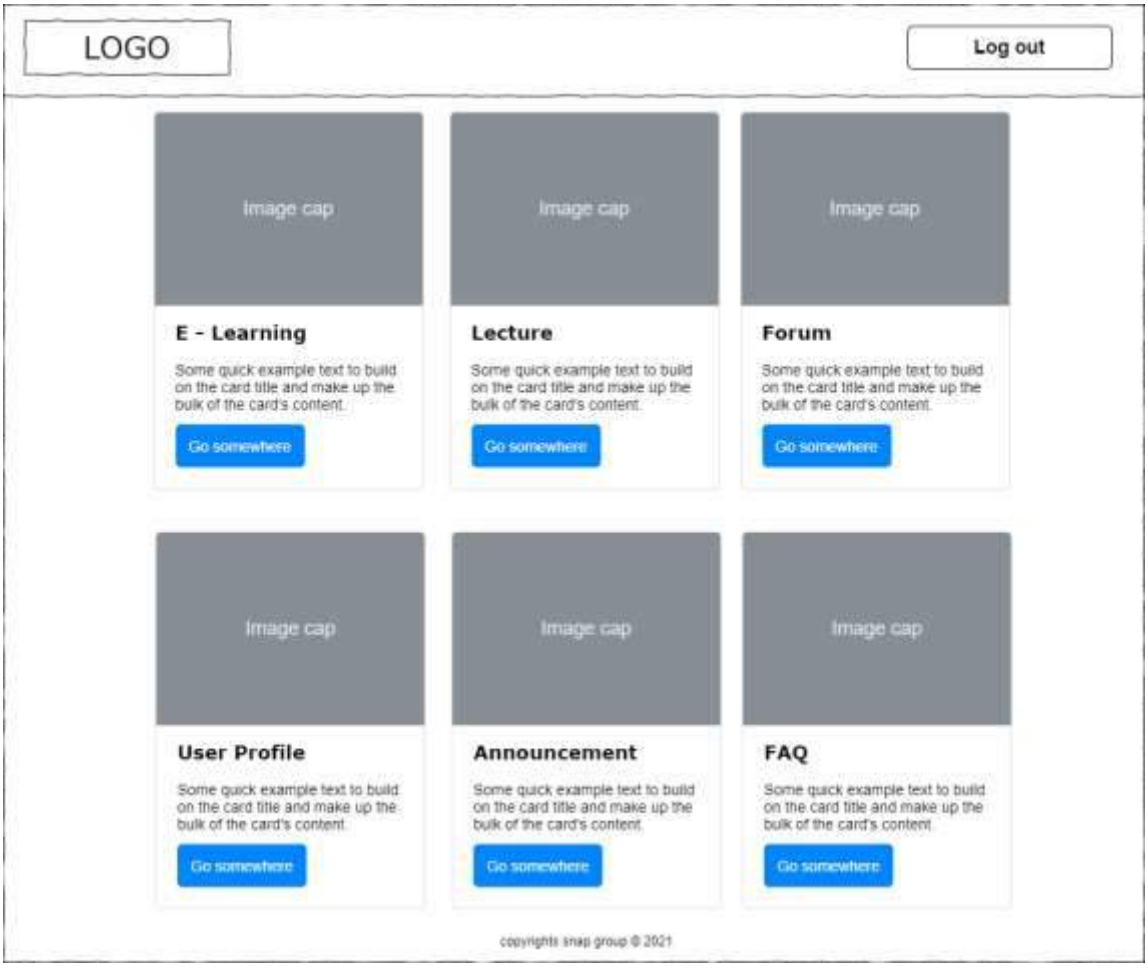
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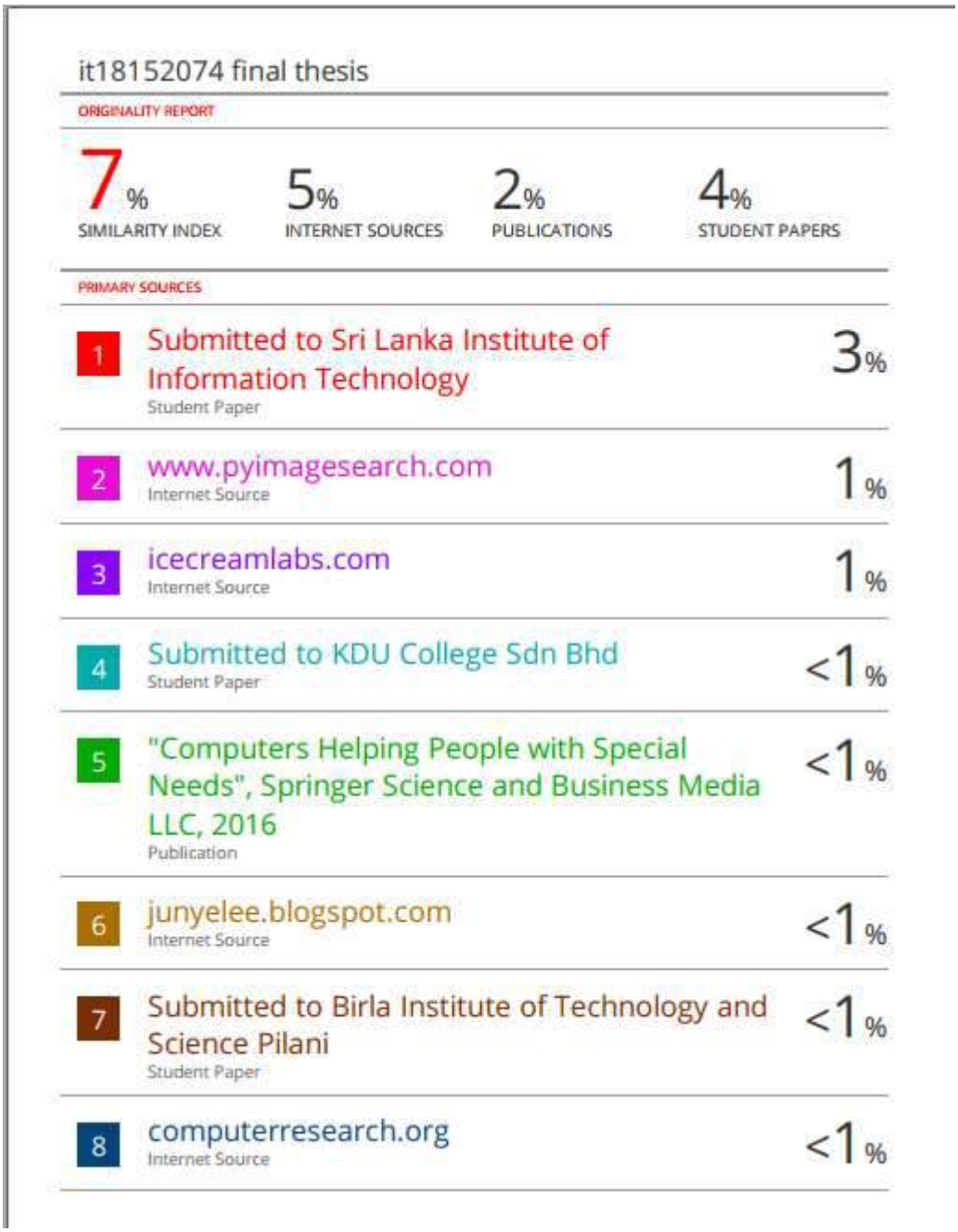

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