DOCUMENTATION

Real-Time Communication System Powered by AI for Specially Abled

TEAM ID: PNT2022TMID06610

TEAM MEMBERS:

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1. INTRODUCTION:

Project Overview:

In our society, we have people with disabilities. The technology is developing day by day but no significant developments are undertaken for the betterment of these people. Communications between deaf-mute and a normal person has always been a challenging task. It is very difficult for mute people to convey their message to normal people. Since normal people are not trained on 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. 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 in any language. The project aims to develop a system that converts the sign language into a human hearing voice in the desired language to convey a message to normal people, as well as convert speech into understandable sign language for the deaf and dumb. We are making use of a convolution neural network to create a model that is trained on different hand gestures. An app is built which uses this model. This app enables deaf and dumb people to convey their information using signs which get converted to human-understandable language and speech is given as output.

Purpose:

As per our Indian Constitution, Article 51A (h),

"It shall be the duty of every citizen of India to develop the scientific temper, humanism and the spirit of inquiry and reform"

Accordingly, we, the future engineers of this great nation, have developed this project with the following purposes:

- Bridge the gap between specially-abled people and the normal people.
- To use technology to address the problems faced by the society.
- To contribute to the inclusive growth of the society.
- To make a positive impact/change in the society we live in.

2. LITERATURE SURVEY:

Existing Problems:

1. AAWAAZ: A Communication System for Deaf & Dumb by Anchal Sood, Anju Mishra (2016) [1]

Abstract: The paper proposes a framework for recognizing hand gesture which would serve not only as a way of communication between deaf and dumb and mute people, but also, as an instructor. Deaf and dumb individuals lack in proper communication with normal people and find it difficult to properly express themselves. Thus, they are subjected to face many issues in this regard. The sign language is very popular among them and they use it to express themselves. Thus, there is a need of a proper translator. The deaf and dumb are not idle as past, they are working outside and doing great at it. So, an efficient system must be set up, to interact with them, to know their views and ideas. The framework here, act as a communication system for deaf and dumb individuals. It would take the sign language as an input which would display the result not only in the form of text but also in the form of audio. Similarly, if there is any input in the form of text, it would display the corresponding image.

Methodology: From the input RGB image, the hand is separated and morphological operations are performed to identify the region of interest. The features of the gesture are then extracted and compared to a database of features of standard gestures. Finally, based on the comparison the output is generated.

Limitations: The proposed framework is good for recognizing hand gestures. But it is not feasible in every environment.

2. Full Duplex Communication System for Deaf & Dumb People by Shraddha R. Ghorpade, Surendra K. Waghamare (2015) [2]

Abstract: One of the important problems that our society faces is that people with disabilities are finding it hard to cope-up with the fast-growing technology. The access to communication technologies has become essential for the handicapped people. Generally deaf and dumb people use sign language for communication but they find difficulty in communicating with others who don't understand sign language. Sign language is an expressive and natural way for communication between normal and dumb people (information majorly conveyed through the hand gesture). So, we need a translator to understand what

they speak and communicate with us. The sign language translation system translates the normal sign language to speech and hence makes the communication between normal person and dumb people easier. But the question arises, how the deaf person understands the speech of a normal person and hence we need a system which converts the speech of normal person to text and the corresponding gesture is displayed on display. So, the whole idea is to build a device that enables two-way communications between deaf-mute person and a normal person.

Methodology: The methodology used is similar to [1] except that, instead of bare hands, the system requires the user to wear gloves to extract hand gesture.

Limitations: Gloves are mandatory. Without them, the system would not work. It is not feasible to carry gloves all the time. These are expensive as well.

3. Sign Language Recognition System by Er. Aditi Kalsh, Dr N.S. Garewal (2013) [3]

Abstract: Communication is the process of exchanging information, views and expressions between two or more persons, in both verbal and non-verbal manner. Hand gestures are the non-verbal method of communication used along with verbal communication. A more organized form of hand gesture communication is known as sign language. In this language each alphabet of the English vocabulary is assigned a sign. The physically disabled person like the deaf and the dumb uses this language to communicate with each other. The idea of this project is to design a system that can understand the sign language accurately so that the less fortunate people may communicate with the outside world without the need of an interpreter. By keeping in mind, the fact that in normal cases every human being has the same hand shape with four fingers and one thumb, this project aims at designing a real time system for the recognition of some meaningful shapes made using hands.

Methodology: The image is converted into grayscale and the edges of the fingers are detected using Canny edge detection. Then using the detected finger tips the gesture is recognized.

Limitations: The background of an image must be free from external objects. Also, the distance between the image and the camera is kept fixed.

4. Intelligent Sign Language Recognition Using Image Processing by Sawant Pramada, Deshpande Saylee, NalePranita, NerkarSamiksha, Mrs. Archana S. Vaidya (2013) [4]

Abstract: Computer recognition of sign language is an important research problem for enabling communication with hearing impaired people. This project introduces an efficient and fast algorithm for identification of the number of fingers opened in a gesture representing an alphabet of the Binary Sign Language. The system does not require the hand to be perfectly aligned to the camera. The project uses image processing system to identify, especially English alphabetic sign language used by the deaf people to communicate. The basic objective of this project is to develop a computer based intelligent system that will enable dumb people significantly to communicate with all other people using their natural hand gestures. The idea consisted of designing and building up an intelligent system using image processing, machine learning and artificial intelligence concepts to take visual inputs of sign language's hand gestures and generate easily recognizable form of outputs. Hence the objective of this project is to develop an intelligent system which can act as a translator between the sign language and the spoken language dynamically and can make the communication between people with hearing impairment and normal people both effective and efficient. The system is we are implementing for Binary sign language but it can detect any sign language with prior image processing.

Methodology: The RGB image is converted into a binary image. Certain coordinates are mapped to the binary image. Using a pattern matching algorithm the coordinates are then compared to the coordinates in a database. Based on the comparison, the gesture is identified.

Limitations: There is a specific camera orientation and specification. Thus, it is not feasible in every environment.

References:

[1] Sood Anchal, and Anju Mishra, "AAWAAZ: A communication system for deaf and dumb," 2016 5th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO). IEEE, 2016.

[2] Shraddha R. Ghorpade, Surendra K. Waghamare, "Full Duplex Communication System for Deaf & Dumb People," International Journal of

Emerging Technology and Advanced Engineering (IJETAE), Volume 5, Issue 5, May 2015, ISSN 2250-2459.

[3] Er. Aditi Kalsh, Dr N.S. Garewal, "Sign Language Recognition System," International Journal of Computational Engineering Research (IJCER), Volume 03, Issue 6, June 2013.

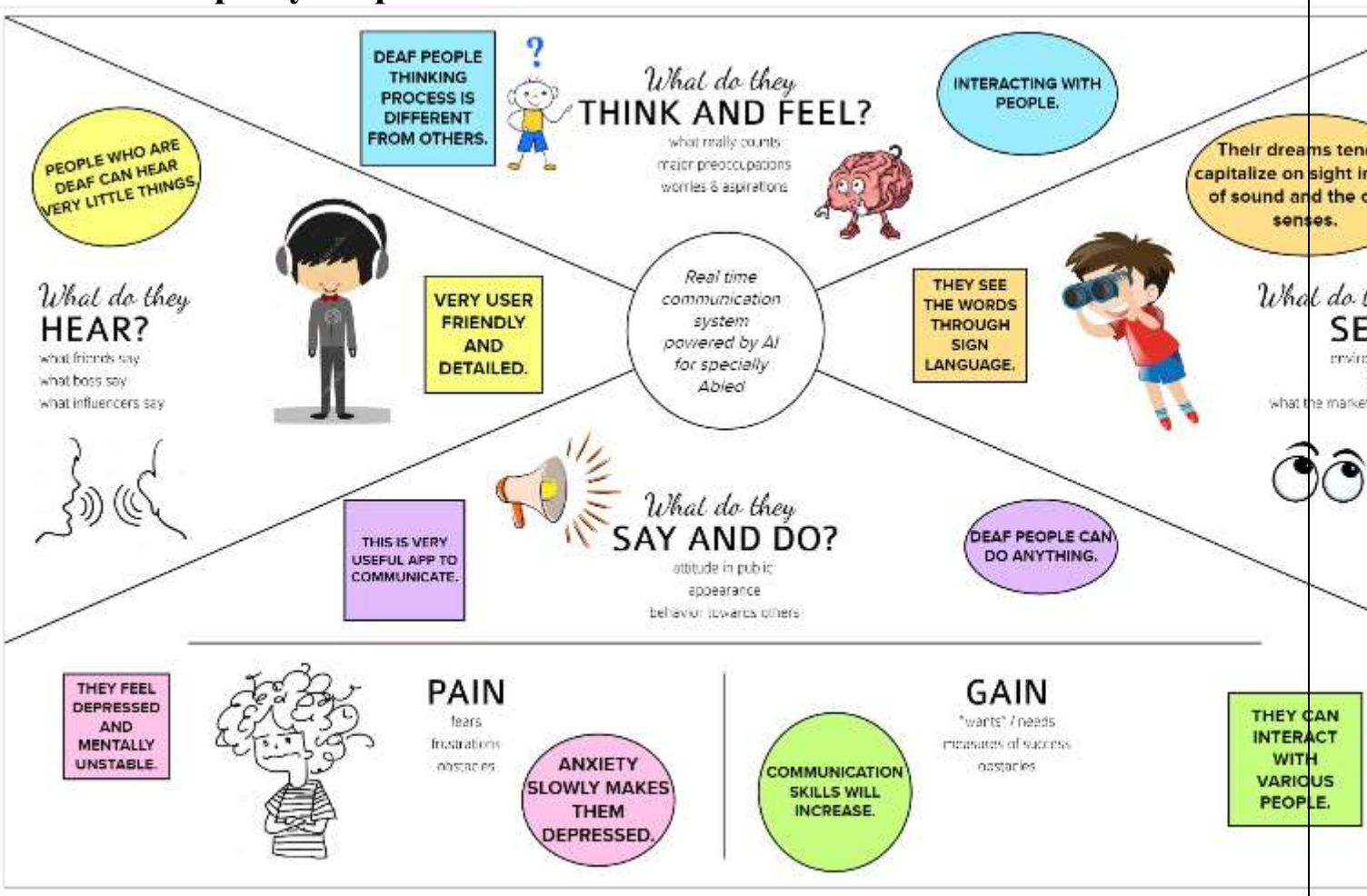
[4] Sawant Pramada, Deshpande Saylee, NalePranita, NerkarSamiksha, Mrs.Archana S. Vaidya "Intelligent Sign Language Recognition Using Image Processing," IOSR Journal of Engineering (IOSRJEN), Volume 3, Issue 2, Feb. 2013, PP 45-51.

Problem Statement Definition:

Problem Statement (PS)	I am	I'm trying to	But	Because	Which makes me feel
PS-1	Singh (a deaf-mute person)	Communicate with other (normal people)	I find it difficult to express/ communicate	They don't understand my sign language	Left alone
PS-2	Sita (a deaf-mute person)	Express my feelings to others	I can't do so like the normal people	I can't communicate in a way they can easily comprehend	Depressed and sad
PS-3	John (a deaf-mute person)	Reach a place in a new city	I can't ask for directions/help from others	They can't understand my sign language well	Insecure and worried
PS-4	Ahmed (a deaf-mute person)	Complain about an issue to a public authority	I find it difficult to do so	The public authority finds it difficult to understand me	Inferior and incompeten t

3. IDEATION & PROPOSED SOLUTION:

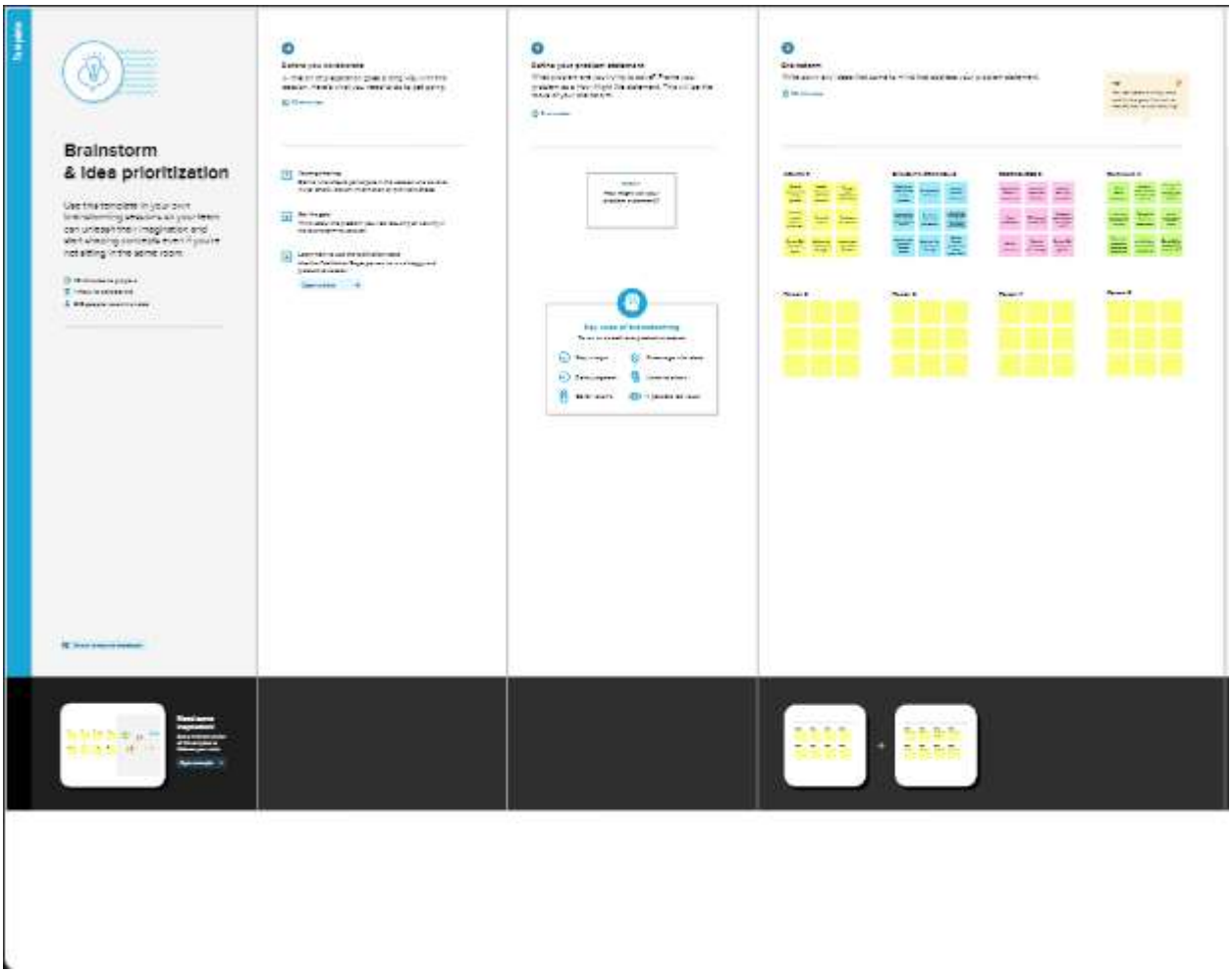
Empathy Map Canvas:

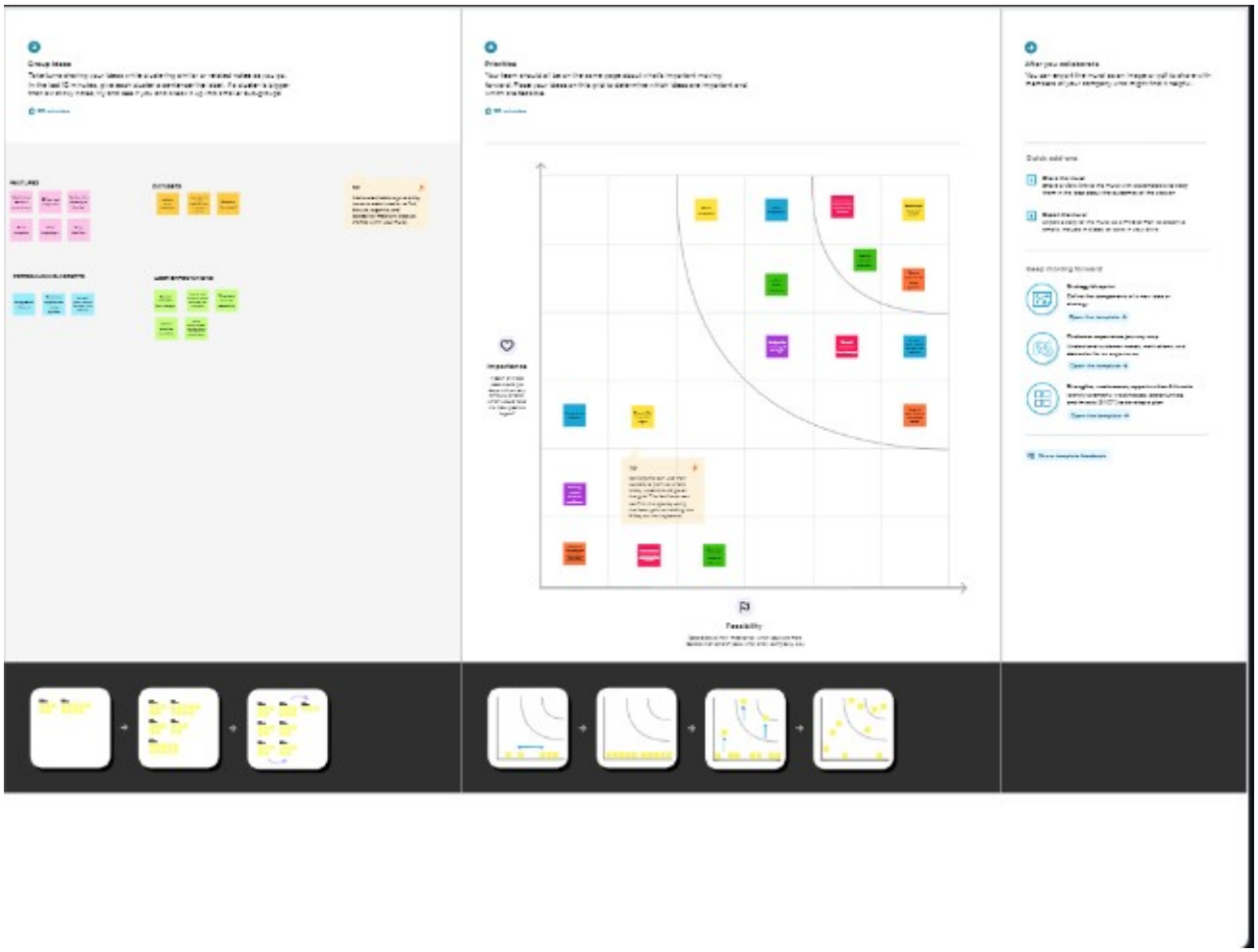


Ideation & Brainstorming:

Problem Statement

A deaf-mute person is trying to communicate with other normal people, but he/she finds it difficult to do so because the rest of them cannot understand their sign language with the exception of a few, which makes him/her feel left alone, depressed, sad, inferior, insecure and incompetent.


Brainstorm
& Idea prioritization

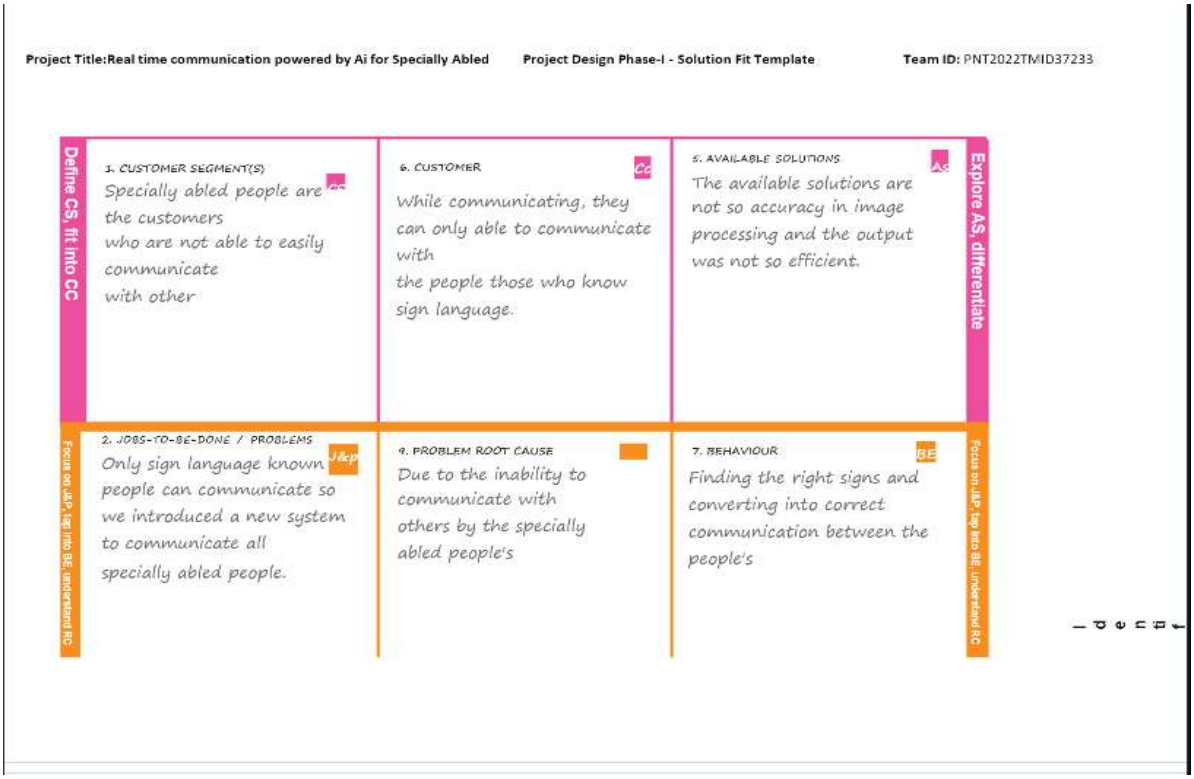


Proposed Solution:

S. No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	A deaf-mute person is trying to communicate with other normal people, but he/she finds it difficult to do so because the rest of them cannot understand their sign language with the exception of a few, which makes him/her feel left alone, depressed, sad, inferior, insecure and incompetent.
2.	Idea / Solution description	To design a system that used deep-learning to convert deaf-mute's sign language input to normal message and voice, so that, normal people can easily understand the deaf-mute.
3.	Novelty / Uniqueness	This idea is unique as it includes artificial intelligence (deep learning, etc) to solve the problem of deaf-mute communication. Also, it can result in higher accuracy of translation.
4.	Social Impact / Customer Satisfaction	The social impact of the solution is huge. It can create a positive and optimistic society for the deaf-mute to live in. The deaf-mute people may be immensely satisfied and overjoyed when they could communicate with normal people.
5.	Business Model (Revenue Model)	The solution has a business potential as it can tap the deaf-mute people's market. Also, public offices can use

		this system for their communication with deaf-mute people.
6.	Scalability of the Solution	The solution can be scaled easily to include new features and functionalities, and to cover wider range of people in the future.

Problem Solution Fit:



Identify strong TR & EM

3. TRIGGERS TR

Some of the triggers are introducing in all hospitals, medical trusts and also in advertisements.

4. EMOTIONS: BEFORE / AFTER EM

specially abled people hesitate to communicate with others but know using this system they can easily communicate with others.

10. YOUR SOLUTION SL

Created an application using AI , that will able to convert the sign language by image processing of the specially abled people.

8. CHANNELS of BEHAVIOUR CH

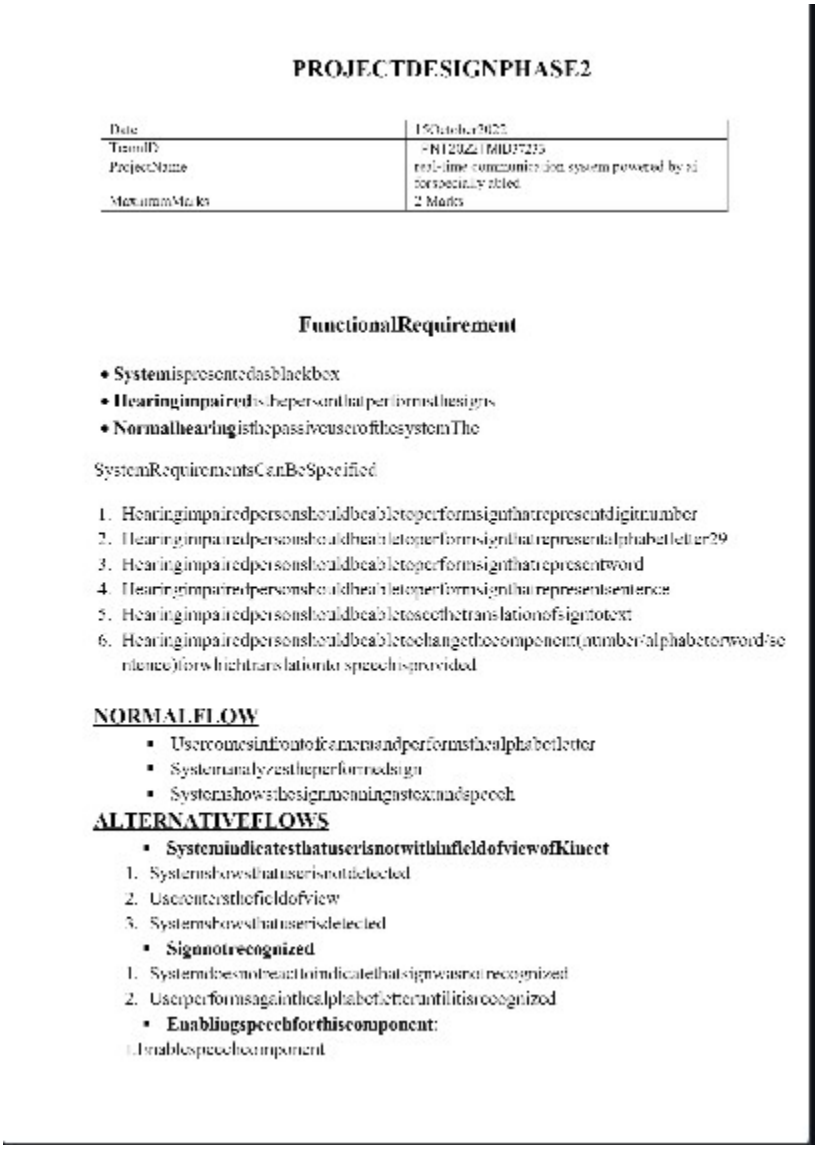
ONLINE

We can update our application and use it in a very efficient way.

OFFLINE

In offline mode we use it but not so efficient we can use it with a recently updated application.

4. REQUIREMENT ANALYSIS:



PROJECTDESIGNPHASE2

Date	15October2022
TeamID	PNT2022TMID37223
ProjectName	real-time communication system powered by ai for specially abled
MaximumMarks	2 Marks

FunctionalRequirement

- **System**ispresentedasblackbox
- **Hearingimpaired**isthepersonthatperformsthesigns
- **Normalhearing**isthepassiveuseroftheSystemThe

SystemRequirementsCanBeSpecified

1. Hearingimpairedpersonshouldbeabletoperformsignthatrepresentdigitnumber
2. Hearingimpairedpersonshouldbeabletoperformsignthatrepresentalphabetletter29
3. Hearingimpairedpersonshouldbeabletoperformsignthatrepresentword
4. Hearingimpairedpersonshouldbeabletoperformsignthatrepresentsentence
5. Hearingimpairedpersonshouldbeabletoseethetranslationofsigntotext
6. Hearingimpairedpersonshouldbeabletochangethecomponent(number/alphabet/word/sentence)forwhichtranslationtospeechisprovided

NORMALFLOW

- Usercomesinfrontoftheframeandperformsthealphabetletter
- Systemanalyzestheperformedsign
- Systemshowsthesignmeaningstextandspeech

ALTERNATIVEFLOWS

- **Systemindicatesthatuserisnotwithinfieldofview ofKinect**

1. Systemshowsthatuserisnotdetected
2. Usercentersthefieldofview
3. Systemshowsthatuserisdetected

- **Signnotrecognized**

1. Systemdoesnotreactoindicatethatsignwasnotrecognized
2. Userperformsagainthealphabetletterantilitisrecognized

- **Enablingspeechforthiscomponent:**

1.Enablespeechcomponent

5. PROJECT DESIGN:

Data Flow Diagrams:

ProjectDesignPhase-II
DataFlowDiagram&UserStories

Date	14October2022
TeamID	PNT2002TMID37233
ProjectName	Project—Realtimecommunicationpoweredby Artificialintelligenceforspeciallyabled
MaximumMarks	4Marks

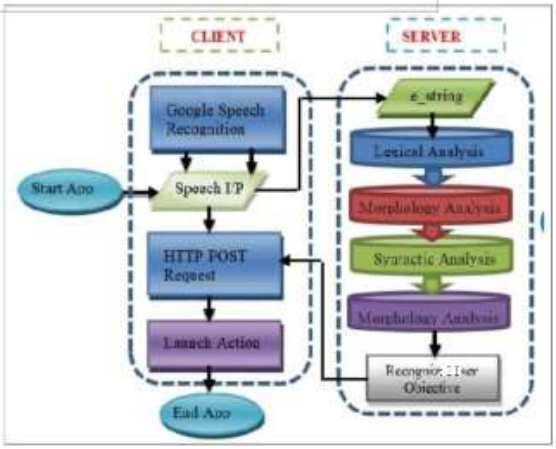
DataFlowDiagrams:

ADataFlowDiagram(DFD)is a traditionalvisual representationof the informationflowswithin a system. Aneatand clearDFDcan depict the right amountof the system requirementgraphically.It shows howdataenters andleaves the system, whatchanges the information, andwheredatais stored.

Example:(Simplified)

(I)Lexicalanalysisconcertscharactersequenceintotokensequence.
(II)Morphologyanalysisdefines,analyzes anddescribestheStructureoflanguageunitsofaparticularlanguage.
(III)Syntacticanalysisanalyzesthetextmadefromaseriesofmarkerstodeterminegrammarstructures.
(IV)SemanticAnalysisrelates syntacticstructuresfrom thelevels of phrasesandsentencestotheirlanguage-independentmeanings.

Example:Realtimecommunication



Solution & Technical Architecture:

Project Design Phase-II

TechnologyStack(Architecture&Stack)

Date	12October2022
TeamID	PNT2022TMID37233
ProjectName	Project–**Real-TimeCommunicationSystem Powered By AI For Specially Abled**
MaximumMarks	4Marks

TechnicalArchitecture:

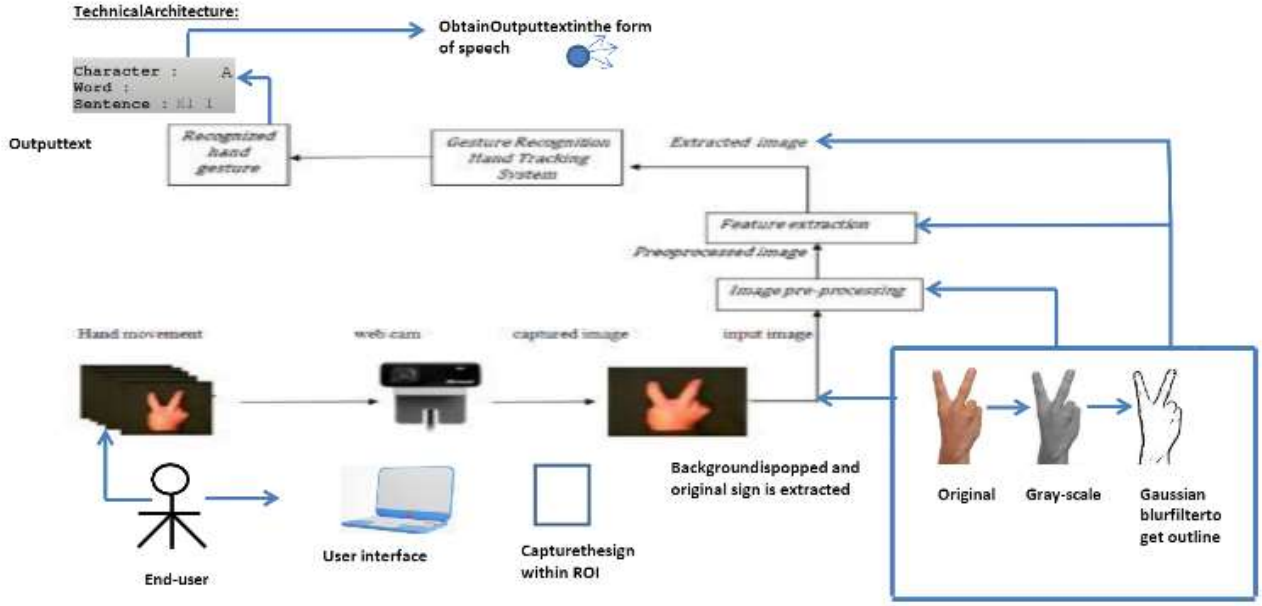


Table-1: Components & Technologies:

Table-1:Components&Technologies:

S.No	Component	Description	Technology
1.	UserInterface	Howuserinteractswithapplicationi.e.**Desktopusage and clicking the concerned app.**	HTML,CSS,JavaScriptand Angular JS
2.	ApplicationLogic-1	• Camera**detectsthesignshownbytheuser**. • Capture**sthesignwithinROI.**	**Adaboostfacedetectorisused**todifferentiate between faces and hand as both involves similar skin-colour.
3.	ApplicationLogic-2	• **Backgroundispoppedandoriginalsignisextracted.**	Bydefault,Originalimagecapturedisconverted into Gray-scale image.
4.	ApplicationLogic-3	• Extract**theedgesofthegray-scaleimage**.	**Apply Gaussian-blurfilterand threshold to the frametakenwithOpenCV**togettheprocessed image after feature-extraction.
5.	ApplicationLogic-4	• Convert**theoutputtextintospeech**	**TheFinaltextobtainedisconvertedtospeech using the speech assistant implemented ,** whichinturnproducesoundfromspeaker.
6.	Database	• **BinaryLargeObject(BLOB)**isthedatatypeusedtostorethe images in the dataset. • /etc/mysql/my.cnfisthedefaultconfiguration/directoriesforMYSQL that is used.	**MySQLdatabase** isused.
7.	FileStorage	• **CreateaBLOBcolumnfortheimagefiles,whethertheybe JPEG,PNG,PSD**orwhatever,andthen loadtheimages into thetable/column,createdforthem.	**LocalFilesystem**isusedforstoringthe images.
8.	MachineLearningModel	**Allowstheusertofeed acomputeralgorithmanimmenseamountof data and have the computer analyze and make data-driven recommendations** and decisions based on only the input data	**SupervisedandUnsupervisedlearningmodel etc.**

Table-2: Application Characteristics:

Table-2:ApplicationCharacteristics:

S.No	Characteristics	Description	Technology
1.	Open-SourceFrameworks	• **Palmdetector**operatesonfullimagesandoutputsan oriented bounding box. • **Handlandmark**takesthecroppedimagedefinedbythepalm detector and returns 3D hand key points. • **Gesturerecognizer**thenclassifiesthepreviouslycomputed keypointconfigurationintoadiscretesetofgestures	**Media Pipe Framework is used**. Within this framework,thepipelineisbuiltasadirected graph of modular components.
2.	ScalableArchitecture	• It'saThree–TierArchitecturecomprisesthefollowing technology, Convolutionalneuralnetworkcanbescaledinthreedimensions:*depth, width,resolution*. • **Depth**ofthenetworkcorrespondstothenumberoflayersina network. • **Width**isassociatedwiththenumberofneuronsinalayer. • **Resolution**istheimageresolutionthatisbeingpassedtoCNN. **Increasingthedepth**,bystackingmoreconvolutionallayers, allows the network to learn **more complex features**.	**ConvolutionNeuralNetworksisused.**
3.	Availability	Hand gestures are **the natural way of interactions when one personiscommunicatingwithoneanother**andthereforehand movements can be treated as a non verbal form of communication. Hand gesture recognition is a process of understanding and classifying meaningful movements by the humanhands	**CNN,MediaPipe,Gaussianblurfilter, Machinelearningmodelsalongwith Speech assistant** is used.

User Stories:

UserType	Functional Requirement (Epic)	UserStory Number	UserStory/Task	Acceptancecriteria	Priority	Release
Customer (Deaf people)	Registration	USN-1	As a user, Ican registerfortheapplicationbyenteringmyemail,password,andconfirming mypassword.	I canregistered my account.	High	Sprint-1
		USN–2	Asa user,Iwillreceiveconfirmationemail once I have registeredfor the application	Icanreceived confirmationgmail & click confirm.	High	Sprint-2
	Login	USN-3	Asa user,Ican logintothe applicationthrough gmail .	Icanregistered&access the dashboardwith gmailLogin.	Low	Sprint-1
		USN–4	Asauser,Icanseemyapplicationandmade changesinanybrowsers.	Icanloginandseemy Account at anywhere.	Medium	Sprint-2
	Dashboard	USN–5	Asauser,Icancreatemyaccountina givendashboard.	Icanaccessmyaccount/ Dashboard.	High	Sprint-1
Customer (Dumbpeople)	Registration	USN-6	AsaUser,Icanregisermyapplicationthrough gmail.	Icanregisteredmyaccount	High	Sprint-2
		USN–7	AsaUser,Icanreceiveconfirmationmailandget verificationcodefromOTPandgmail.	Icanreceivedconfirmation mail&clickconfirm.	Low	Sprint-2
	Login	USN-8	AsaUser,Icanlogintomyaccountby anywebbrowsers.	Icanloginandseemy account.	Medium	Sprint-1
	Dashboard	USN-9	AsaUser,Icancreatemyaccountinagiven Dashboard.	Icancreatedmyaccount& accessintodashboard.	High	Sprint-2

Customercare Executive	Userinterface	USN-10	Professionalresponsibleforuserrequirements& Needs.	Communicateandresolve customercomplaints.	High	Sprint-1
Administration	Objective	USN-11	Thegoalistodescribealltheinputsandoutputs.	Leadingcustomer Fieldsfromadmin.	High	Sprint-2
CyberSecurity	privacy	USN-12	Thedevelopedapplicationshouldbesecure fortheusers.	Theapplicationisfully managed.	High	Sprint-3

6. PROJECT PLANNING & SCHEDULING:

Sprint Planning & Estimation:

Product Backlog, Sprint Schedule, and Estimation:

ProjectPlanningPhase

ProjectPlanningTemplate(ProductBacklog,SprintPlanning,Stories,Storypoints)

Date	22October2022
TeamID	PNT2022TMID37233
ProjectName	ProjectRealTimeCommunicationSystem Powered byAIforSpeciallyAbled
MaximumMarks	8Marks

ProductBacklog,SprintSchedule,andEstimation(4Marks)

Usethebelowtemplatetocreateproductbacklogandsprintschedule

Sprint	FunctionalRequirement(Epic)	UserStoryNumber	UserStory/Task	Story Points	Priority	TeamMembers
Sprint-1	DataCollection	USN-1	CollectDataset.	9	High	Santhosh R
Sprint-1		USN-2	Imagepreprocessing	8	Medium	Santhosh R
Sprint-2	ModelBuilding	USN-3	Import the required libraries, add thenecessarylayersandcompilethemodel	10	High	Hari Hara sudhan V
Sprint-2		USN-4	Trainingtheimageclassificationmodelu singCNN	7	Medium	Hari Hara sudhan V
Sprint-3	Trainingand Testing	USN-5	Trainingthemodelandtestingthe model'sperformance	9	High	Madhavan GA
Sprint-4	Implementationoft heapplication	USN-6	Convertingtheinputsignlanguagei magesintoEnglishalphabets	8	Medium	Rahul K

Project Tracker, Velocity & Burndown Chart:

ProjectTracker,Velocity&BurndownChart:(4Marks)

Sprint	Total StoryPoints	Duration	SprintStartDate	SprintEndDate(Planned)	Story PointsCompleted(ason PlannedEndDate)	SprintReleaseDate(Actual)
Sprint-1	10	6Days	24Oct2022	29Oct2022	8	29Oct2022
Sprint-2	10	6Days	31Oct2022	04Nov2022	5	04Nov2022
Sprint-3	10	6Days	07Nov2022	11Nov2022	7	11Nov2022
Sprint-4	10	6Days	14Nov2022	18Nov2022	5	18Nov2022

Velocity:

The team's average velocity (AV) per iteration unit (story points per day):

$$AV = \frac{sprint\ duration}{velocity}$$

AV =7/10=0.7

Burndown Chart:

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.

Sprint Delivery Schedule:

Title	Description	Date
Literature Survey & Information Gathering	Literature survey on the selected project & gatheringinformation by referring the, technical papers, research publications etc.	28 September 2022
Prepare Empathy Map	Prepare Empathy Map Canvasto capture the user Pains & Gains, Prepare list of problem statements	24 September 2022
Ideation	List the by organizing the brainstorming session andprioritize the top 3 ideas based on the feasibility &importance.	25 September 2022
Proposed Solution	Prepare the proposed solutiondocument, which includes thenovelty, feasibility of idea, business model, social impact,scalability of solution, etc.	23 September 2022
Problem Solution Fit	Prepare problem - solution fitdocument.	30 September 2022
Solution Architecture	Prepare solution architecturedocument.	28 September 2022

Customer Journey	Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit).	20 October 2022
Functional Requirement	Prepare the functional requirement document.	8 October 2022
Data Flow Diagrams	Draw the data flow diagrams and submit for review.	9 October 2022
Technology Architecture	Prepare the technology architecture diagram.	10 October 2022
Prepare Milestone & Activity List	Prepare the milestones & activity list of the project.	22 October 2022
Project Development - Delivery of Sprint 1, 2, 3 & 4	Develop & submit the developed code by testing it.	19 November 2022

7. CODING & SOLUTIONING:

Feature 1 – Building the Model to Classify Sign Language:

In Feature – 1 of our project, we collect the dataset, pre-process it, create our CNN model, train the model, and save the trained model.

We have used a dataset from Kaggle.com to classify the ISL (Indian Sign Language) alphabets (A-Z).

Data Collection

Note: We use our custom dataset downloaded from kaggle.

```
[1]  !unzip '/content/drive/MyDrive/Dataset.zip'
```
Python

We split the dataset into training dataset and testing dataset. Then, we build a Convolutional Neural Network (CNN) model to classify the training dataset. Finally, the trained model is tested using the testing dataset.

ImageDataGenerator for training and testing set

```
16]  train_datagen = ImageDataGenerator(rescale=1./255, zoom_range=0.2, horizontal_flip=True)
```
Python

```
17]  test_datagen = ImageDataGenerator(rescale=1./255)
```
Python

```
training_data = train_datagen.flow_from_directory('/content/Dataset/training_set',
                                                  target_size=(128,128),
                                                  class_mode='categorical',
                                                  batch_size=100, color_mode='grayscale')
```

Importing ImageDataGenerator

Note: We use our custom dataset downloaded from kaggle.

```
5]  from tensorflow.keras.preprocessing.image import ImageDataGenerator
    import matplotlib.pyplot as plt
    import cv2
```
Python

```
training_data.class_indices #All categories in training data
```

Python

```
testing_data.class_indices # All categories in testing data
```

Python

Model Building

Import the required model building libraries

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, Flatten, Dense, MaxPooling2D
```

Python

For the Convolutional Neural Network (CNN), we used:

1. Input layer
2. Conv2D layer
3. Conv2D layer
4. Dense layer (Hidden layer)
5. Dense layer (Hidden layer)
6. Output layer

Initialize the model, Add convolution layer, pooling layer, flatten layer, dense layer

```
model = Sequential() # Sequential Model

model.add(Conv2D(128, (3,3), activation='relu', input_shape=(128,128,1))) # Convolution Layer
model.add(MaxPooling2D(pool_size=(2,2))) # Pooling Layer

model.add(Conv2D(128, (3,3), activation='relu')) # Convolution Layer
model.add(MaxPooling2D(pool_size=(2,2))) # Pooling Layer

model.add(Flatten()) # Flatten Layer
model.add(Dense(128, activation='relu')) # Hidden Layer
model.add(Dense(128, activation='relu')) # Hidden Layer
model.add(Dense(26, activation='softmax')) # Hidden Layer
```

Python

Compiler the model

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

Python

Fit the Model

```
In [20]: tr=model.fit(x_train,y_train,epochs=10,batch_size=32)
```

The model is trained for 3 epochs and the accuracy of the model is above 95%.

```
Epoch 1/10
140/140 [==============================] - 145s 1s/step - loss: 2.3884 - accuracy: 0.9515
Epoch 2/10
140/140 [==============================] - 143s 1s/step - loss: 0.0294 - accuracy: 0.9960
Epoch 3/10
140/140 [==============================] - 144s 1s/step - loss: 0.0184 - accuracy: 0.9980
Epoch 4/10
140/140 [==============================] - 142s 1s/step - loss: 0.4600 - accuracy: 0.9852
Epoch 5/10
140/140 [==============================] - 143s 1s/step - loss: 1.0050 - accuracy: 0.9751
Epoch 6/10
140/140 [==============================] - 144s 1s/step - loss: 0.6864 - accuracy: 0.9881
Epoch 7/10
140/140 [==============================] - 142s 1s/step - loss: 0.7326 - accuracy: 0.9829
Epoch 8/10
140/140 [==============================] - 142s 1s/step - loss: 0.2823 - accuracy: 0.9930
Epoch 9/10
140/140 [==============================] - 142s 1s/step - loss: 0.0183 - accuracy: 0.9987
Epoch 10/10
140/140 [==============================] - 142s 1s/step - loss: 0.0077 - accuracy: 0.9984
```

Finally, the trained model is saved for future use.

Save The Model

```
In [21]: model.save("sms.h5")
```

Feature 2 – Building the Flask Application:

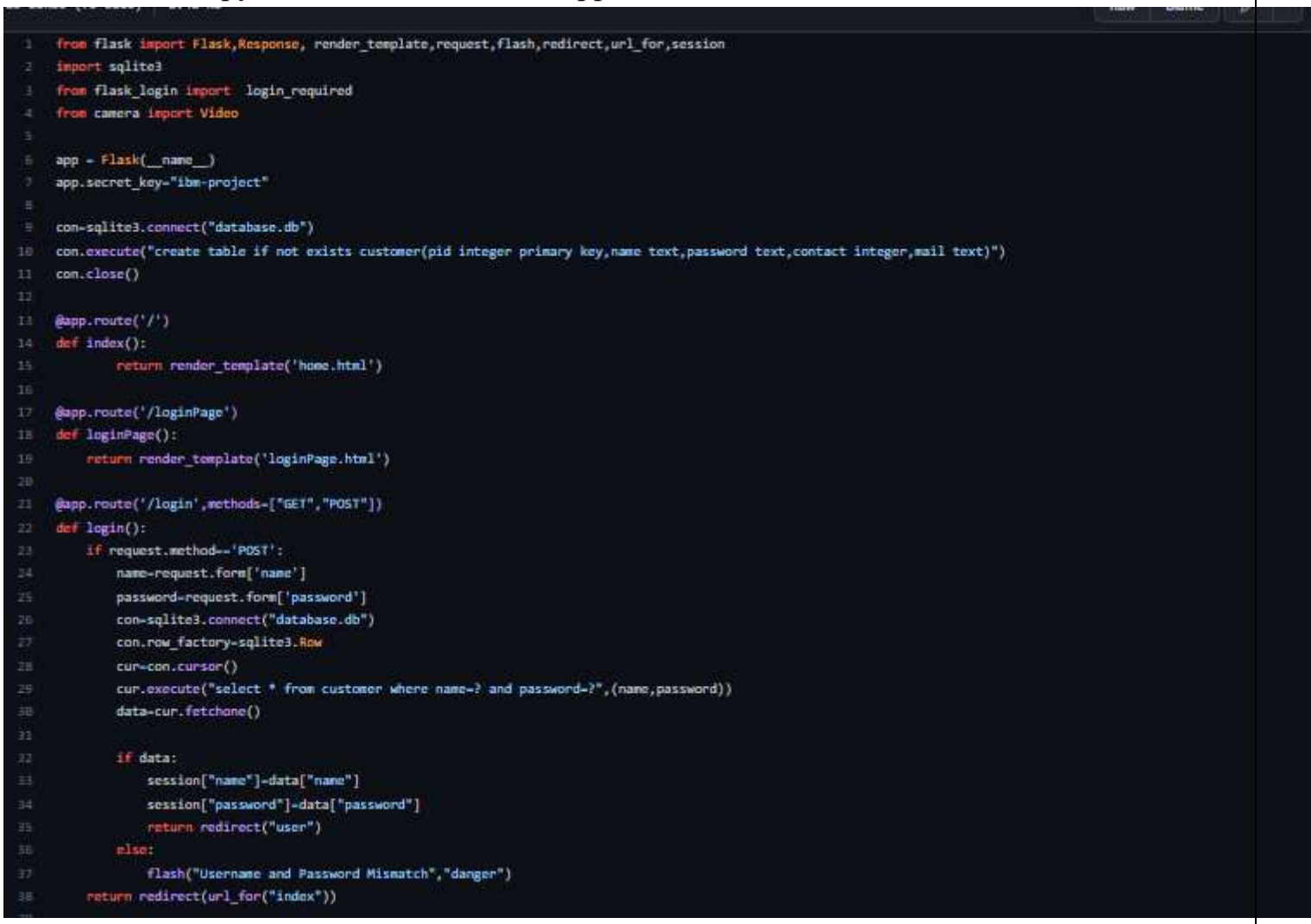
In Feature – 2 of our project, we create a Flask based web application to present it to the user.

The Flask application consists of:

- app.py (main script)
- backend.py (contains the trained model)
- index.html (frontend of the application)
- translate.html (frontend of the application)

App.py:

This is the main script for the Flask application. This script communicates with backend.py and the frontend of the application.



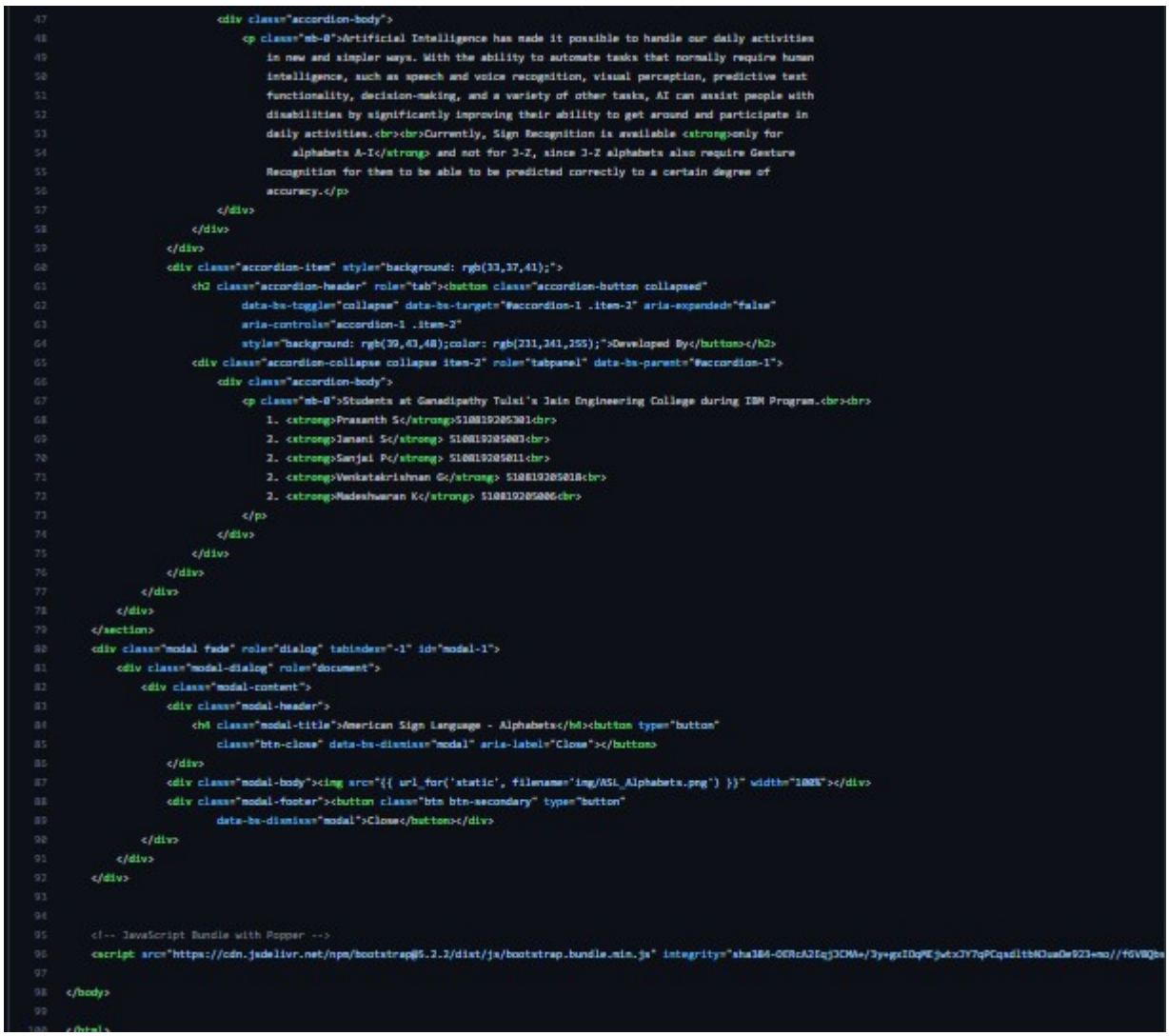
```python
from flask import Flask,Response, render_template,request,flash,redirect,url_for,session
import sqlite3
from flask_login import  login_required
from camera import Video

app = Flask(__name__)
app.secret_key="ibm-project"

con=sqlite3.connect("database.db")
con.execute("create table if not exists customer(pid integer primary key,name text,password text,contact integer,mail text)")
con.close()

@app.route('/')
def index():
        return render_template('home.html')

@app.route('/loginPage')
def loginPage():
    return render_template('loginPage.html')

@app.route('/login',methods=["GET","POST"])
def login():
    if request.method=='POST':
        name=request.form['name']
        password=request.form['password']
        con=sqlite3.connect("database.db")
        con.row_factory=sqlite3.Row
        cur=con.cursor()
        cur.execute("select * from customer where name=? and password=?",(name,password))
        data=cur.fetchone()

        if data:
            session["name"]=data["name"]
            session["password"]=data["password"]
            return redirect("user")
        else:
            flash("Username and Password Mismatch","danger")
    return redirect(url_for("index"))
```

```python

@app.route('/user',methods=["GET","POST"])
def user():
    return render_template("user.html")

@app.route('/register',methods=['GET','POST'])
def register():
    if request.method=='POST':
        try:
            name=request.form['name']
            password=request.form['password']
            contact=request.form['contact']
            mail=request.form['mail']
            con=sqlite3.connect("database.db")
            cur=con.cursor()
            cur.execute("insert into customer(name,password,contact,mail)values(?,?,?,?)",(name,password,contact,mail))
            con.commit()
            flash("Record Added  Successfully","success")
        except:
            flash("Error in Insert Operation","danger")
        finally:
            return redirect(url_for("index"))
            con.close()

    return render_template('register.html')

@app.route('/logout')
def logout():
    session.clear()
    return redirect(url_for("index"))


def gen(camera):
        while True:
                frame = camera.get_frame()
                yield(b'--frame\r\n'
                        b'Content-Type: image/jpeg\r\n\r\n' + frame +
                        b'\r\n\r\n')

@app.route('/video_feed')
def video_feed():
        video = Video()
        return Response(gen(video), mimetype='multipart/x-mixed-replace; boundary = frame')


if __name__ == '__main__':
        app.run()
```

Index.html:

This is the script for the frontend of the application. It contains the necessary code (HTML and CSS) to make the user interactable with the application.

```
<!DOCTYPE html>
<html lang="en">

<head>
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0, shrink-to-fit=no">
    <title>SmartBridge_WebApp_VideoTemplate</title>
    <!-- CSS only -->
    <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.2/dist/css/bootstrap.min.css" rel="stylesheet" integrity="sha384-Zenh87qX5JnK2Jl0vWa8Ck2rdkQ2Bzep5IDxbcnCeuOxjzrPF/c
    <link rel="stylesheet" href="/static/css/Banner-Heading-Image.css">
    <link rel="stylesheet" href="../static/css/Navbar-Centered-Brand.css">
    <link rel="stylesheet" href="/static/css/styles.css">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/styles.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/Navbar-Centered-Brand.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/Banner-Heading-Image') }}">
<body>
    <nav class="navbar navbar-light navbar-expand-md py-3 bg-primary shadow-lg">
        <div class="container">
            <div></div><a class="navbar-brand d-flex align-items-center" href="#"><span
                    class="bs-icon-sm bs-icon-rounded bs-icon-primary d-flex justify-content-center align-items-center me-2 bs-icon"><i
                        class="fas fa-flask"></i></span><span style="color: rgb(255,255,255);">Real-Time Communication
                    System Powered By AI For Specially Abled</span></a>
            <div></div>
        </div>
    </nav>
    <section>
        <div class="d-flex flex-column justify-content-center align-items-center">
            <div class="d-flex flex-column justify-content-center align-items-center" id="div-video-feed"
                style="width: 640px;height: 480px;margin: 10px;min-height: 480px;min-width: 640px;border-radius: 10px;border: 4px dashed rgb(255,255,255) ;">
                <img src="{{ url_for('video_feed') }}" style="width: 100%;height: 100%;color: rgb(255,255,255);text-align: center;font-size: 20px;"
                    alt="Camera Access Not Provided!">
            </div>
        </div>
        <div class="d-flex flex-column justify-content-center align-items-center" style="margin-bottom: 10px;"><button
                class="btn btn-info" type="button" data-bs-target="#modal-1" data-bs-toggle="modal">Quick Reference
                -<strong> ASL Alphabets</strong></button></div>
    </section>
    <section>
        <div class="container">
            <div class="accordion text-white" role="tablist" id="accordion-1">
                <div class="accordion-item" style="background: rgb(33,37,41);">
                    <h2 class="accordion-header" role="tab"><button class="accordion-button" data-bs-toggle="collapse"
                            data-bs-target="#accordion-1 .item-1" aria-expanded="true"
                            aria-controls="accordion-1 .item-1"
                            style="background: rgb(39,43,48);color: rgb(255,255,255);">About The Project</button></h2>
                    <div class="accordion-collapse collapse show item-1" role="tabpanel" data-bs-parent="#accordion-1">
                        <div class="accordion-body">
                            <p class="mb-0">Artificial Intelligence has made it possible to handle our daily activities
```



```
                        <div class="accordion-body">
                            <p class="mb-0">Artificial Intelligence has made it possible to handle our daily activities
                                in new and simpler ways. With the ability to automate tasks that normally require human
                                intelligence, such as speech and voice recognition, visual perception, predictive text
                                functionality, decision-making, and a variety of other tasks, AI can assist people with
                                disabilities by significantly improving their ability to get around and participate in
                                daily activities.<br><br>Currently, Sign Recognition is available <strong>only for
                                    alphabets A-I</strong> and not for J-Z, since J-Z alphabets also require Gesture
                                Recognition for them to be able to be predicted correctly to a certain degree of
                                accuracy.</p>
                        </div>
                    </div>
                </div>
                <div class="accordion-item" style="background: rgb(33,37,41);">
                    <h2 class="accordion-header" role="tab"><button class="accordion-button collapsed"
                            data-bs-toggle="collapse" data-bs-target="#accordion-1 .item-2" aria-expanded="false"
                            aria-controls="accordion-1 .item-2"
                            style="background: rgb(39,43,48);color: rgb(231,241,255);">Developed By</button></h2>
                    <div class="accordion-collapse collapse item-2" role="tabpanel" data-bs-parent="#accordion-1">
                        <div class="accordion-body">
                            <p class="mb-0">Students at Ganadipathy Tulsi's Jain Engineering College during IBM Program.<br><br>
                                1. <strong>Prasanth S</strong>510819205301<br>
                                2. <strong>Janani S</strong> 510819205003<br>
                                2. <strong>Sanjai P</strong> 510819205011<br>
                                2. <strong>Venkatakrishnan G</strong> 510819205018<br>
                                2. <strong>Madeshwaran K</strong> 510819205006<br>
                            </p>
                        </div>
                    </div>
                </div>
            </div>
        </div>
    </section>
    <div class="modal fade" role="dialog" tabindex="-1" id="modal-1">
        <div class="modal-dialog" role="document">
            <div class="modal-content">
                <div class="modal-header">
                    <h4 class="modal-title">American Sign Language - Alphabets</h4><button type="button"
                        class="btn-close" data-bs-dismiss="modal" aria-label="Close"></button>
                </div>
                <div class="modal-body"><img src="{{ url_for('static', filename='img/ASL_Alphabets.png') }}" width="100%"></div>
                <div class="modal-footer"><button class="btn btn-secondary" type="button"
                        data-bs-dismiss="modal">Close</button></div>
            </div>
        </div>
    </div>


    <!-- JavaScript Bundle with Popper -->
    <script src="https://cdn.jsdelivr.net/npm/bootstrap@5.2.2/dist/js/bootstrap.bundle.min.js" integrity="sha384-OERcA2EqjJCMA+/3y+gxIOqMEjwtxJY7qPCqsdltbNJuaOe923+mo//f6V8Qbs

</body>

</html>
```

8. TESTING:

Test Cases:

Testing of a built application is as important as building the application itself. Here, we test the built model with our testing dataset images.

Testing The Model

Making necessary imports

```
from tensorflow.keras.preprocessing import image
import numpy as np
from tensorflow.keras.models import load_model
import cv2
```

[8] Python

Load the Trained Model

```
model = load_model('/content/drive/MyDrive/trained_model.h5')
```

Python

Test Case – 1: ISL Alphabet 'D':

Predicting Test Images

Indian Sign Language(ISL) Alphabet - 'D'

```
img = image.load_img('/content/Dataset/test_set/D/1027.jpg', target_size=(128,128), color_mode=
img
```

6] Python

```
x = image.img_to_array(img)
x = np.expand_dims(x, axis=0)
prediction = np.argmax(model.predict(x))
get_prediction(prediction)
```

[27] Python

```
1/1 [==============================] - 0s 57ms/step
'D'
```

Test Case – 2: ISL Alphabet ‘F’:

Indian Sign Language(ISL) Alphabet - 'F'

```
img = image.load_img('/content/Dataset/test_set/F/1022.jpg', target_size=(128,128), color_mode=
img
```

Python

+ Code + Markdown

```
x = image.img_to_array(img)
x = np.expand_dims(x, axis=0)
prediction = np.argmax(model.predict(x))
get_prediction(prediction)
```

Python

```
1/1 [==============================] - 0s 49ms/step
'F'
```

+ Code + Markdown

Test Case – 3: ISL Alphabet ‘S’:

Indian Sign Language(ISL) Alphabet - 'S'

```
img = image.load_img('/content/Dataset/test_set/S/108.jpg', target_size=(128,128), color_mode='
img
```

Python

```
x = image.img_to_array(img)
x = np.expand_dims(x, axis=0)
prediction = np.argmax(model.predict(x))
get_prediction(prediction)
```

Python

```
1/1 [==============================] - 0s 48ms/step
'S'
```

Test Case – 4: ISL Alphabet ‘C’:

We used our own image to simulate real-world working of the trained model.

Testing our own images in the model to simulate real-world usage

Our own test image - Indian Sign Language(ISL) Alphabet - 'C'

```
img = image.load_img('/content/drive/MyDrive/C.jpg', target_size=(128,128), color_mode='graysca
img
```

[13] Python

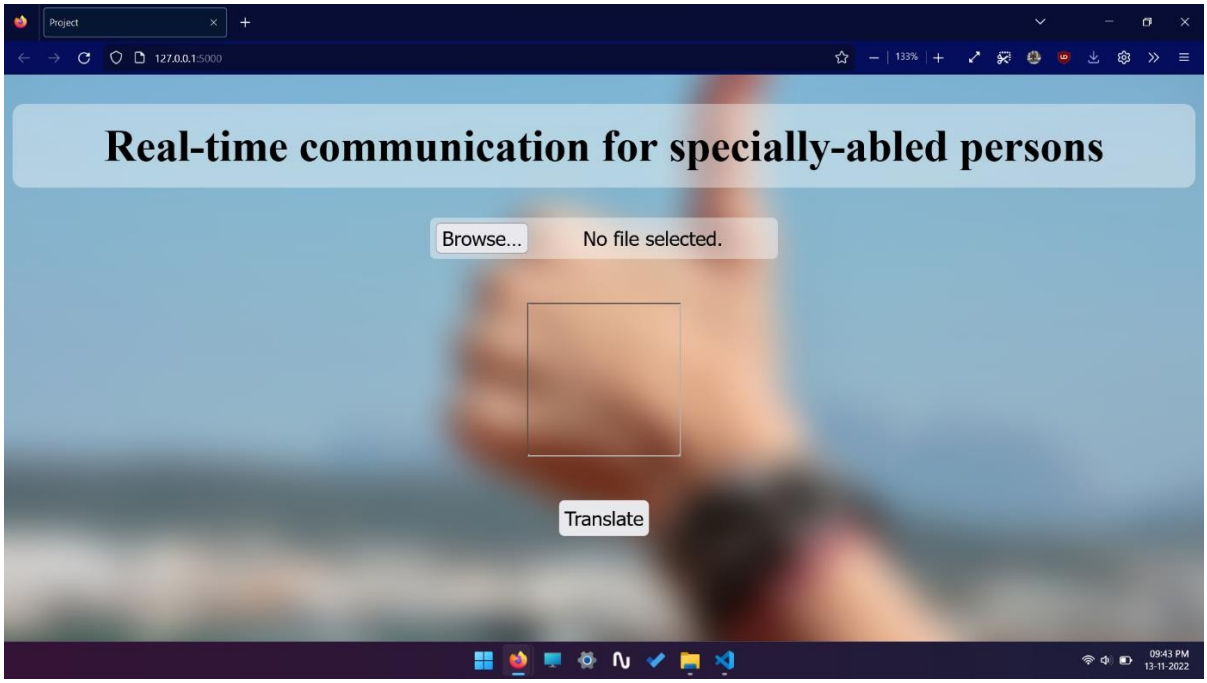
+ Code + Markdown

```
x = image.img_to_array(img)
x = np.expand_dims(x, axis=0)
prediction = np.argmax(model.predict(x))
get_prediction(prediction)
```

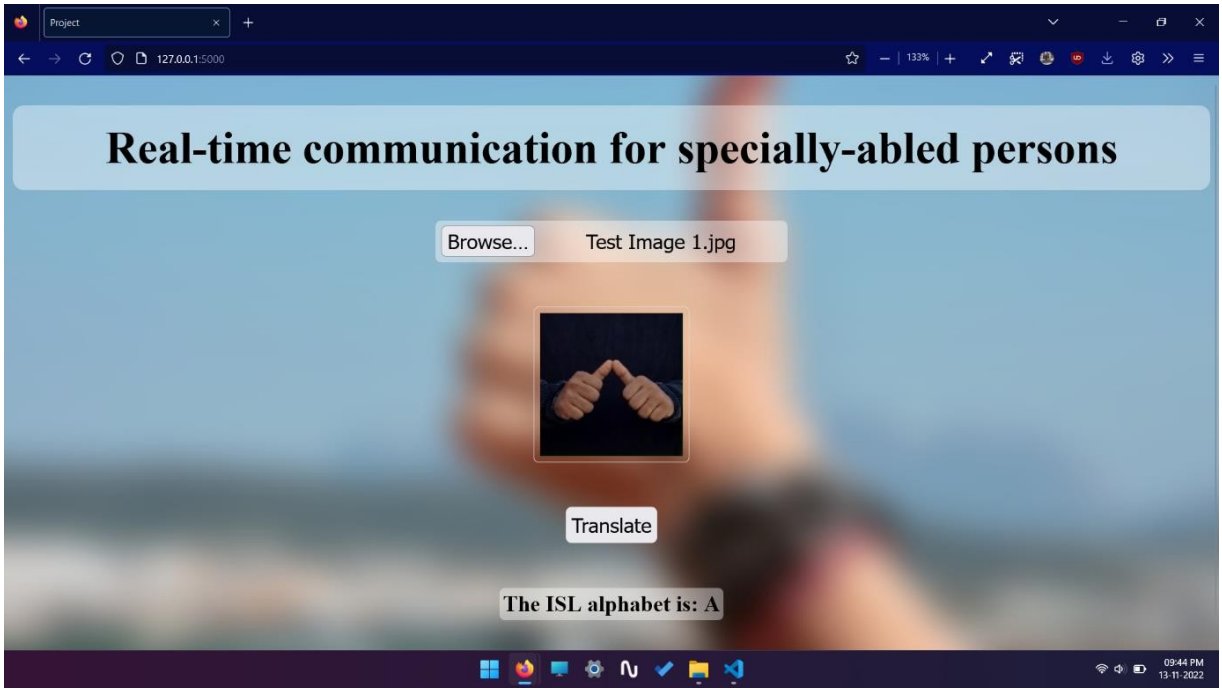
[14] Python

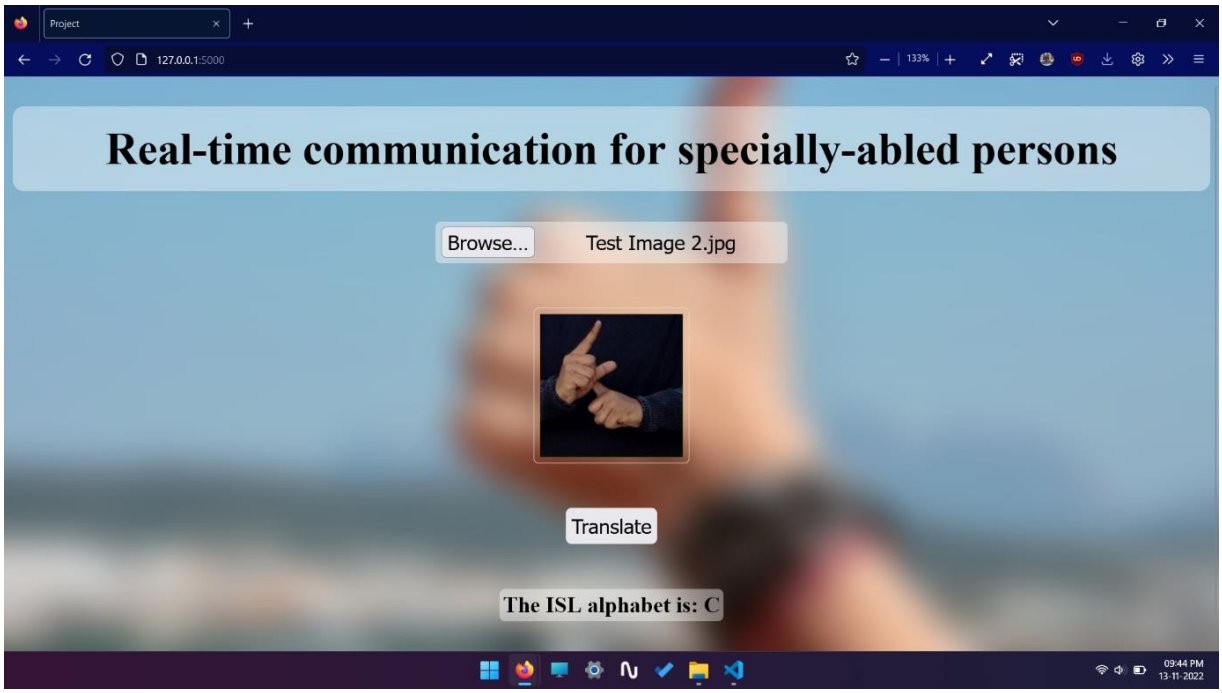
```
1/1 [==============================] - 0s 66ms/step
'C'
```

User Acceptance Testing:



Real-time usage output:





The created software (above) satisfies the user requirements and the purposes of our project listed in page no. 2.

9. RESULTS:

Performance Metrics:

RAM & CPU usage:

The software when run, only consumes:

- minimal RAM of around 1.8 to 7 MB [1]
- CPU usage of around 1.4% during translation [1][2]

[1] – Results are computed based on the average of running the software in multiple computers. Also, results may vary from one computer to another.

[2] – Tested on Ryzen 5 4500U (Hexa-core processor) with base clock 2.8 GHz.

Evaluation metrics:

The trained Convolutional Neural Network (CNN) model used in the software has an accuracy score of more than 95%.

10. ADVANTAGES & DISADVANTAGES:

Advantages:

- It lets the specially-abled persons communicate with normal person using their sign language.
- If used properly, the software can bridge the gap between specially-abled persons and normal persons.
- The application is scalable, i.e., its scope can be expanded to recognize digits, words, etc.

Disadvantages:

- Specially-abled persons need to be trained to work with the software.
- Since the trained model's accuracy is not 100%, sometimes there may be cases where the model may produce erroneous results.
- The input image needs to be of good quality for the model to classify correctly.

11. CONCLUSION:

- The project we developed can bridge the gap of communication between deaf-mute people and the normal people.
- The project can be expanded with several functionalities in future.
- The project also has a business potential which can be tapped.

12. FUTURE SCOPE:

This project has tremendous scope for future work. As this software includes components integrated into a Flask web application, components can be replaced or updated as per the changing requirements in the future.

Many new functionalities can be added like:

- Making the application predict words by combing multiple signs.
- Using NLP (Natural Language Processing) & ML (Machine Learning) to combine predicted words to create a meaningful sentence.
- Add many User Experience (UX) enhancing changes.
- Making the web application's UI (User Interface) look more appealing and user-friendly.

13. APPENDIX:

Source Code:

App.py:

```python
from flask import Flask,Response, render_template,request,flash,redirect,url_for,session
import sqlite3
from flask_login import  login_required
from camera import Video

app = Flask(__name__)
app.secret_key="ibm-project"

con=sqlite3.connect("database.db")
con.execute("create table if not exists customer(pid integer primary key,name text,password text,contact integer,mail text)")
con.close()

@app.route('/')
def index():
        return render_template('home.html')

@app.route('/loginPage')
def loginPage():
    return render_template('loginPage.html')

@app.route('/login',methods=["GET","POST"])
def login():
    if request.method=='POST':
        name=request.form['name']
        password=request.form['password']
        con=sqlite3.connect("database.db")
        con.row_factory=sqlite3.Row
        cur=con.cursor()
        cur.execute("select * from customer where name=? and password=?",(name,password))
        data=cur.fetchone()

        if data:
            session["name"]=data["name"]
            session["password"]=data["password"]
            return redirect("user")
        else:
            flash("Username and Password Mismatch","danger")
    return redirect(url_for("index"))


@app.route('/user',methods=["GET","POST"])
def user():
```

```
    return render_template("user.html")

@app.route('/register',methods=['GET','POST'])
def register():
    if request.method=='POST':
        try:
            name=request.form['name']
            password=request.form['password']
            contact=request.form['contact']
            mail=request.form['mail']
            con=sqlite3.connect("database.db")
            cur=con.cursor()
            cur.execute("insert into customer(name,password,contact,mail)values(?,?,?,?)",(name,password,contact,mail))
            con.commit()
            flash("Record Added  Successfully","success")
        except:
            flash("Error in Insert Operation","danger")
        finally:
            return redirect(url_for("index"))
            con.close()

    return render_template('register.html')

@app.route('/logout')
def logout():
    session.clear()
    return redirect(url_for("index"))


def gen(camera):
        while True:
                frame = camera.get_frame()
                yield(b'--frame\r\n'
                        b'Content-Type: image/jpeg\r\n\r\n' + frame +
                        b'\r\n\r\n')

@app.route('/video_feed')
def video_feed():
        video = Video()
        return Response(gen(video), mimetype='multipart/x-mixed-replace; boundary = frame')


if __name__ == '__main__':
        app.run()
```

Index.html:

```
<!DOCTYPE html>
<html lang="en">

<head>
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0, shrink-to-fit=no">
    <title>SmartBridge_WebApp_VideoTemplate</title>
    <!-- CSS only -->
    <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.3/dist/css/bootstrap.min.css" rel="stylesheet" integrity="sha384-ZvpUoO/+PpLXR1lu4jmpXWu80pZlYUAfxl5NsBMWOEPSjUn/6Z/hRTt8+pR6L4N2" crossorigin="anonymous">
    <link rel="stylesheet" href="/static/css/Banner-Heading-Image.css">
    <link rel="stylesheet" href="../static/css/Navbar-Centered-Brand.css">
    <link rel="stylesheet" href="/static/css/styles.css">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/styles.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/Navbar-Centered-Brand.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/Banner-Heading-Image') }}">
</head>

<body>
    <nav class="navbar navbar-light navbar-expand-md py-3 bg-primary shadow-lg">
        <div class="container">
            <div></div><a class="navbar-brand d-flex align-items-center" href="#"><span
                    class="bs-icon-sm bs-icon-rounded bs-icon-primary d-flex justify-content-center align-items-center me-2 bs-icon"><i
                        class="fas fa-flask"></i></span><span style="color: rgb(255,255,255);">Real-Time Communication
                    System Powered By AI For Specially Abled</span></a>
            <div></div>
        </div>
    </nav>
    <section>
        <div class="d-flex flex-column justify-content-center align-items-center">
            <div class="d-flex flex-column justify-content-center align-items-center" id="div-video-feed"
                style="width: 640px;height: 480px;margin: 10px;min-height: 480px;min-width: 640px;border-radius: 10px;border: 4px dashed rgb(255,255,255) ;">
                <img src="{{ url_for('video_feed') }}" style="width: 100%;height: 100%;color: rgb(255,255,255);text-align: center;font-size: 20px;"
                    alt="Camera Access Not Provided!">
            </div>
        </div>
        <div class="d-flex flex-column justify-content-center align-items-center" style="margin-bottom: 10px;"><button
                class="btn btn-info" type="button" data-bs-target="#modal-1" data-bs-toggle="modal">Quick Reference
                -<strong> ASL Alphabets</strong></button></div>
    </section>
    <section>
        <div class="container">
            <div class="accordion text-white" role="tablist" id="accordion-1">
                <div class="accordion-item" style="background: rgb(33,37,41);">
                    <h2 class="accordion-header" role="tab"><button class="accordion-button" data-bs-toggle="collapse"
                            data-bs-target="#accordion-1 .item-1" aria-expanded="true"
                            aria-controls="accordion-1 .item-1"
                            style="background: rgb(39,43,48);color: rgb(255,255,255);">About The Project</button></h2>
                    <div class="accordion-collapse collapse show item-1" role="tabpanel" data-bs-parent="#accordion-1">
                        <div class="accordion-body">
                            <p class="mb-0">Artificial Intelligence has made it possible to handle our daily activities
                                in new and simpler ways. With the ability to automate tasks that normally require human
                                intelligence, such as speech and voice recognition, visual perception, predictive text
                                functionality, decision-making, and a variety of other tasks, AI can assist people with
                                disabilities by significantly improving their ability to get around and participate in
                                daily activities.<br><br>Currently, Sign Recognition is available <strong>only for
                                    alphabets A-I</strong> and not for J-Z, since J-Z alphabets also require Gesture
                                Recognition for them to be able to be predicted correctly to a certain degree of
                                accuracy.</p>
                        </div>
                    </div>
                </div>
                <div class="accordion-item" style="background: rgb(33,37,41);">
```

```
                <div class="accordion-item" style="background: rgb(33,37,41);">
                    <h2 class="accordion-header" role="tab"><button class="accordion-button collapsed"
                            data-bs-toggle="collapse" data-bs-target="#accordion-1 .item-2" aria-expanded="false"
                            aria-controls="accordion-1 .item-2"
                            style="background: rgb(33,43,48);color: rgb(231,241,255);">Developed By</button></h2>
                    <div class="accordion-collapse collapse item-2" role="tabpanel" data-bs-parent="#accordion-1">
                        <div class="accordion-body">
                            <p class="mb-0">Students at Ganadipathy Tulsi's Jain Engineering College during IBM Program.<br><br>
                                1. <strong>Prasanth S</strong>510819205301<br>
                                2. <strong>Janani S</strong> 510819205003<br>
                                2. <strong>Sanjai Pc/strong> 510819205011<br>
                                2. <strong>Venkatakrishnan G</strong> 510819205018<br>
                                2. <strong>Madeshwaran K</strong> 510819205006<br>
                            </p>
                        </div>
                    </div>
                </div>
            </div>
        </div>
    </section>
    <div class="modal fade" role="dialog" tabindex="-1" id="modal-1">
        <div class="modal-dialog" role="document">
            <div class="modal-content">
                <div class="modal-header">
                    <h4 class="modal-title">American Sign Language - Alphabets</h4><button type="button"
                        class="btn-close" data-bs-dismiss="modal" aria-label="Close"></button>
                </div>
                <div class="modal-body"><img src="{{ url_for('static', filename='img/ASL_Alphabets.png') }}" width="100%"></div>
                <div class="modal-footer"><button class="btn btn-secondary" type="button"
                        data-bs-dismiss="modal">Close</button></div>
            </div>
        </div>
    </div>


    <!-- JavaScript Bundle with Popper -->
    <script src="https://cdn.jsdelivr.net/npm/bootstrap@5.2.2/dist/js/bootstrap.bundle.min.js" integrity="sha384-OERcA2EqjJCMA+/3y+gxIOqMEjwtxJY7qPCqsdltbNJuaOe923+mo//f6V8Qbs

</body>

</html>
```

GitHub Link:

https://github.com/IBM-EPBL/IBM-Project-18759-1659689579

Project Demo Video Link:

https://youtu.be/ygI7sq41yT4