Project Report

1. INTRODUCTION

1.1 Project Overview

In our society, we have people with disabilities. Technology is developing day by day, but no significant developments are being undertaken for the betterment of these people. Communication between deaf-mute and a normal person has always been a challenging task. Since normal people are not trained in hand sign language, In emergency times, conveying their message is very difficult. The human hand has remained a popular choice to convey information in situations where other forms like speech cannot be used. A Voice Conversion System with Hand Gesture Recognition and Translation will be very useful to have a proper conversation between a normal person and an impaired person.

1.2 Purpose

The main purpose of this project is to make deaf and dumb people to communicate with normal people.

In emergency situations they can easily communicate with each other.

2. LITERATURE SURVEY

- **Sign language recognition using CNN** - This research paper is focused on the recognition of American Sign Language using Convolutional Neural Network.
- **Design of a Communication System using Sign Language aid for Differently Abled Peoples** - This research paper is focused on the design of a two-way communication system between the deaf and dumb and normal people.
- **SPEECH TO ISL (INDIAN SIGN LANGUAGE) TRANSLATOR -** This research paper is focused on converting speech into Indian Sign Language. The noise removal process is used in this project to improve output accuracy.
- **Sign Language Recognition Techniques: A survey -** This research paper describes the various sign language recognition techniques in brief.
- **SIGN LANGUAGE RECOGNITION SYSTEM -** This research paper overcomes the disadvantages of glove-based hand-sign recognition systems by detecting hand gestures with Raspberry Pi and a camera.

2.1 Existing System

The existing system recognizes gestures using flex sensors, and the Arduino is at the heart of the setup. The output will change as the flex sensor bends. Each sign will have a corresponding output in this system. Output will be displayed on the LCD as text.

Disadvantages

- The level of accuracy is low.
- Flex sensors will easily get damaged.

2.1 References

[1] Dr. Thamaraiselvi, Challa Sai Hemanth, j Hruday Vikas, “SIGN LANGUAGE RECOGNITION USING CNN”, *International Research Journal of Engineering and Technology (IRJET)*, Vol. 09, Issue 03, pp. 819-824, Mar 2022.

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[3] Kajal Jadhav, Shubham Gangdhar, Viraj Ghanekar, “SPEECH TO ISL (INDIAN SIGN LANGUAGE) TRANSLATOR”, *International Research Journal of Engineering and Technology (IRJET),* Vol. 08, Issue 04, pp. 3696-3698, Apr 2021.

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[5] M.HEMANTH, K.EDWARD IRUDAYA RAJ, M.ABUBAKKER SITHIK, M.JENITH RUBAN, G.MADHUSUDANAN, “SIGN LANGUAGE RECOGNITION SYSTEM”, *International Research Journal of Engineering and Technology (IRJET),* Vol. 07, Issue 03, pp. 4198-4200, Mar 2020.

[6] Sanket Bankar, Tushar Kadam, Vedant Korhale, Mrs. A. A. Kulkarni, “Real Time Sign Language Recognition Using Deep Learning”, *International Research Journal of Engineering and Technology (IRJET),* Vol. 09, Issue 04, pp. 955-959, Apr 2022.

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[8] Mr. R. Augustian Issac, S. Sri Gayathri, “Sign Language Interpreter”, *International Research Journal of Engineering and Technology (IRJET),* Vol. 05, Issue 10, pp. 248-251, Oct 2018.

[9] Dr.M.P. Chitra, Vaishnavi Devi. R, Shalini M, Sriee Sathana. L.B, “Sign Language Recognition For Deaf and Mute”, *International Research Journal of Engineering and Technology (IRJET),* Vol. 08, Issue 04, pp. 570-574, Apr 2021.

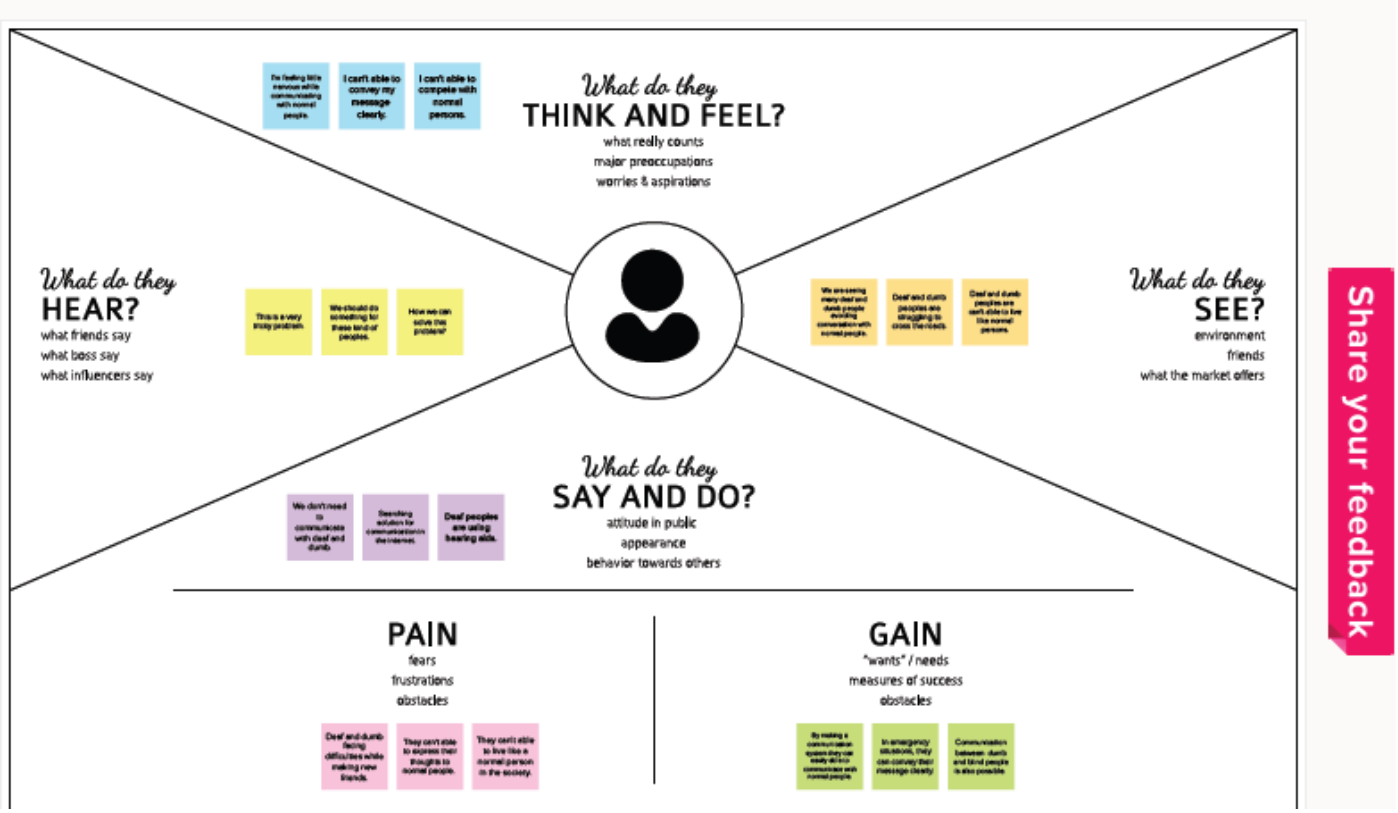
[10] Shailesh bachani, Shubham dixit, Rohin chadha, Prof. Avinash Bagul, “SIGN LANGUAGE RECOGNITION USING NEURAL NETWORK”, *International Research Journal of Engineering and Technology (IRJET),* Vol. 07, Issue 04, pp. 583-586, Apr 2020.

2.3 Problem Statement

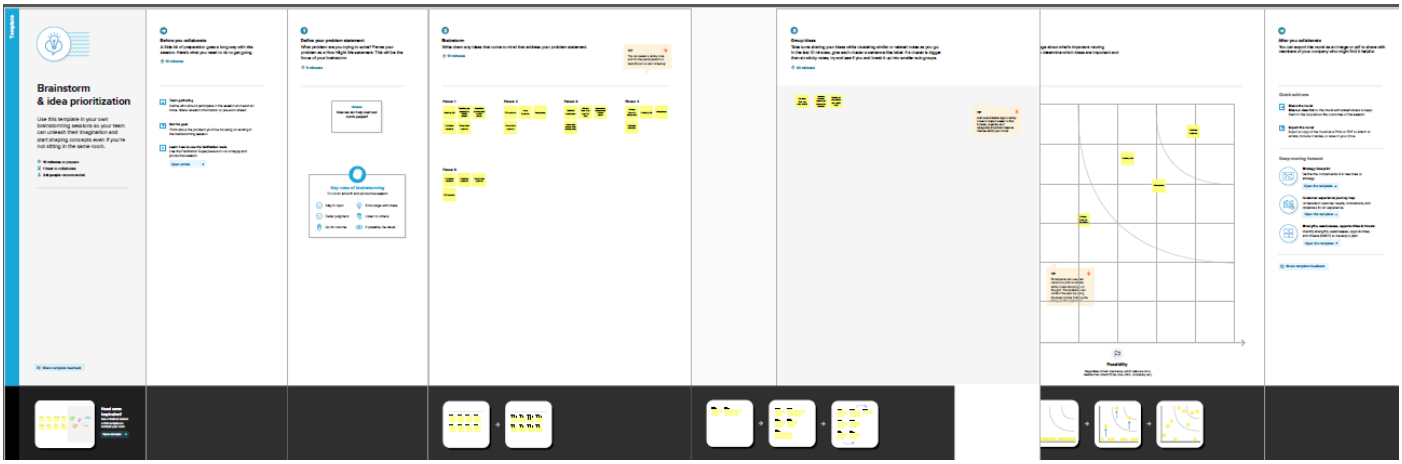
Communication is the only medium by which we can share our thoughts or convey the message but for a person with disability (deaf and dumb) faces difficulty in communication with normal person. Generally dumb people use sign language for communication but they find difficulty in communicating with others who don’t understand sign language. So there is a barrier in communication between these two communities.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.2 Brainstorming



3.3 Proposed Solution

S.no	Parameter	Description
1.	Problem Statement	Generally deaf and dumb people use sign language to communicate with each other. But normal people don't understand sign language. In emergency situations, deaf and dumb people cannot able to convey their message to normal people. So, there is a barrier between these two communities.
2.	Idea / Solution description	We are going to design a real-time communication system using AI that is going to act as an interpreter between deaf-mute and normal people.
3.	Novelty / Uniqueness	The existing system recognizes gestures using flex sensors, and the Arduino is at the heart of the setup. The output will change as the flex sensor bends. Each sign will have a corresponding output in this system. Output will be displayed on the LCD as text. There are lot of disadvantages in this system. So, we propose a computer-vision system for sign language recognition. Our proposed system is not dependent on the use of gloves and microcontrollers like Arduino and Raspberry Pi. We are going to design a communication system by making use of Convolutional Neural Network. The hand gestures will be captured by the camera, and our pre-trained model will make predictions based on the input. Finally, the output will be delivered in the form of voice or text.
4.	Social Impact / Customer Satisfaction	By using this application deaf and dumb people can confidently communicate with normal people without any interruption. The barrier between deaf-mute and normal people will be disappeared.
5.	Business Model	We can build this project as a web application and fix a subscription cost. Subscription cost should be reasonable so that everyone can use this application. By this way, we can make revenue from this project.
6.	Scalability of the Solution	We can build this web application using python flask and newer AI technologies can be used to improve the functionality, features and performance of this application.

3.4 Problem Solution Fit

4. REQUIREMENT ANALYSIS

4.1 Functional Requirements

FR NO.	Functional Requirement
FR-1	A camera should be used to capture the hand gestures. Deaf-mute people show hand gestures very fast during communication. So, the camera should be fast enough to capture the hand gestures.
FR-2	Sign language should be converted into human understandable voice. So that normal people can understand what deaf-mute people are trying to say.

FR-3	Voice should be converted into sign language. So that deaf-mute people can understand what normal trying to say.
FR-4	We need to integrate the above functionalities and build this project as a web application.

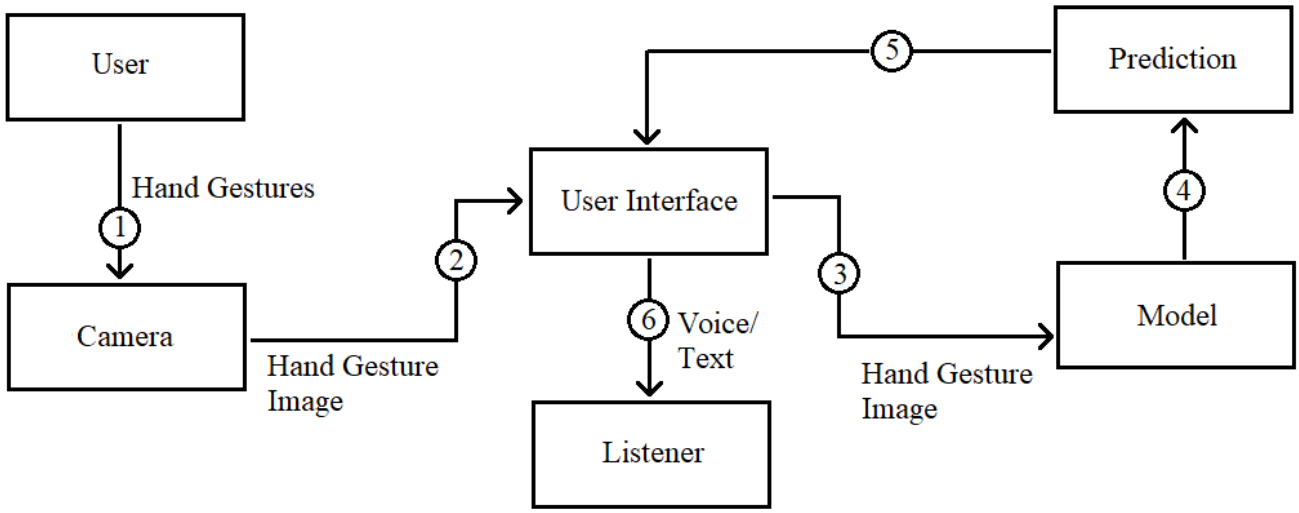
4.2 Non-Functional Requirements

FR NO.	Non-Functional Requirement	Description
NFR-1	Usability	We are going to use Flask UI in this application for better user experience. UI should be very simple. So that every people can easily use this application.
NFR-2	Reliability	We are going to fix a subscription cost for this application. The subscription cost should be reasonable. So that every people can afford it.
NFR-3	Performance	AI model needs some processing resources. So we need to have a decent hardware. The application should be well optimized. Load time and latency should be less.
NFR-4	Availability	It is a web application. So it should be accessible to people anywhere anytime.
NFR-5	Scalability	There are lot of deaf and mute people in our society. So definitely we can expect more number users for this application. We can also enhance this application for home automation by integrating this with Alexa smart home.

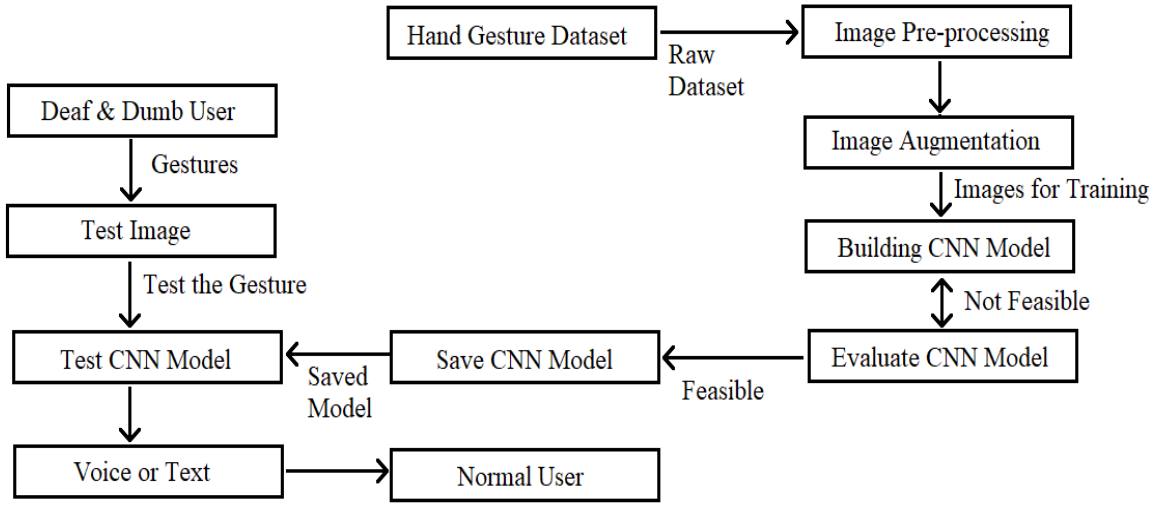
5. PROJECT DESIGN

5.1 Data Flow Diagrams

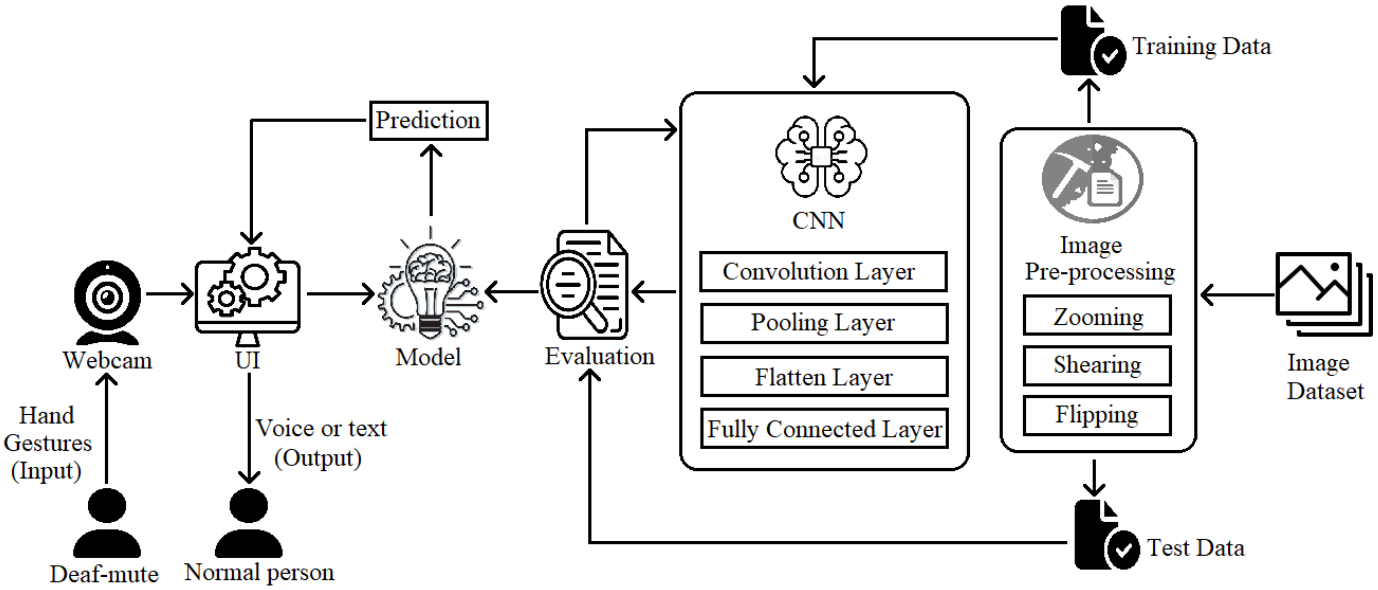
Flow Chart:



Data Flow Diagram:



5.2 Solution and Technical Architecture



5.3 User Stories:

User Type	Functional Requirement (Epic)	User Story Number	User story/ Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application.	I can access my account.	Medium	Sprint-4
	Login	USN-2	As a user, I can log in to the application.	I can successfully log in every time.	Medium	Sprint-4
Customer (Desktop User)	Main page	USN-3	As a user, I want use the application as website.	Website should be responsive and optimized.	High	Sprint-3
	Hand gesture detection	USN-4	As a user, I want the application to detect sign language.	Application should detect all relevant hand gestures.	High	Sprint-1
	Sign language to text conversion	USN-5	As a user, I want the application to convert sign language into text.	Application should convert quickly.	High	Sprint-2
	Sign language to voice conversion	USN-6	As a user, I want the application to convert sign language into voice.	Voice output should be delivered accurately.	High	Sprint-2
	Customer Support	USN-7	As a user, I want some immediate customer support.	Chat bot should answer all important queries.	Low	Sprint-4

6. PROJECT PLANNING AND SCHEDULING

6.1 Sprint Planning & Estimation

Milestone List:

Milestone Number	Milestone Name	Duration	Submission Dates
MN – 01	Ideation Phase	3 Weeks	27 September, 2022
MN – 02	Project Design Phase – I	2 Weeks	08 October, 2022
MN – 03	Project Design Phase – II	2 Weeks	17 October, 2022
MN – 04	Project Planning Phase	1 Week	25 October, 2022
MN – 05	Project Development Phase	3 Weeks	17 November, 2022
MN – 06	Pre-requisites	1 Week	30 September, 2022
MN – 07	Project Structure	1 Week	03 October, 2022
MN – 08	Data Collection	2 Days	05 October, 2022
MN – 09	Image Pre-processing	4 Days	10 October, 2022
MN – 10	Model Building	1 Week	30 October, 2022
MN – 11	Test the model	2 Days	31 October, 2022
MN – 12	Application Building	1 Week	05 November, 2022
MN – 13	Train CNN Model on IBM	2 Days	07 November, 2022

Activity List:

Milestone Number	Activity Number	Activity Name	Description	Submission Dates
MN – 01	AN – 01	Literature survey	Literature survey on the selected project & Information Gathering	27 September, 2022
	AN – 02	Empathy Map	Empathize & Discover about the user.	20 September, 2022
	AN – 03	Brain – Storming	Ideation, Brainstorming & Idea Prioritization for the project.	27 September, 2022
	AN – 04	Problem Statements	Define the Problem Statement to understand your customer's point of view about the problem.	20 September, 2022
MN – 02	AN – 05	Proposed Solution	Describes the Problem Statement (Problem to be solved), Idea/ Solution description, Novelty/ Uniqueness, Social Impact/ Customer Satisfaction, Business Model (Revenue Model) and Scalability of the Solution of the project.	24 September, 2022
	AN – 06	Problem Solution Fit	Prepare Problem Solution Fit document.	31 September, 2022
	AN – 07	Solution Architecture	Bridge the gap between business problems and technology solutions.	31 September, 2022
MN – 03	AN – 08	Customer Journey Map	Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit).	05 October, 2022
	AN – 09	Solution Requirements	Describe the Functional & Non-functional Requirement for the Proposed Solution.	17 October, 2022
	AN – 10	Data Flow Diagram	A visual representation of the information flows within a system, and provide information about right amount of the system requirement. Show how data enters and leaves the system and where data is stored.	17 October, 2022
	AN – 11	Technology Stack	Describe Architectural Diagram, it's Components, Technologies used and Application Characteristics.	17 October, 2022
MN – 04	AN – 12	Prepare Milestone & Activity List	Prepare the milestones & activity list of the project	25 October, 2022
	AN – 13	Sprint Delivery Plan	Describe about the Product Backlog, Sprint Planning, Stories, Story points using Agile Software Development Methodologies such as Scrum, JIRA etc.	25 October, 2022
MN – 05	AN – 14	Delivery of Sprint – 1	Creating a standard Webpage.	29 October, 2022
	AN – 15	Delivery of Sprint – 2	Creating a user-friendly website.	04 November, 2022
	AN – 16	Delivery of Sprint – 3	Mobile and Desktop accessibility.	11 November, 2022
	AN – 17	Delivery of Sprint – 4	Adding new features.	17 November, 2022
MN – 06	AN – 18	Pre-requisites	Install the required software, it's supporting packages and create a project development environment.	30 September, 2022
MN – 07	AN – 19	Project Structure	Create the Project Structure for building Conversation Engine.	06 October, 2022
MN – 08	AN – 20	Data Collection	Collect data for building the project.	19 October, 2022
	AN – 21	Create Train and Test Folders	Create Train and Test folders with each folder having folders with images of different hand signs	01 October, 2022
MN – 09	AN – 22	Image Pre-processing	We will pre-process the images which will be used for building the model.	10 October, 2022
	AN – 23	Import Image Data Generator Library.	Generate batches of tensor image data with real-time data augmentation.	10 October, 2022
	AN – 24	Apply Image Data Generator functionality.	Splitting the dataset for training and testing purpose in an appropriate ratio.	12 October, 2022
MN – 10	AN – 25	Import the required model building libraries	Add packages containing the appropriate functions and other entities for constructing the model.	17 October, 2022

6.2 Sprint Delivery Scheme

Product Backlog, Sprint Schedule, and Estimation (4 Marks)

Sprint	Functional Requirment (Epic)	User Story Number	User Story/Task	Story Points	Priority	Team Members
Sprint-1	User Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password or through Gain, Facebook.	20	High	Daniel Durai J, Manikandan K
Sprint-2	Data Input	USN-2	As a user, I will be giving the input via Camera as sign language or via speech.	20	High	Rajesh T, Sam Willbert S
Sprint-3	Data Verification	USN-3	Once the user gives the data input via Camera it verifies the database.	20	High	Esakky Raja M, Daniel Durai J
Sprint-4	Final Delivery	USN-4	Verifies with the data set and converts the input to text.	20	High	Manikandan K, Sam Willbert S

Project Tracker, Velocity & Burndown Chart:(4 Marks)

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (planned)	Story Points Completed (as on planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	29 Oct 2022	01 Nov 2022	20	04 Nov 2022
Sprint-2	20	6 Days	31 Oct 2022	04 Nov 2022	20	04 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

$$AV = Sprint\ duration / Velocity = 20 / 10 = 2$$

7. CODING & SOLUTIONING

7.1 Feature 1

The AI model has been created using Convolutional Neural Networks. The model is trained on different hand gestures in American Sign Language. The model is able to detect 26 Alphabets in ASL.

7.2 Feature 2

The model is integrated with Flask UI. So that user can easily interact.

8. TESTING

8.1 Test Cases

The pre-trained model is tested on different hand gestures of American Sign Language. The model is tested with placing hands in different distances from the camera.

8.2 User Acceptance Testing

The model should predict the output without any errors. The accuracy of the model should be more than 80%.

9. RESULTS

9.1 Performance Metrics

Compiling the Model

```
[ ] model.compile(loss="categorical_crossentropy",optimizer="adam",metrics=['accuracy'])
```

```
[ ] model.fit(x_train,epochs=10,steps_per_epoch=len(x_train)/8,validation_data=x_test,validation_steps=len(x_test)/8)
```

```
Epoch 1/10
261/261 [==============================] - 450s 2s/step - loss: 1.6308 - accuracy: 0.2748 - val_loss: 1.5175 - val_accuracy: 0.5570
Epoch 2/10
261/261 [==============================] - 408s 2s/step - loss: 1.2087 - accuracy: 0.4901 - val_loss: 1.2166 - val_accuracy: 0.7011
Epoch 3/10
261/261 [==============================] - 327s 1s/step - loss: 0.9624 - accuracy: 0.6130 - val_loss: 1.1014 - val_accuracy: 0.7613
Epoch 4/10
261/261 [==============================] - 300s 1s/step - loss: 0.8385 - accuracy: 0.6618 - val_loss: 1.0195 - val_accuracy: 0.7441
Epoch 5/10
261/261 [==============================] - 264s 1s/step - loss: 0.6818 - accuracy: 0.7221 - val_loss: 1.6549 - val_accuracy: 0.7247
Epoch 6/10
261/261 [==============================] - 229s 878ms/step - loss: 0.6331 - accuracy: 0.7336 - val_loss: 0.9067 - val_accuracy: 0.7656
Epoch 7/10
261/261 [==============================] - 218s 836ms/step - loss: 0.5734 - accuracy: 0.7588 - val_loss: 0.8711 - val_accuracy: 0.8344
Epoch 8/10
261/261 [==============================] - 179s 683ms/step - loss: 0.4952 - accuracy: 0.7969 - val_loss: 1.0337 - val_accuracy: 0.8538
Epoch 9/10
261/261 [==============================] - 156s 599ms/step - loss: 0.4712 - accuracy: 0.8229 - val_loss: 1.4849 - val_accuracy: 0.7892
Epoch 10/10
261/261 [==============================] - 132s 505ms/step - loss: 0.4682 - accuracy: 0.8130 - val_loss: 0.8138 - val_accuracy: 0.8172
<keras.callbacks.History at 0x7f4e34a05dd0>
```

10. ADVANTAGES AND DISADVANTAGES

Advantages

- It does not require any hardwares like Arduino and Raspberry pi.
- It is feasible to work with an web application.

Disadvantages

- Powerful hardwares are required to run this loacally.
- The model may give some wrong predictions sometime.

11. CONCLUSION

This real-time communication system is an initiative for helping people with disabilities. This is a basic model of a real-time communication system. It can further enhanced to reach new heights. This communication system is used to convey the messages in emergency situations. However, it can be further developed to act as a full fledged interpreter between deaf-mute and normal people.

12. FUTURE SCOPE

The model used in this project is created using CNN. But, using RCNN , YOLO kind of algorithms may give some better results. The accuracy can be increased to obtain better predictions. This model can be integrated with Alexa and Amazon echo to implement smart homes.

13. APPENDIX

Source Code

Flask app

```
from flask import Flask, render_template,Response
import cv2
from cvzone.HandTrackingModule import HandDetector
from cvzone.ClassificationModule import Classifier
import numpy as np
import math

app=Flask(__name__)
camera=cv2.VideoCapture(0)
detector = HandDetector(maxHands=1)
classifier = Classifier("D:\ASL Recognition\Model\keras_model.h5",
                        "D:\ASL Recognition\Model\labels.txt")

offset = 20
imgSize = 300

# folder = "Data/C"
counter = 0

labels = ["A", "B", "C", "D", "E", "F", "G", "H", "I", "J", "K", "L", "M", "N", "O", "P", "Q", "R", "S", "T",
"U", "V",
          "W", "X", "Y", "Z", "del", "nothing", "space"]
def gen_frames():
```

```
while True:
    success, frame=camera.read()
    if not success:
        break
    imgOutput = frame.copy()
    hands, frame = detector.findHands(frame)
    if hands:
        hand = hands[0]
        x, y, w, h = hand['bbox']

        imgWhite = np.ones((imgSize, imgSize, 3), np.uint8) * 255
        imgCrop = frame[y - offset:y + h + offset, x - offset:x + w + offset]

        imgCropShape = imgCrop.shape

        aspectRatio = h / w

        if aspectRatio > 1:
            k = imgSize / h
            wCal = math.ceil(k * w)
            imgResize = cv2.resize(imgCrop, (wCal, imgSize))
            imgResizeShape = imgResize.shape
            wGap = math.ceil((imgSize - wCal) / 2)
            imgWhite[:, wGap:wCal + wGap] = imgResize
            prediction, index = classifier.getPrediction(imgWhite, draw=False)
            print(prediction, index)
            cv2.putText(imgOutput, labels[index], (x, y - 26), cv2.FONT_HERSHEY_COMPLEX, 1.7, (255,
255, 255), 2)

        else:
            k = imgSize / w
            hCal = math.ceil(k * h)
            imgResize = cv2.resize(imgCrop, (imgSize, hCal))
            imgResizeShape = imgResize.shape
```

```
            hGap = math.ceil((imgSize - hCal) / 2)
            imgWhite[hGap:hCal + hGap, :] = imgResize
            prediction, index = classifier.getPrediction(imgWhite, draw=False)
            cv2.putText(imgOutput, labels[index], (x, y - 26), cv2.FONT_HERSHEY_COMPLEX, 1.7, (255, 255, 255), 2)

        cv2.rectangle(imgOutput, (x - offset, y - offset - 50),
                      (x - offset + 90, y - offset - 50 + 50), (255, 0, 255), cv2.FILLED)
        cv2.putText(imgOutput, labels[index], (x, y - 26), cv2.FONT_HERSHEY_COMPLEX, 1.7, (255, 255, 255), 2)
        cv2.rectangle(imgOutput, (x - offset, y - offset),
                      (x + w + offset, y + h + offset), (255, 0, 255), 4)

        ret,buffer=cv2.imencode('.jpg',frame)
        frame = buffer.tobytes()
        yield(b'--frame\r\n'
            b'Content-Type:image/jpeg\r\n\r\n' + frame+b'\r\n')
@app.route('/')
def index():
    return render_template('index.html')
@app.route('/video_feed')
def video_feed():
    return Response(gen_frames(),mimetype='multipart/x-mixed-replace;boundary=frame')
if __name__=='__main__':
    app.run(debug=True)
```

Hand Gesture Detection

```
from cvzone.HandTrackingModule import HandDetector
from cvzone.ClassificationModule import Classifier
import numpy as np
import math
import cv2
```

```
cap = cv2.VideoCapture(0)
detector = HandDetector(maxHands=1)
classifier = Classifier("D:\ASL Recognition\Model\keras_model.h5",
                        "D:\ASL Recognition\Model\labels.txt")

offset = 20
imgSize = 300

# folder = "Data/C"
counter = 0

labels = ["A", "B", "C", "D", "E", "F", "G", "H", "I", "J", "K", "L", "M", "N", "O", "P", "Q", "R", "S", "T",
"U", "V",
          "W", "X", "Y", "Z", "del", "nothing", "space"]

while True:
    success, img = cap.read()
    if img is None:
        break
    imgOutput = img.copy()
    hands, img = detector.findHands(img)
    if hands:
        hand = hands[0]
        x, y, w, h = hand['bbox']

        imgWhite = np.ones((imgSize, imgSize, 3), np.uint8) * 255
        imgCrop = img[y - offset:y + h + offset, x - offset:x + w + offset]

        imgCropShape = imgCrop.shape

        aspectRatio = h / w

        if aspectRatio > 1:
            k = imgSize / h
```

```
            wCal = math.ceil(k * w)
            imgResize = cv2.resize(imgCrop, (wCal, imgSize))
            imgResizeShape = imgResize.shape
            wGap = math.ceil((imgSize - wCal) / 2)
            imgWhite[:, wGap:wCal + wGap] = imgResize
            prediction, index = classifier.getPrediction(imgWhite, draw=False)
            print(prediction, index)
            cv2.putText(imgOutput, labels[index], (x, y - 26), cv2.FONT_HERSHEY_COMPLEX, 1.7, (255,
255, 255), 2)


        else:
            k = imgSize / w
            hCal = math.ceil(k * h)
            imgResize = cv2.resize(imgCrop, (imgSize, hCal))
            imgResizeShape = imgResize.shape
            hGap = math.ceil((imgSize - hCal) / 2)
            imgWhite[hGap:hCal + hGap, :] = imgResize
            prediction, index = classifier.getPrediction(imgWhite, draw=False)
            cv2.putText(imgOutput, labels[index], (x, y - 26), cv2.FONT_HERSHEY_COMPLEX, 1.7, (255,
255, 255), 2)


        cv2.rectangle(imgOutput, (x - offset, y - offset - 50),
                      (x - offset + 90, y - offset - 50 + 50), (255, 0, 255), cv2.FILLED)
        cv2.putText(imgOutput, labels[index], (x, y - 26), cv2.FONT_HERSHEY_COMPLEX, 1.7, (255, 255,
255), 2)
        cv2.rectangle(imgOutput, (x - offset, y - offset),
                      (x + w + offset, y + h + offset), (255, 0, 255), 4)


        cv2.imshow("ImageCrop", imgCrop)
        cv2.imshow("ImageWhite", imgWhite)


    cv2.imshow("Image", imgOutput)
    cv2.waitKey(1)
```

Github link

https://github.com/IBM-EPBL/IBM-Project-46411-1660746749

Demo Video Link

https://drive.google.com/file/d/1Rzk68wa-v1kgJUAfhpt4bJICUHP3E7AT/view?usp=share_link