ASL - ALPHABET IMAGE RECOGNITION PROJECT REPORT

1. INTRODUCTION

1.1 Project Overview

The goal of the "Sign Language Recognition using Deep Learning" project is to create an approachable, real-time system for identifying gestures in American Sign Language (ASL). By utilizing TensorFlow and Keras to enable deep learning, the model can decipher a predetermined set of ASL signs, facilitating communication for those who are hard of hearing. The project's salient characteristics encompass resilient gesture identification in diverse settings, a user-friendly interface, and the possibility of ongoing enhancement via user input and supplementary training materials. The ultimate objective is to support the target audience—which includes educators, persons with hearing impairments, and those interested in sign language communication—in creating a more communicative and inclusive workplace.

1.2 Purpose

The purpose of the 'Sign Language Recognition using Deep Learning' project is to create an innovative solution that enables individuals with hearing impairments to communicate effectively through the recognition of American Sign Language (ASL) gestures.

2. LITERATURE SURVEY

2.1 Existing problem

Extensive research has been conducted on the recognition of American Sign Language (ASL) gestures with the goal of improving communication accessibility for those with hearing impairments. Previous research has identified a number of difficulties in this field. Robust recognition across a variety of environmental conditions, including different lighting and backdrops, is a major difficulty that can greatly affect the performance of recognition models. Furthermore, maintaining accuracy in real-time recognition presents a technological challenge. In certain situations, the feasibility of the state-of-the-art solutions is limited since they frequently call for substantial computational resources. This review of the literature dives into the current issues surrounding ASL recognition and provides the framework for a novel approach that tackles these issues.

2.2 References

https://www.researchgate.net/publication/262187093_Sign_language_recognition_State_of_the_art
https://ieeexplore.ieee.org/document/9432296
https://github.com/Sri-Tulasi/VIT_Morning_Slot
https://www.sciencedirect.com/science/article/pii/S2666990021000471

2.3 Problem Statement Definition

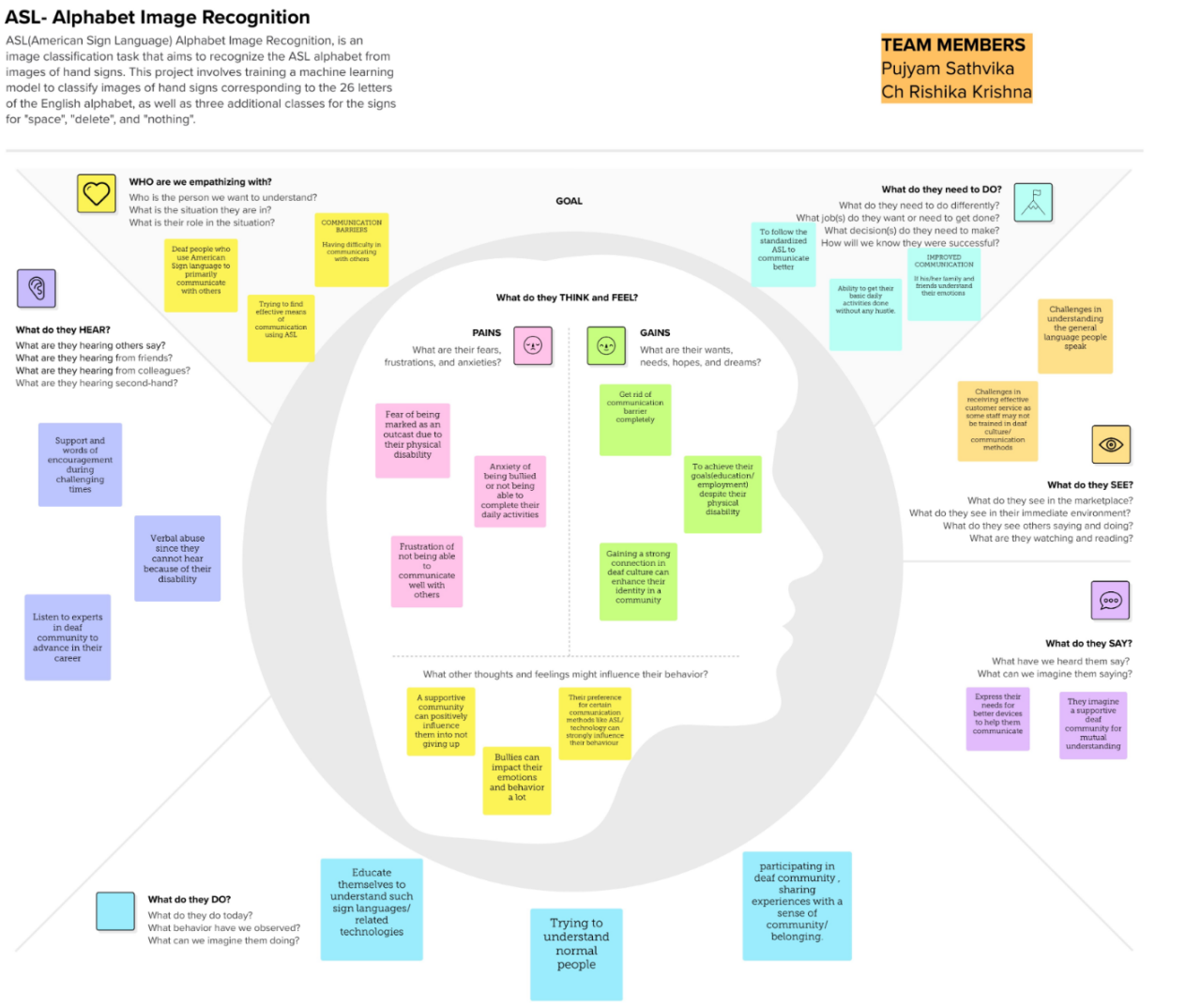
Limited accessibility to American Sign Language (ASL) resources and education hinders effective communication for the deaf community. Our project aims to solve these challenges by implementing an ASL recognition system based on convolution neural networks (CNNs) to improve ASL accessibility and for better communication.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviors and attitudes. It is a useful tool to help us better understand our users. Creating an effective solution requires understanding the true problem and the person who is experiencing it.

The users of our project would be deaf individuals who use ASL(American Sign Language) to communicate with others. We tried to put ourselves into various situations the deaf might experience and have completed the following empathy canvas map.



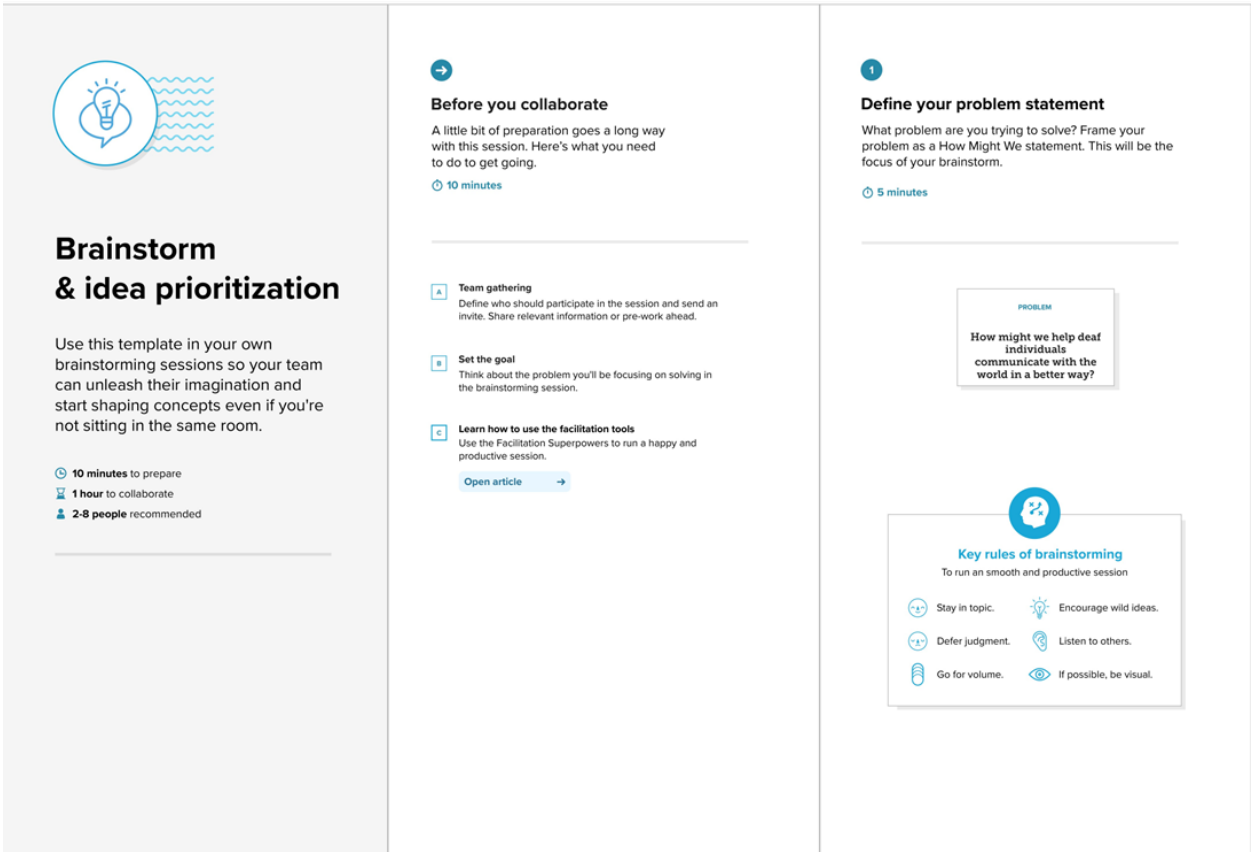
3.2 Ideation & Brainstorming

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate, helping each other develop a rich number of creative solutions.

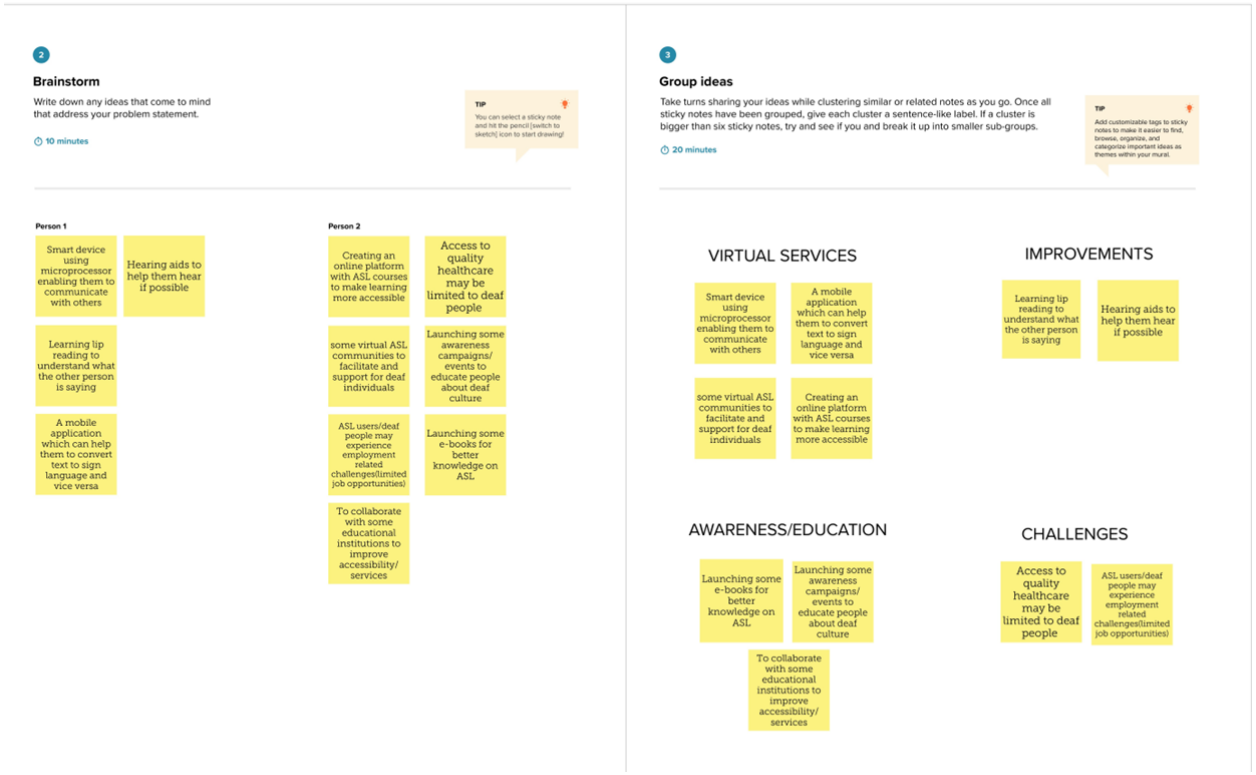
Our problem statement was “How might we help deaf individuals communicate with the world in a better way?”

The users of our project would be deaf individuals who use ASL(American Sign Language) to communicate with others. We tried to put ourselves into various situations the deaf might experience and tried to come up with various solutions for their problems, grouped the solutions and prioritized them to give us a better understanding of our users.

Step 1: Team Gathering, Collaboration and Select the Problem Statement



Step 2: Brainstorm, Idea Listing and Grouping



Step 3: Idea Prioritization

4

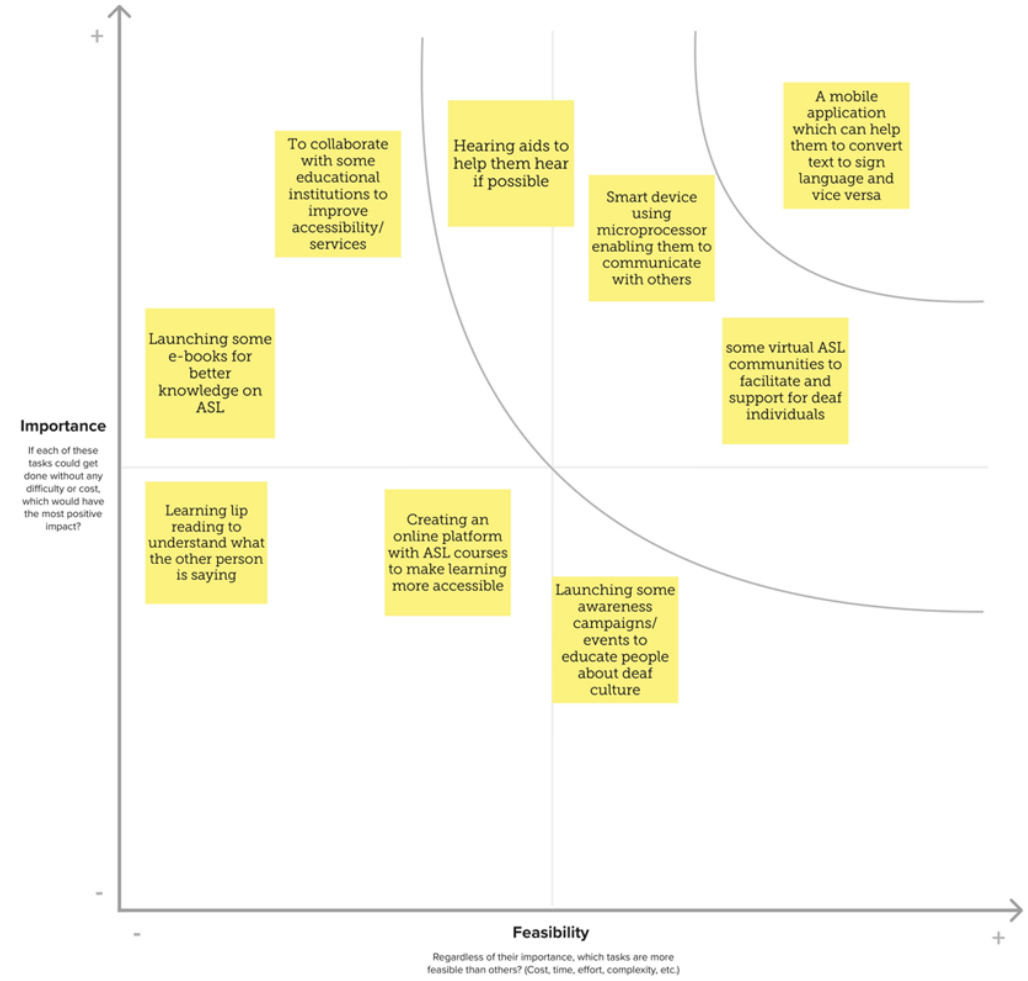
Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes

TIP

Participants can use their cursors to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using the laser pointer holding the **H key** on the keyboard.



4. REQUIREMENT ANALYSIS

4.1 Functional requirement

ASL Recognition:

The system should accurately recognize and interpret American Sign Language gestures.

It should be able to recognize a predefined set of ASL signs and translate them into corresponding text or spoken language.

User Interface:

The system should have a user-friendly interface that enables easy interaction, especially for users with limited technical knowledge.

The interface should include options for users to initiate, pause, or stop the recognition process.

Real-time Processing:

The system should be capable of processing ASL gestures in real-time, ensuring minimal delay between the user's sign and the system's response.

4.2 Non-Functional requirements

Integration with Communication Tools:

The system should be designed to integrate seamlessly with existing communication tools and platforms, such as video conferencing applications or messaging apps.

Multi-Gesture Recognition:

It should support the recognition of multi-gesture sequences to capture complex expressions and sentences in ASL.

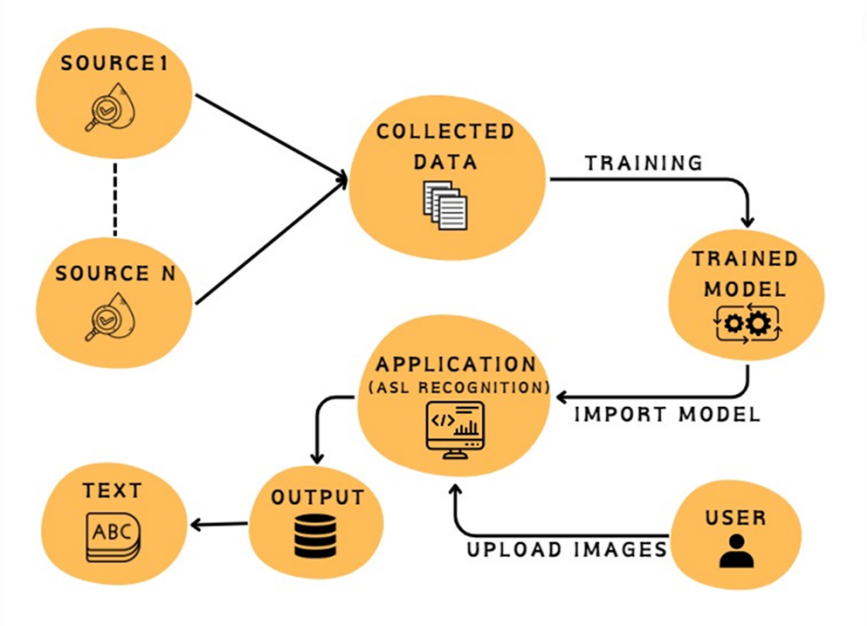
Accessibility:

Ensure that the user interface is accessible to individuals with varying degrees of physical abilities, including those who may use assistive technologies.

5. PROJECT DESIGN

5.1 Data Flow Diagrams & User Stories

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



USER STORIES:

User Type	Functional Requirement(Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
As a developer	Projet setup and infrastructure	USN-1	Set up the development environment with the required tools and frameworks to start the ASL project .	Successfully configured with all necessary tools and frameworks.	High	Sprint-1
As a developer	Data collection	USN-2	Gather a diverse and large dataset of images containing all the different classes of alphabets(A, B, C, D, ….., Z), space, nothing, delete.	Gathered a diverse dataset of images (alphabets).	High	Sprint-1

As a developer	Data Preprocessing	USN-3	Preprocess the collected images by resizing and normalizing. Split the data into training and testing sets.	Preprocessed the dataset.	High	Sprint-2
As a developer	Model Development	USN - 4	Explore different deep learning architectures (CNN) to select the most suitable one for our ASL project.	Explore different DL models.	High	Sprint-2
As a customer	Training	USN-5	As a customer, I want a well trained model and very accurate predictions for the images I upload. Task: Implement data augmentation techniques to improve model's accuracy.	Test the model after training to check accuracy.	Medium	Sprint - 2
As a developer	Integrate the ASL recognition system into applications and services.	USN - 6	As a developer, I want the ASL recognition system to offer an API or web browser for easy accessibility.	Develop a website using HTML, CSS, JS.	Medium	Sprint - 3
Customer	Develop a web-based user interface for the ASL recognition system that provides users with a simple way to interact with the system.	USN - 7	As a customer, I want to access the ASL recognition system through a user-friendly web interface, so I can easily interact with the system without the need to install additional software	Users can access the ASL recognition system through a web browser.	High	Sprint - 3

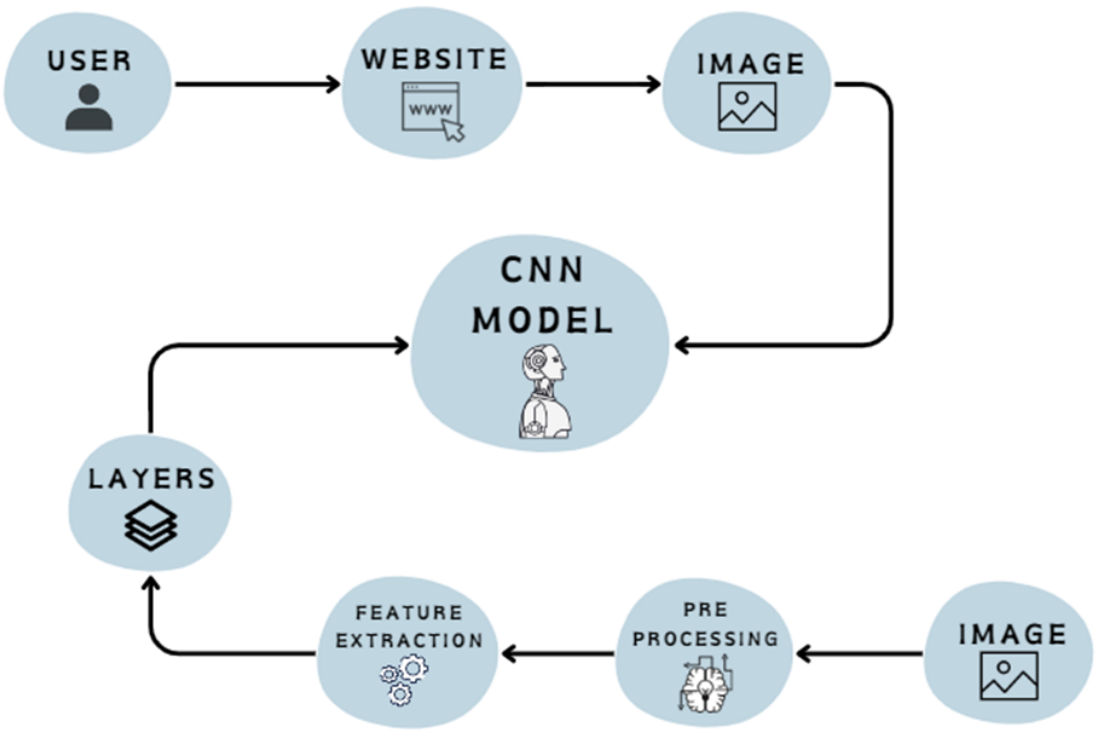
5.2 Solution Architecture

Our problem statement is - "How might we help deaf individuals communicate with the world in a better way?"

Our solution architecture uses machine learning to provide image-based classification for the conversion of sign language to text. We are using CNN(Convolutional Neural Networks) for multi class image classification. Our model can accurately predict the 26

letters of the English alphabet, as well as three additional classes for the signs for "space", "delete", and "nothing".
The steps in our solution architecture include:

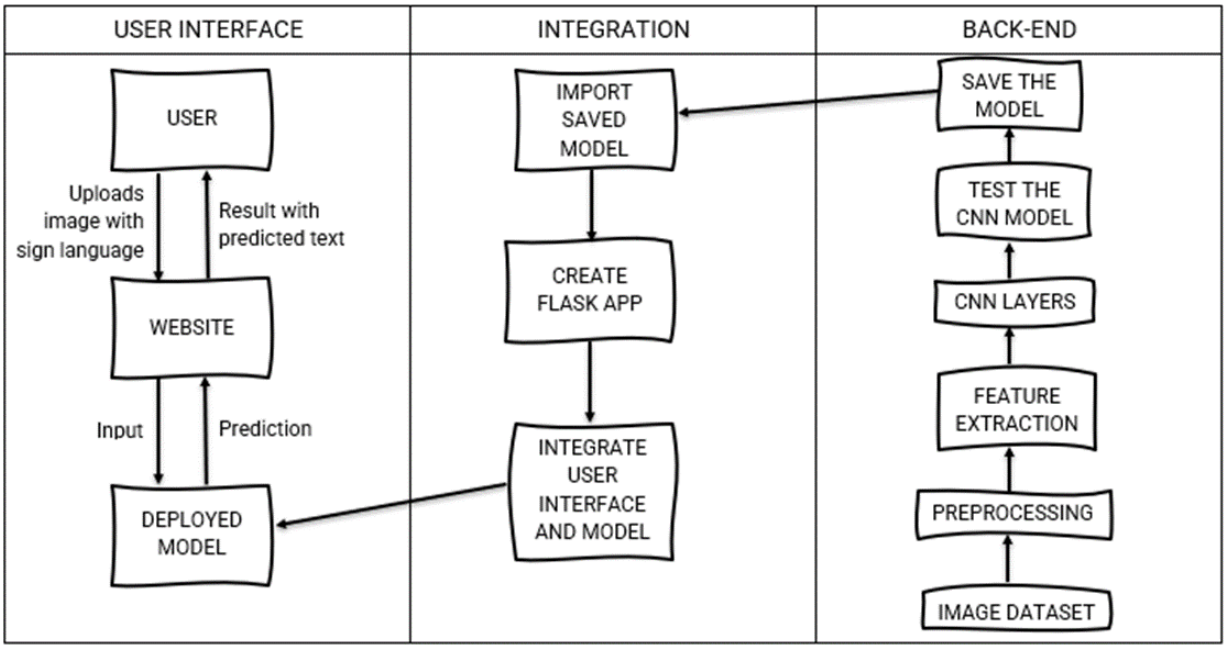
- Data gathering
- Image preprocessing
- Model building
    - Training the model
    - Testing the model
- Sign language prediction
- Website building
- Integrate sign language CNN model using Flask
- Host the website locally
    - Real time analysis



6. PROJECT PLANNING & SCHEDULING

6.1 Technical Architecture

The technical architecture shows the user interface, the integration, and the back end and how they are tied together to make the project.



6.2 Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story points	Priority	Team Members
Sprint-1	Projet setup and infrastructure	USN-1	Set up the development environment with the required tools and frameworks to start the ASL project .	1	High	Rishika, Sathvika
Sprint-1	Data collection	USN-2	Gather a diverse and large dataset of images containing all the different classes of alphabets(A, B, C, D, ….., Z), space, nothing, delete.	2	High	Rishika, Sathvika
Sprint-2	Data Preprocessing	USN-3	Preprocess the collected images by resizing and normalizing. Split the data into training and testing sets.	3	High	Sathvika

Sprint-2	Model Development	USN - 4	Explore different deep learning architectures to select the most suitable one(CNN) for our ASL project.	4	High	Rishika
Sprint-2	Training	USN-5	As a customer, I want a well trained model and very accurate predictions for the images I upload. Task: Implement data augmentation techniques to improve model's accuracy.	4	Medium	Sathvika, Rishika
Sprint-3	Integrate the ASL recognition system into applications and services.	USN - 6	As a developer, I want the ASL recognition system to offer an API or web browser for easy accessibility.	6	Medium	Sathvika, Rishika
Sprint-3	Develop a web-based user interface for the ASL recognition system that provides users with a simple way to interact with the system.	USN - 7	As a customer, I want to access the ASL recognition system through a user-friendly web interface, so I can easily interact with the system without the need to install additional software	6	High	Sathvika, Rishika

6.3 Sprint Delivery Schedule

Sprint	**Total Story Points**	**Duration**	**Sprint Start Date**	**Sprint End Date (Planned)**	**Story Point Completed (as on Planned End Date)**	**Sprint Release Date (Actual)**
Sprint-1	3	3 Days	25 Oct 2023	27 Oct 2023	3	27 Oct 2022
Sprint-2	11	5 Days	28 Oct 2023	01 Nov 2023	11	01 Nov 2023
Sprint-3	12	5 Days	02 Nov 2023	06 Nov 2023	12	09 Nov 2023

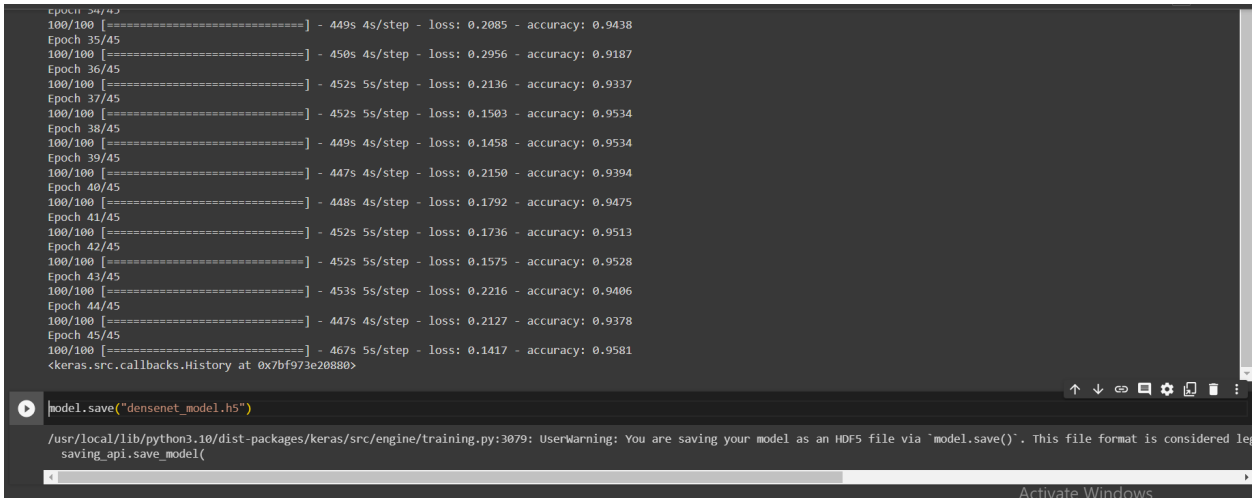
7. CODING & SOLUTIONING (Explain the features added in the project along with code)

7.1 Feature 1 - User Interface :

The UI is designed with simplicity and intuitiveness in mind, ensuring that users, regardless of technical expertise, can easily navigate and interact with the system. The interface is designed to be simple and easy to navigate, ensuring a hassle-free experience for users.

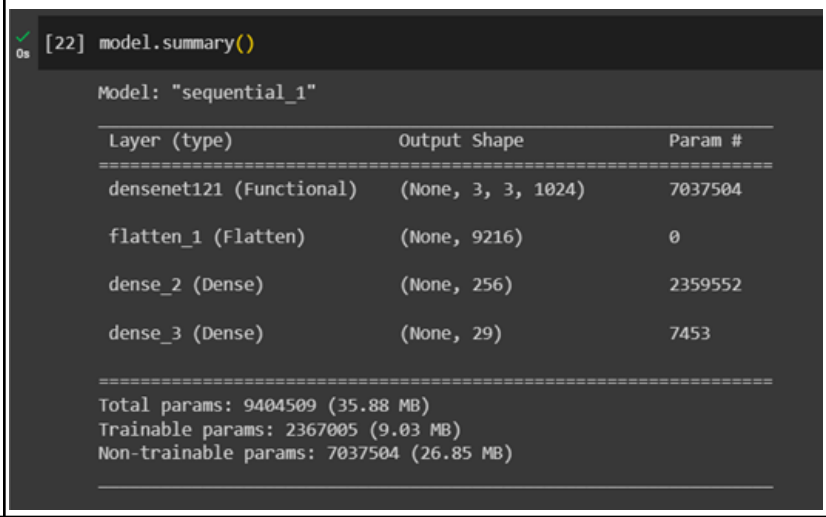
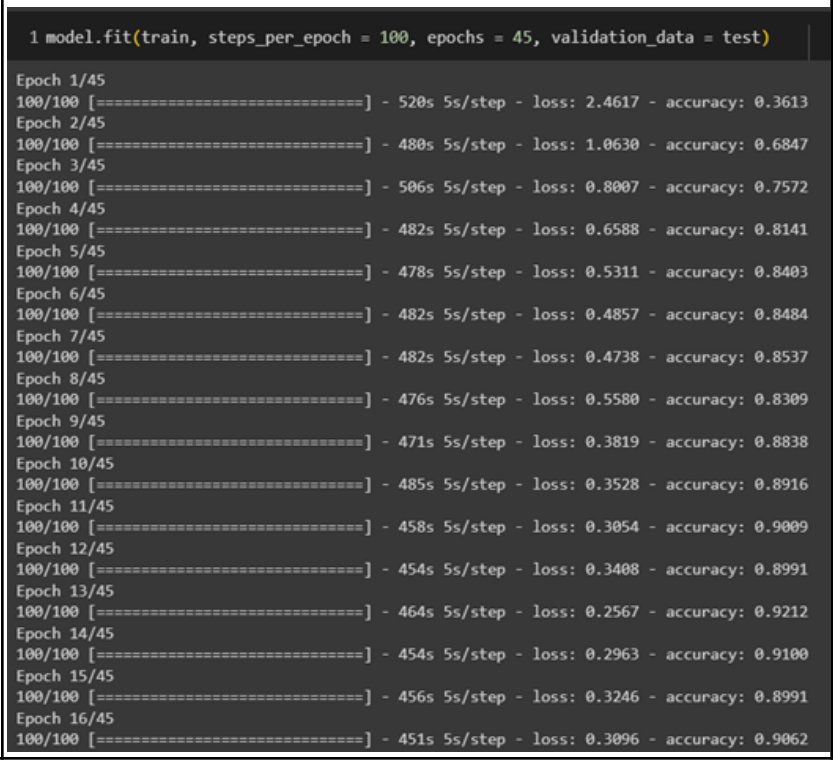
7.2 Feature 2 - Gesture Recognition :

The system should be able to recognize a diverse set of ASL gestures, including individual signs and multi-gesture sequences. In our project we used the Densenet121 pretrained model for better results.



8. PERFORMANCE TESTING

8.1 Performance Metrics

S.No.	Parameter	Values	Screenshot
1.	Model Summary	Total params: 9404509 Trainable params: 2367005 Non-trainable params: 7037504	
2.	Accuracy	Final training accuracy – 0.9581	

Model Summary:

```
[22] model.summary()

Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 densenet121 (Functional)    (None, 3, 3, 1024)        7037504

 flatten_1 (Flatten)         (None, 9216)              0

 dense_2 (Dense)             (None, 256)               2359552

 dense_3 (Dense)             (None, 29)                7453

=================================================================
Total params: 9404509 (35.88 MB)
Trainable params: 2367005 (9.03 MB)
Non-trainable params: 7037504 (26.85 MB)
_________________________________________________________________
```

Training accuracy:

```
model.fit(train, steps_per_epoch = 100, epochs = 45, validation_data = test)

Epoch 1/45
100/100 [==============================] - 520s 5s/step - loss: 2.4617 - accuracy: 0.3613
Epoch 2/45
100/100 [==============================] - 480s 5s/step - loss: 1.0630 - accuracy: 0.6847
Epoch 3/45
100/100 [==============================] - 506s 5s/step - loss: 0.8007 - accuracy: 0.7572
Epoch 4/45
100/100 [==============================] - 482s 5s/step - loss: 0.6588 - accuracy: 0.8141
Epoch 5/45
100/100 [==============================] - 478s 5s/step - loss: 0.5311 - accuracy: 0.8403
Epoch 6/45
100/100 [==============================] - 482s 5s/step - loss: 0.4857 - accuracy: 0.8484
Epoch 7/45
100/100 [==============================] - 482s 5s/step - loss: 0.4738 - accuracy: 0.8537
Epoch 8/45
100/100 [==============================] - 476s 5s/step - loss: 0.5580 - accuracy: 0.8309
Epoch 9/45
100/100 [==============================] - 471s 5s/step - loss: 0.3819 - accuracy: 0.8838
Epoch 10/45
100/100 [==============================] - 485s 5s/step - loss: 0.3528 - accuracy: 0.8916
Epoch 11/45
100/100 [==============================] - 458s 5s/step - loss: 0.3054 - accuracy: 0.9009
Epoch 12/45
100/100 [==============================] - 454s 5s/step - loss: 0.3408 - accuracy: 0.8991
Epoch 13/45
100/100 [==============================] - 464s 5s/step - loss: 0.2567 - accuracy: 0.9212
Epoch 14/45
100/100 [==============================] - 454s 5s/step - loss: 0.2963 - accuracy: 0.9100
Epoch 15/45
100/100 [==============================] - 456s 5s/step - loss: 0.3246 - accuracy: 0.8991
Epoch 16/45
100/100 [==============================] - 451s 5s/step - loss: 0.3096 - accuracy: 0.9062
```

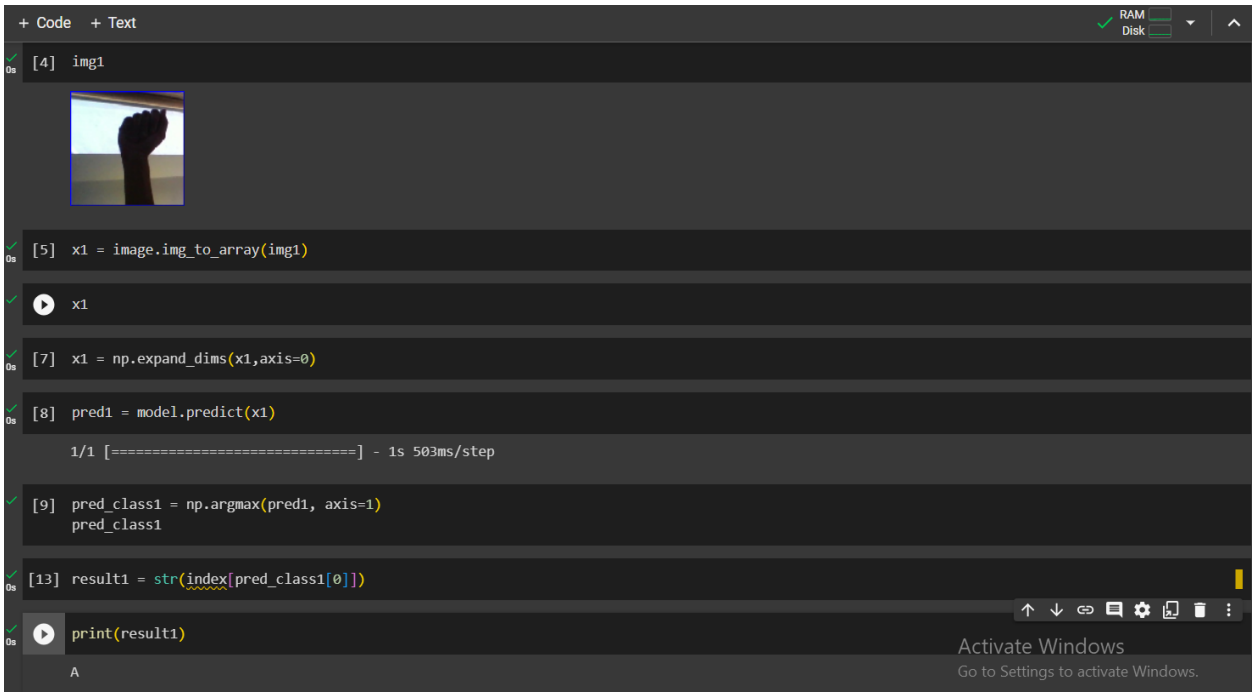
```
model.fit(train, steps_per_epoch = 100, epochs = 45, validation_data = test)
```

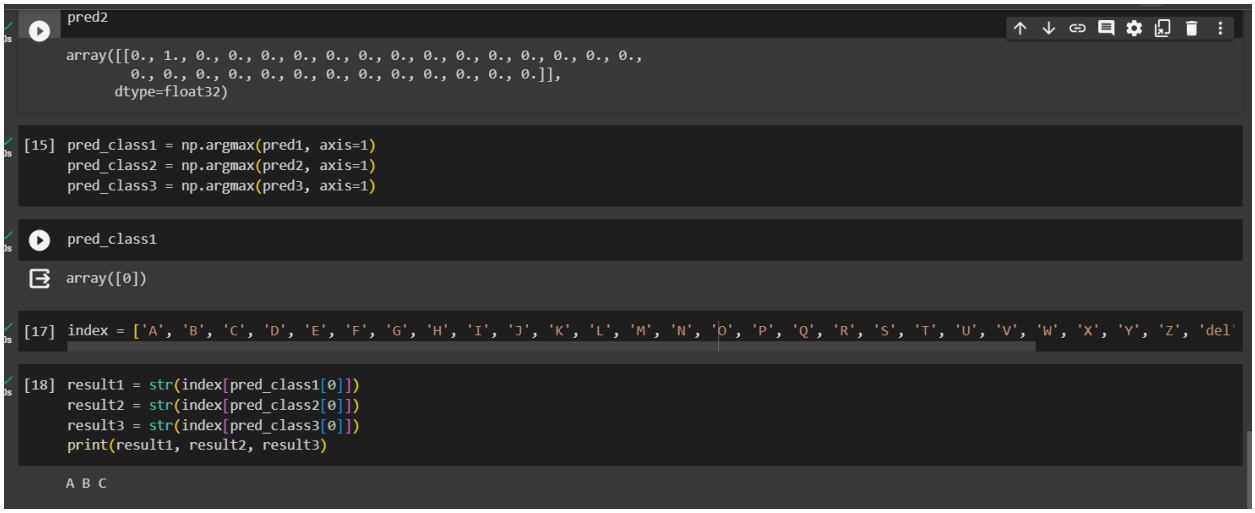
```
Epoch 16/45
100/100 [==============================] - 451s 5s/step - loss: 0.3096 - accuracy: 0.9062
Epoch 17/45
100/100 [==============================] - 460s 5s/step - loss: 0.2730 - accuracy: 0.9216
Epoch 18/45
100/100 [==============================] - 463s 5s/step - loss: 0.2688 - accuracy: 0.9228
Epoch 19/45
100/100 [==============================] - 463s 5s/step - loss: 0.2482 - accuracy: 0.9222
Epoch 20/45
100/100 [==============================] - 469s 5s/step - loss: 0.3183 - accuracy: 0.8988
Epoch 21/45
100/100 [==============================] - 475s 5s/step - loss: 0.2512 - accuracy: 0.9237
Epoch 22/45
100/100 [==============================] - 455s 5s/step - loss: 0.2507 - accuracy: 0.9303
Epoch 23/45
100/100 [==============================] - 460s 5s/step - loss: 0.2350 - accuracy: 0.9319
Epoch 24/45
100/100 [==============================] - 458s 5s/step - loss: 0.2460 - accuracy: 0.9231
Epoch 25/45
100/100 [==============================] - 469s 5s/step - loss: 0.1844 - accuracy: 0.9375
Epoch 26/45
100/100 [==============================] - 460s 5s/step - loss: 0.2047 - accuracy: 0.9319
Epoch 27/45
100/100 [==============================] - 461s 5s/step - loss: 0.2295 - accuracy: 0.9316
Epoch 28/45
100/100 [==============================] - 466s 5s/step - loss: 0.2013 - accuracy: 0.9378
Epoch 29/45
100/100 [==============================] - 460s 5s/step - loss: 0.2113 - accuracy: 0.9362
Epoch 30/45
100/100 [==============================] - 457s 5s/step - loss: 0.2060 - accuracy: 0.9428
Epoch 31/45
100/100 [==============================] - 449s 4s/step - loss: 0.2795 - accuracy: 0.9234
Epoch 32/45
```

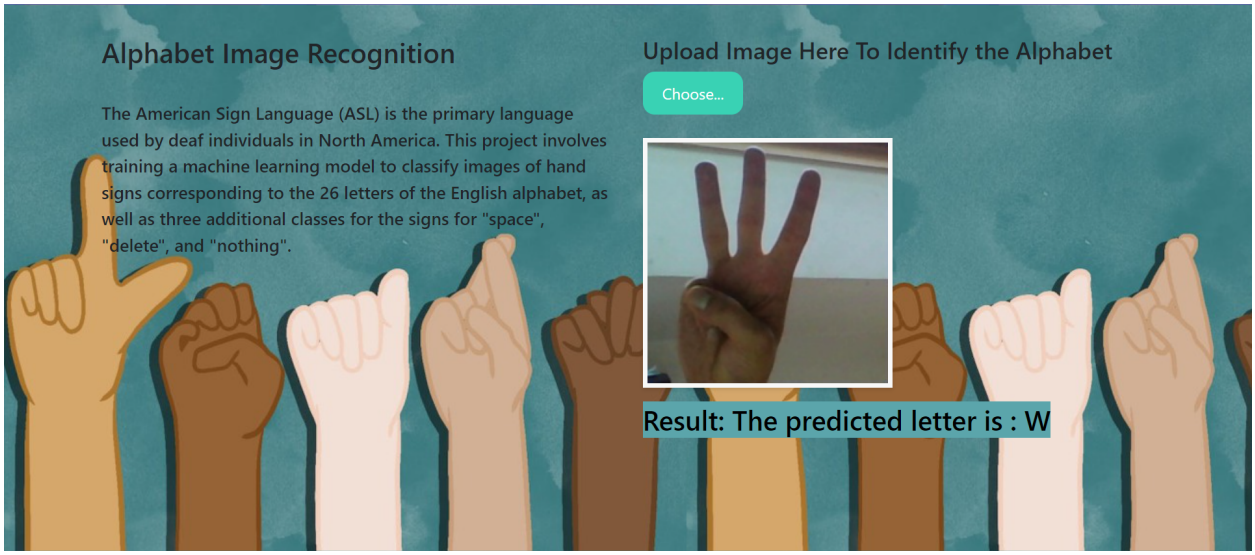
```
Epoch 32/45
100/100 [==============================] - 454s 5s/step - loss: 0.1805 - accuracy: 0.9463
Epoch 33/45
100/100 [==============================] - 448s 4s/step - loss: 0.1723 - accuracy: 0.9466
Epoch 34/45
100/100 [==============================] - 449s 4s/step - loss: 0.2085 - accuracy: 0.9438
Epoch 35/45
100/100 [==============================] - 450s 4s/step - loss: 0.2956 - accuracy: 0.9187
Epoch 36/45
100/100 [==============================] - 452s 5s/step - loss: 0.2136 - accuracy: 0.9337
Epoch 37/45
100/100 [==============================] - 452s 5s/step - loss: 0.1503 - accuracy: 0.9534
Epoch 38/45
100/100 [==============================] - 449s 4s/step - loss: 0.1458 - accuracy: 0.9534
Epoch 39/45
100/100 [==============================] - 447s 4s/step - loss: 0.2150 - accuracy: 0.9394
Epoch 40/45
100/100 [==============================] - 448s 4s/step - loss: 0.1792 - accuracy: 0.9475
Epoch 41/45
100/100 [==============================] - 452s 5s/step - loss: 0.1736 - accuracy: 0.9513
Epoch 42/45
100/100 [==============================] - 452s 5s/step - loss: 0.1575 - accuracy: 0.9528
Epoch 43/45
100/100 [==============================] - 453s 5s/step - loss: 0.2216 - accuracy: 0.9406
Epoch 44/45
100/100 [==============================] - 447s 4s/step - loss: 0.2127 - accuracy: 0.9378
Epoch 45/45
100/100 [==============================] - 467s 5s/step - loss: 0.1417 - accuracy: 0.9581
<keras.src.callbacks.History at 0x7bf973e20880>
```

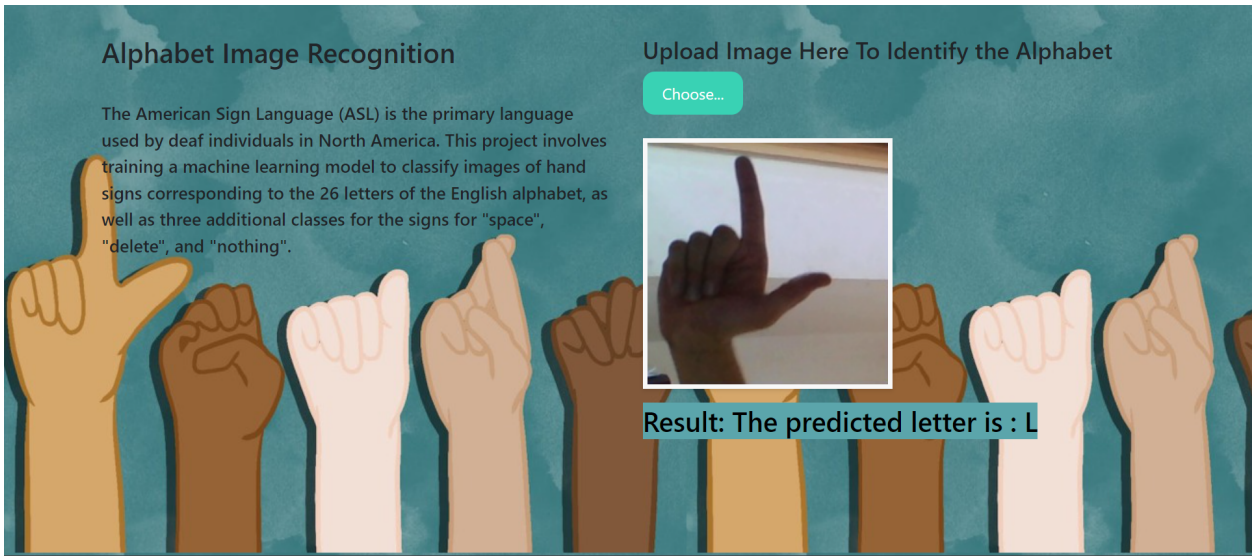
9. RESULTS

9.1 Output Screenshots









10. ADVANTAGES & DISADVANTAGES

Advantages:

1. By giving people with hearing impairments a dependable tool for deciphering American Sign Language (ASL) motions, the project greatly improves accessibility and promotes improved communication.
2. Real-time ASL gesture recognition is incorporated to provide quick and flexible interpretation, making the user experience more responsive and smooth.
3. Because of its architecture, the model can be continuously improved over time by adding more training data and incorporating user feedback, which guarantees its accuracy and adaptability.

Disadvantages:

1. The deep learning model's requirement for real-time processing in environments with limited resources could present difficulties, as it requires a significant amount of computational power to achieve optimal performance.
2. The vocabulary that can be used for communication is limited by the current implementation, which concentrates on a predetermined set of ASL gestures. More training and data would be needed to expand the vocabulary.
3. Deep learning models with high levels of complexity, like VGG16/Densenet121, may require more processing power during training and inference, and their length may cause these issues.
4. The model’s performance can be influenced by certain environmental conditions, such as lighting and background variations affecting accuracy in some cases.

11. CONCLUSION

A major step towards promoting inclusive communication for people with hearing impairments has been made with the completion of the "Sign Language Recognition using Deep Learning" project. Real-time American Sign Language (ASL) gesture recognition is implemented in this project to fulfill the urgent need for accessible tools that close communication gaps.

With the conclusion of the "Sign Language Recognition using Deep Learning" project, a significant step has been made towards encouraging inclusive communication for those with hearing impairments. This project implements real-time gesture recognition in American Sign Language (ASL) to meet the pressing need for accessible tools that bridge communication gaps.

12. FUTURE SCOPE

Vocabulary Expansion:
In order to create a more complete and adaptable communication tool, future versions of the project may concentrate on increasing the vocabulary of ASL gestures that are recognised.

Adaptive Learning:
By enabling the model to continuously change and get better based on user interactions and feedback, adaptive learning mechanisms could improve the model's performance.

13. APPENDIX

Source Code - Model building

```
!pip install -q kaggle
!mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle
!kaggle datasets download -d
debashishsau/aslamerican-sign-language-aplhabet-dataset
!unzip /content/aslamerican-sign-language-aplhabet-dataset.zip

from tensorflow.keras.preprocessing.image import ImageDataGenerator
trainpath = "/content/ASL_Alphabet_Dataset/asl_alphabet_train"
testpath = "/content/ASL_Alphabet_Dataset/asl_alphabet_test"
train_datagen = ImageDataGenerator(rescale = 1. / 255, zoom_range = 0.2,
shear_range = 0.2)
test_datagen = ImageDataGenerator(rescale = 1. / 255)
train = train_datagen.flow_from_directory(trainpath, target_size = (108,
108), batch_size = 32)
test = test_datagen.flow_from_directory(testpath, target_size =(108,
108), batch_size = 32)
train.class_indices
from keras.applications import DenseNet121
from keras.models import Sequential
from keras.layers import Flatten, Dense
from keras.optimizers import Adam

densenet_model = DenseNet121(weights='imagenet', include_top=False,
input_shape=(108, 108, 3))
model = Sequential()
model.add(densenet_model)
densenet_model.trainable = False
model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dense(29, activation='softmax'))
model.summary()
model.compile(optimizer='adam', loss='categorical_crossentropy',
metrics=['accuracy'])
model.fit(train, steps_per_epoch = 100, epochs = 45, validation_data =
test)
model.save("densenet_model.h5")
```

Source Code - Model testing

```
from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image
import numpy as np
model = load_model("/content/densenet_model.h5")
img2 = image.load_img(r"/content/B_test.jpg", target_size = (108, 108))
x2 = image.img_to_array(img2)
x2 = np.expand_dims(x2,axis=0)
pred2 = model.predict(x2)
pred_class2 = np.argmax(pred2, axis=1)
pred_class2
print(result2)
```

GitHub & Project Demo Link

Github - https://github.com/smartinternz02/SI-GuidedProject-613088-1698898208

Project Demo - https://drive.google.com/file/d/17U5NzrywPw3rNTNeUHwq0ZMYqC7e4AfK/view?usp=sharing