A PROJECT REPORT

ON

CAMERA-BASED SIGN LANGUAGE RECOGNITION AND SPEECH GENERATION

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE
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OF

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INFORMATION TECHNOLOGY

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UNDER THE GUIDANCE OF
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2020-21

CERTIFICATE

This is to certify that the project report titled

CAMERA-BASED SIGN LANGUAGE RECOGNITION AND SPEECH GENERATION

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is a bonafide work carried out by them under the supervision of Prof. T. A. Rane and it is approved for the partial fulfillment of the requirement of Savitribai Phule Pune University for the award of the Degree of Bachelor of Engineering (Information Technology)
This project report has not been earlier submitted to any other Institute or University for the award of any degree or diploma.

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LIST OF ABBREVIATIONS

Term	Meaning
USB	Universal Serial Bus
fMRI	Functional magnetic resonance imaging
WLASL	Word Level American Sign Language
OpenCV	Open Source Computer Vision
CNN	Convolutional Neural Network
GPT	Generative Pre-trained Transformer
GUI	Graphical User Interface
IDE	Integrated Development Environment
FPS	Frames per Second
LSTM	Long Short Term Memory
VGG	Visual Geometry Group
HOG	Histogram of Gradients
RNN	Recurrent Neural Network

CONTENTS

ABSTRACT

People regularly face problems interpreting deaf-mute people, who primarily use sign language for communication amongst themselves and others. Despite efforts being conducted by different governments worldwide such as the provision of a sign language expert for interpreting and communicating all news to the impaired by the New Zealand media, active participation of the impaired is still at a very rudimentary stage.

Further, only a few people today are proficient in communicating via sign language and hence the majority of the population at large is still devoid of any understanding of the matter. This could be problematic for deaf-mute people especially during situations of distress like pain, fraud, or other emergency situations like murder, robbery, kidnapping, etc.

All these problems could be minimized substantially if this language barrier is effectively bridged. Our project aims to tackle this problem by setting up a sign-language interpreter that inputs sign language video from the signer and then processes it to output its equivalent spoken language meaning. Along with that it also generates an audio output to make sure that the illiterate and the blind can also understand what the signers are saying so that no section of the society remains left out.

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Our system works on a video input that is given by the user. This input could be either a pre-recorded video or a live video. Our project aims to interpret sign-language performed by the signers. When provided as a directory path, it takes in the videos individually and first performs a basic verification check of the file type. Once verified, it breaks the video into an image sequence. This image sequence is then checked for relevant content i.e. if the video submitted actually has a human or not. Once confirmed, hand recognition is performed on the system to extract only the hand movements in the video, hence removing all the unnecessary noise. The hand-extracted frames are then worked upon to extract features from them. This sequential data is then passed through a recurrent neural network to make predictions of the words performed by the signer. The output is then shown to the user as text and optionally as audio.

1.2 MOTIVATION

Mute people often face a challenge of actively communicating with the outside world as they are not able to speak and hence rely on sign language to express themselves. However, only a few people except the mute understand and are able to interpret sign language. Moreover, in times of distress such as kidnapping, robbery, etc., mute people could find it extremely difficult to find an interpreter to ask for help.

Therefore, to bridge the gap between the differently abled and the society, we propose a system that aims to interpret sign language and produce an output in textual and audio format, the latter being helpful for the people who are illiterate and/or blind.

CHAPTER 2

LITERATURE REVIEW

2.1 EXISTING METHODOLOGIES

- **Camera-based image or video capturing :** One of the most extensively applied methods has been camera-based image or video capturing for sign language understanding. Capturing one hand, two hand signs as well as working on static and dynamic data have been different ways of going about the problem. Therefore the signs could be a sequence of images (generally for a word) or could be just an individual image (generally for a letter or digit). As far as videos are concerned, they are first split into images, which work as sequential data and then are worked upon by deep learning techniques. These techniques are then analyzed to obtain stable results.
- **Microsoft Kinect :** Researchers are also exploring Kinect as a viable alternative . Signers' hand and body movements can be captured by Microsoft Kinect without much delay. Although the focus of Kinect's audience has been video games, it [1] provides an uncanny edge over other image/video capturing techniques as it adds another dimension to the captured data, which is depth e.g. color depth, etc.. However, as the camera method is cheaper and has more portability, the Kinect approach is not as widely applicable as the camera approach.
- **Using Armband :** Electromyography (EMG) Signals provides a basis to the armband approach. These signals are generated in our muscles whenever there is any movement. Signals originating from this armband are assimilated[2] and then processed to recognize sign language. This approach has light intensity independent and hence has an edge with this respect over the camera and Kinect approaches. However, a major impediment this approach faces is the necessity to connect a number of wires to the system and hence it also hinders portability.
- **Using Cyber Glove :** Groundbreaking research of 1993 gave rise to another approach called the Cyber Glove[3]. Multiple sensors and a motion tracker [4] are attached to the

glove which is supposed to be worn by the signers. The data obtained from these sensors is then sent to a computing device for further processing and subsequent interpretation.This method also faces a similar issue as kinect and armband of system configuration and setup. In real-life situations, this approach is hence not very viable and could be avoided. Moreover, it is also unable to capture facial features and symbols which can be easily done in camera-based systems.

- **Leap Motion Controller Based System :** An economical approach is using a low cost sensor based system called the Leap Motion Controller[5]. APIs are used to send hand and gesture movements to the computer, which are performed on top of a sensor that is horizontally placed. Finally the resultant data is forwarded to a computer. This is a cheaper alternative to the aforementioned techniques however still faces the hurdles as faced by the earlier methods.
- **Brain-Computer Interfacing :** One of the most advanced methods to detect and recognize sign language is brain-computer interfacing. Electroencephalogram [6] brain activities are obtained for the recognition of sign-language.This approach nullifies the need to capture hand movements and solely relies on brain waves which are captured and sent to a computing device for processing. fRMI[7] and Electrocorticography[8] are similar techniques but they all still require gear connected to a human brain to capture the signals and hence have portability issues.
- **Deep Learning:** Multiple approaches[19][20][21][22][23] with deep learning have also been tried out on private datasets and public datasets. Convolutional Neural Networks play an important role for image classification and they along with RNNs can be used for time series classification.

2.2 PROPOSED METHODOLOGY

Our project aims to capture sign language performed by signers on a real-time basis and interpret the language to produce textual and audio output for the illiterate. For this, a camera-based approach will be made use of, owing to the ease of portability and movement that the camera-based method offers over other techniques. The video of the signer will be first captured by a camera-enabled device or can be also given as a series of videos in a directory. This video will then be processed by our application in which the video would be divided into a number of frames which will convert the video into a raw image sequence. Then the presence of a human is checked to make sure the video actually has a person. This image sequence is then worked upon to identify the hands in every frame. Only hands from every frame will be considered for the representation of the sign language words.

These hand-extracted frames will be then passed through a state-of-the-art model to extract features from these hands hence making use of transfer learning. These extracted features will then be passed through a recurrent neural network to make predictions about the specific sign being performed. All the videos for the words have been obtained from the WLASL dataset.

Finally, this output will be sent through an audio generator to generate speech from the same. This provides support for illiterate people and/or blind people, who are not able to understand written text.

CHAPTER 3

REQUIREMENT SPECIFICATION AND ANALYSIS

3.1 PROBLEM DEFINITION

To build a system that can interpret sign language performed by signers on a real-time basis (or a prerecorded video) and translate sign language into its word equivalents and provide textual and audio output to the user to bridge the communication gap between the mute people and the Society.

3.2 CONCEPT

A live or a pre-recorded video will be provided by the user of the system. Image frames will be extracted from this video and verification of the same will be done. This will be followed by hand detection. Then we perform feature extraction using a CNN based transfer learning model which is followed by the use of a RNN to determine the corresponding English word for the sign performed. The output generated will then be presented to the user in textual and audio format.

3.3 SCOPE

- The system will be capable of interpreting the American sign language only, as only one language was to be worked on and sufficient open-source data was only available for this language.
- For the sake of research, only a limited set of words will be used for recognition initially.
- The signer should necessarily stand exactly in front of the video-recording camera.
- It performs only one-way communication i.e. sign language to spoken language.

3.4 OBJECTIVES

- Capture raw image sequence from camera.
- Use face recognition to verify that the video actually has a person.
- Use hand recognition to extract only hand data for all the video frames.
- Use a convolutional neural network for extracting features from the video frames.
- Classification of signs into words based on summation of obtained information using a recurrent neural network.
- Generating speech from the generated text.

3.5 PROJECT REQUIREMENTS:

3.5.1 DATASETS

- Upon extensive research into possible datasets for our Deep learning Model, we have chosen to work on a large video dataset for World Level American Sign Language.
- It includes a json file with links to 20000+ videos hosted on multiple different websites including youtube, asl.org and Facebook.
- These videos refer to about 2000 gestures making it the largest dataset publicly available for research and academic purposes.
- These videos are generally 2-4 second snippets of a sign language expert enacting the signs in front of a blank/easily distinguishable background.
- We have also recorded additional videos for balancing the number of videos per word and boosting the amount of training data for the model.

3.5.2 FUNCTIONAL REQUIREMENTS

- The proposed system must perform boundary identification on the generated raw image sequence and demarcate the areas for hands.

- The proposed system should extract features from the recognized hands by using convolutional neural networks.
- The proposed system must then classify the gesture as a known gesture for which it has been trained.
- The proposed system should then display the identified gesture as text and play audio for the same.

3.5.3 NON-FUNCTIONAL REQUIREMENTS

- The proposed system must be able to accept data as real time video feed from a camera as well as an uploaded video.
- Given the lack of verifiability in real time use and critical nature of the proposed system, the system must be able to identify the performed gesture with a very low false positive rate.
- It could be acceptable if this was achieved with a relatively higher false negative rate.
- The User Interface must be visually intuitive, aesthetically pleasing and follow standard UI development principles and norms.

3.5.4 HARDWARE REQUIREMENTS

- Camera Specifications -
    - 0.307 MegaPixel still image camera (basic)
    - 640 X 480 at 24fps (preferred)
    - Front mounted
- Processing Power requirements
    - 4GB RAM (minimum), 8GB RAM (preferred)
    - Intel i3 processor (minimum), i5/i7 (preferred)
    - Discrete GPU with 15GB dedicated memory (for model training) (preferred)

3.5.5 SOFTWARE REQUIREMENTS

- Operating System - Linux, Windows, Mac OS
- Support for executing Python 3.x
- Libraries/Dependencies :
    - OpenCV
    - TensorFlow
    - Keras
    - Numpy
    - Sci-Kit Learn

3.6 PROJECT PLAN

3.6.1 PROJECT RESOURCES

- Google Colab/Jupyter Notebook as the environment for the model training and testing.
- Python Tkinter for platform development.
- Google Drive as a file system to store uploaded files.
- Python 3.x to be used as the default programming language.
- TensorFlow and OpenCV packages will be used for the Development of CNNs and RNNs

3.6.2 MODULE SPLIT-UP

- **User-Interface**: The GUI that the user interacts with. It bears the responsibility of communicating the results of operations with the User, regardless of the status of the result is a Success or a Failure (e.g., errors and exceptions). It provides the user with an interface to upload videos or provide a Live Video stream. It validates some details of the video and lets the user know if some video details are invalid. Finally, it also communicates the results of the translation to the user.
- **Video Pre-processor:** Undertakes the task of breaking the input video into a set of image

sequences holding potential meaning.

- **Face Recognizer:** Performs a validation check on the video to determine if the video has a human or not by using the Haar Cascade classifier.
- **Hand Gesture processor:** Extracts images out of the given image sequence in terms of meaningful Hand Gestures.
- **Feature Extractor:** Extracts features from the video frames given to it as input by using a state-of-the-art convolutional neural network architecture.
- **Classifier:** Module that takes the input of the well-defined features and classifies the images sequences into words using a recurrent neural network.
- **Text-to-speech:** Generates audio for the output text.

3.6.3 FUNCTIONAL DECOMPOSITION

- The user is provided with the option of either uploading a video file or starting a live stream through the attached camera.
- If the user uploads a video then the video is initially validated for its format.
- Then the video data is passed onto the main module which initially performs pre-processing on the data such as conversion to an image sequence, hand recognition.
- If the preprocessor fails to find relevant data (For eg. the video does not have a human subject) then it notifies the user of the same, and the user is expected to act on the error and restart the process.
- Once the pre-processor demarcates the hand from the image sequence data, the hand recognized data is passed through a CNN model to extract features from it.
- Features are sent back to the main module which then passes the data to the primary classifier that classifies each frame sequence into a word.
- If the gesture cannot be identified then the user is prompted about the lack of identification. The user can then retry the process or exit the process.
- The text is displayed on the User interface and the text is also converted into audio to be played through the speakers ensuring effective communication.

3.6.4 PROJECT TEAM ROLE AND RESPONSIBILITIES

Member Name	**Role**	**Responsibility**
Ayushi Patani	Data Scientist, Full Stack Platform Developer, Tester	Web Scraping and data preprocessing, Model Development, Model Testing, Platform Design and Development, Recording Results and documentation
Varun Gawande	Data Scientist, Full Stack Platform Developer, Tester	Web Scraping and data preprocessing, Model Development, Platform Design and Development, Recording Results and documentation.
Jash Gujarathi	Data Scientist, Full Stack Platform Developer, Tester	Web Scraping and data preprocessing, Model Development, Model Testing, Tuning and optimization, Integration and Live Testing
Vedant Puranik	Data Scientist, Full Stack Platform Developer, Tester	Web Scraping and data preprocessing, Model Development, Tuning and optimization, Integration and Live Testing

Table 3.1: Division of Roles and Responsibilities

3.6.5 PROJECT PLAN 3.0

- We have divided our project into multiple small steps and created a timeline accordingly.
- This timeline has been depicted in the following Gantt chart (Refer fig 3.6.5)
- The timeline has been decided by taking into consideration the current pandemic situation.

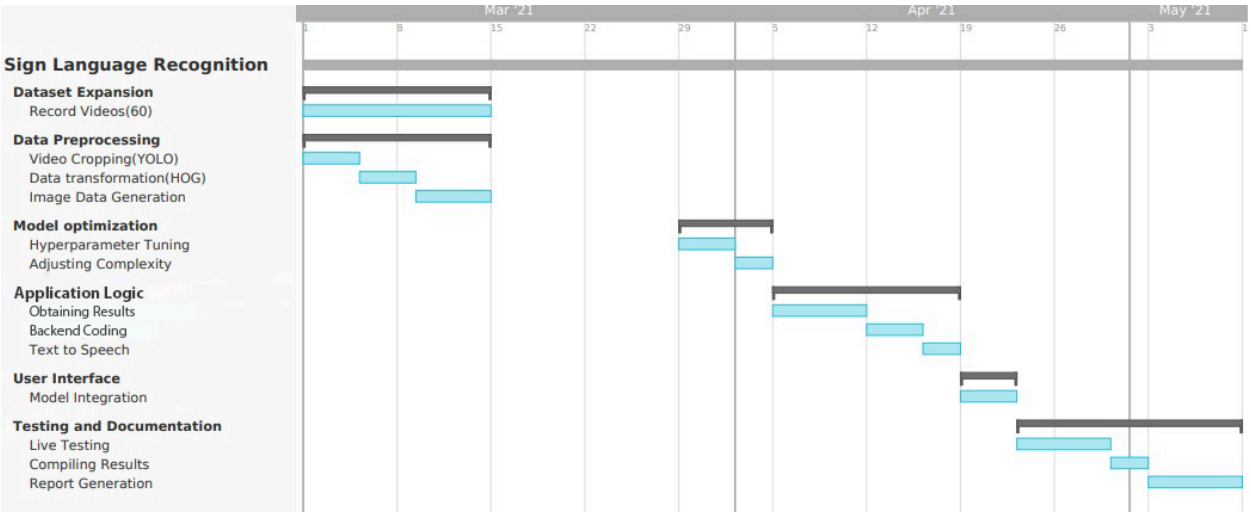

Figure 3.6.5: Project Plan 3.0 Gantt Chart

CHAPTER 4

SYSTEM ANALYSIS AND DESIGN

4.1 ARCHITECTURE

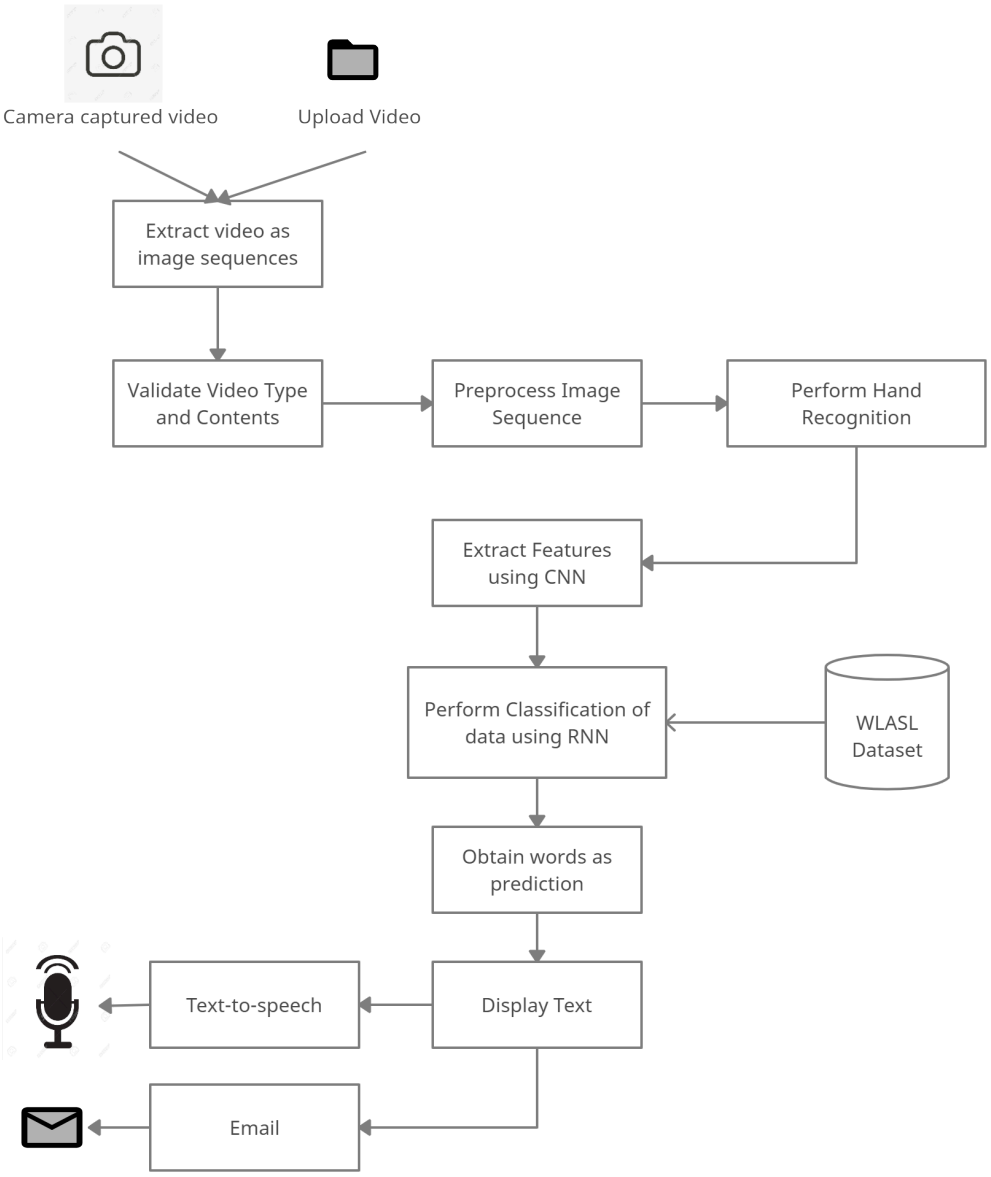

Figure 4.1: Architecture

4.2 DATA FLOW DIAGRAM (DFD)

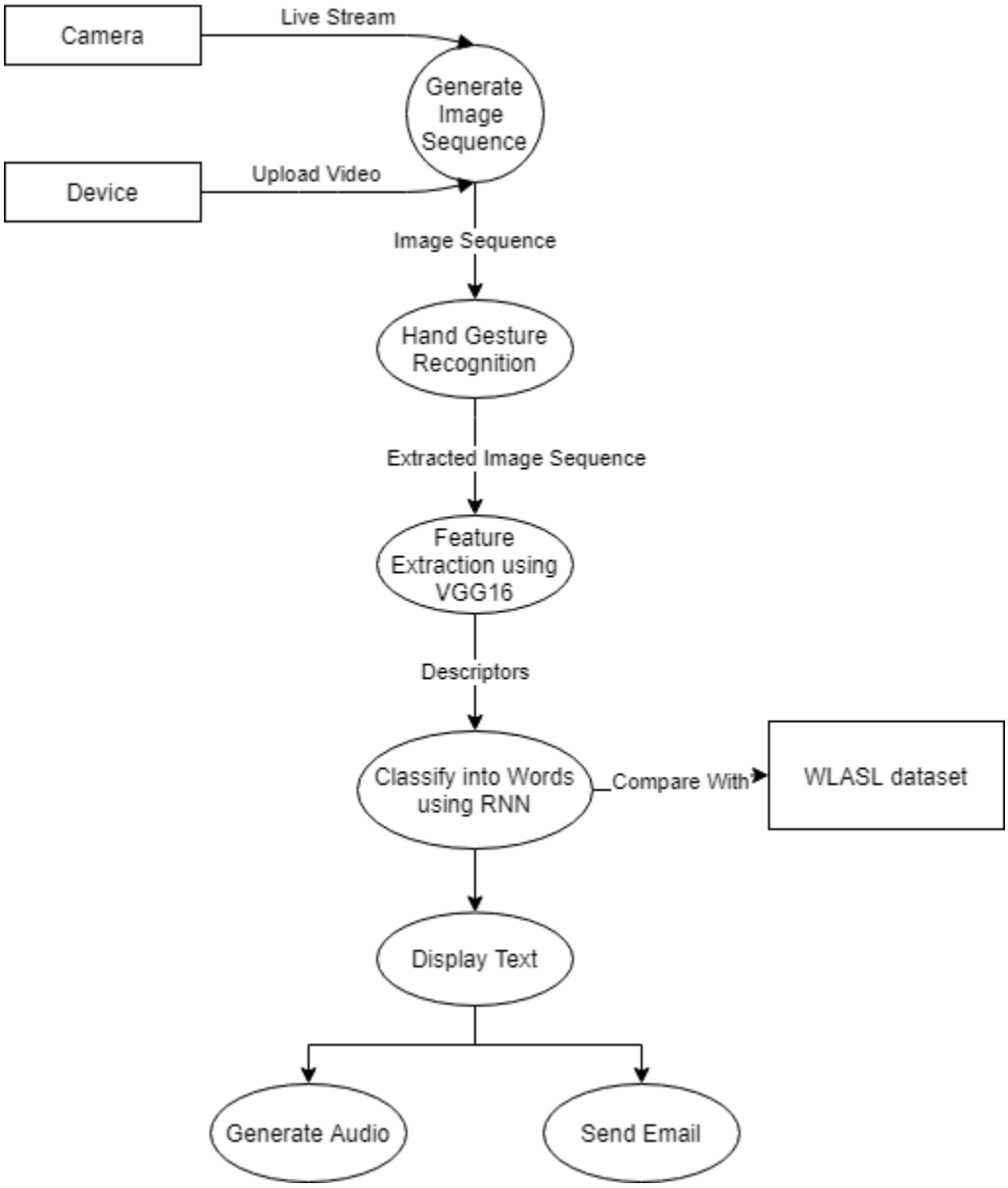

Figure 4.2: Data-Flow Diagram

4.3 BEHAVIORAL DIAGRAMS

4.3.1 ACTIVITY DIAGRAM

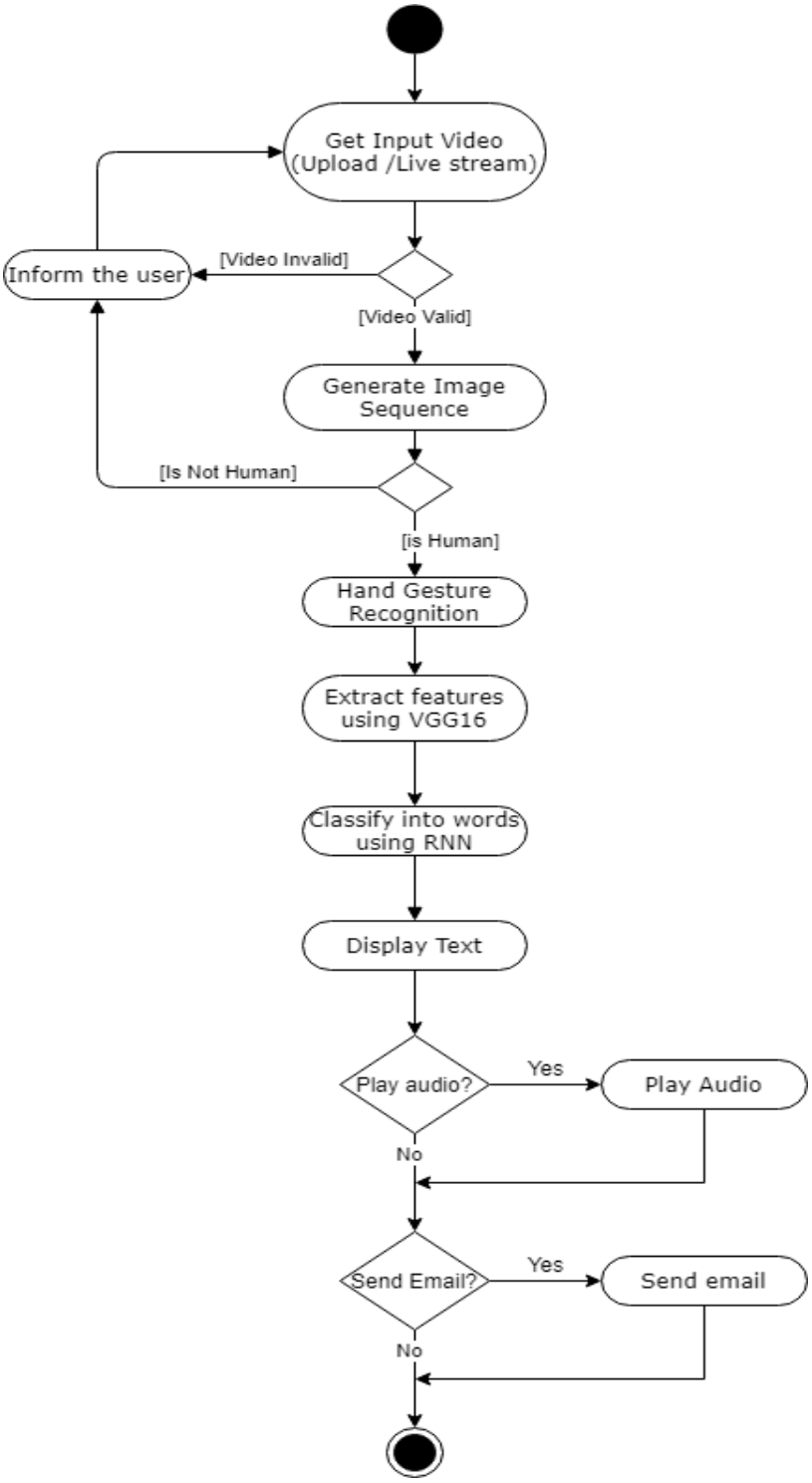

Figure 4.3.1: Activity Diagram

4.3.2 SEQUENCE DIAGRAM

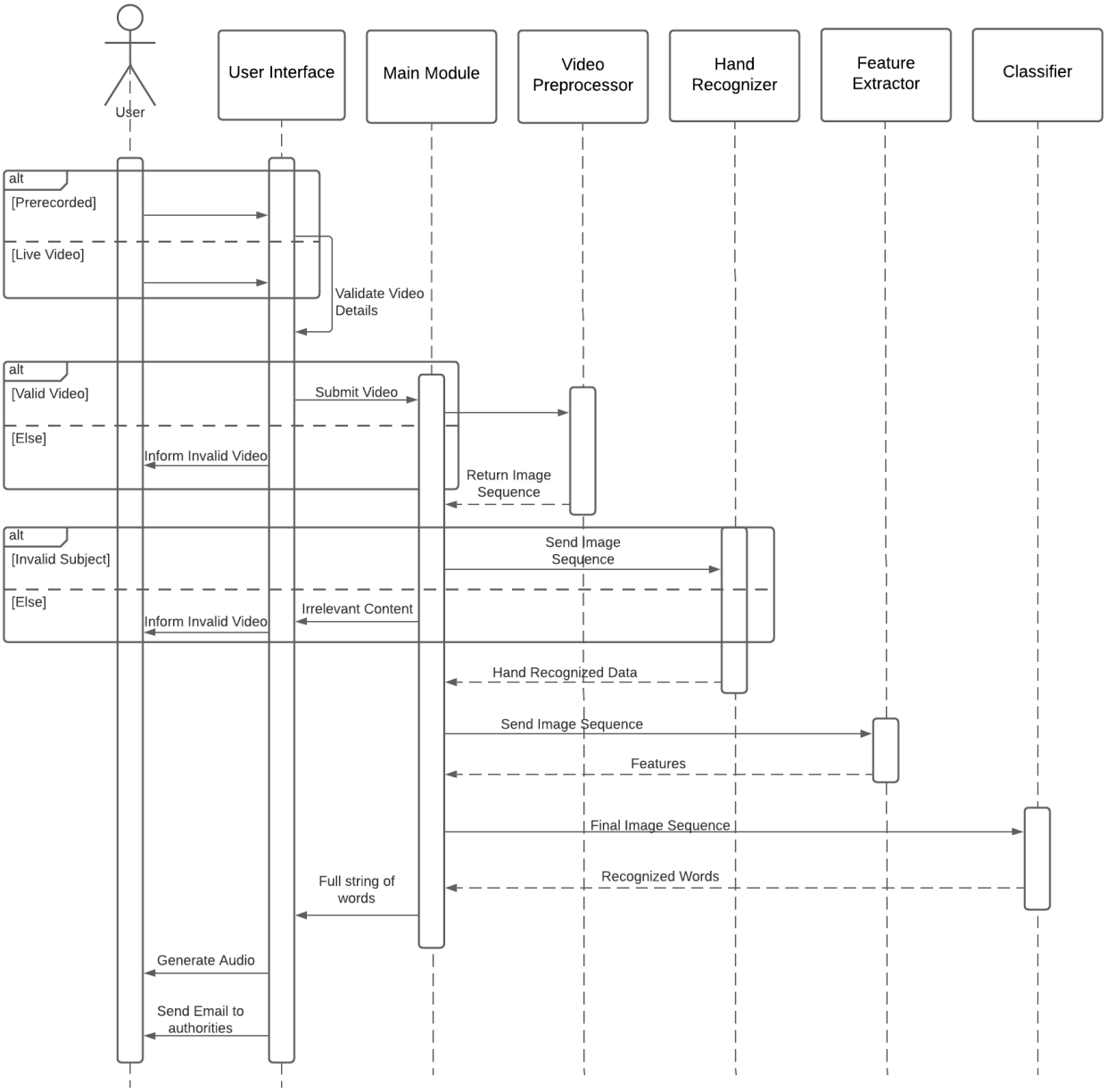

Figure 4.3.2: Sequence Diagram

4.3.3 STATE DIAGRAM

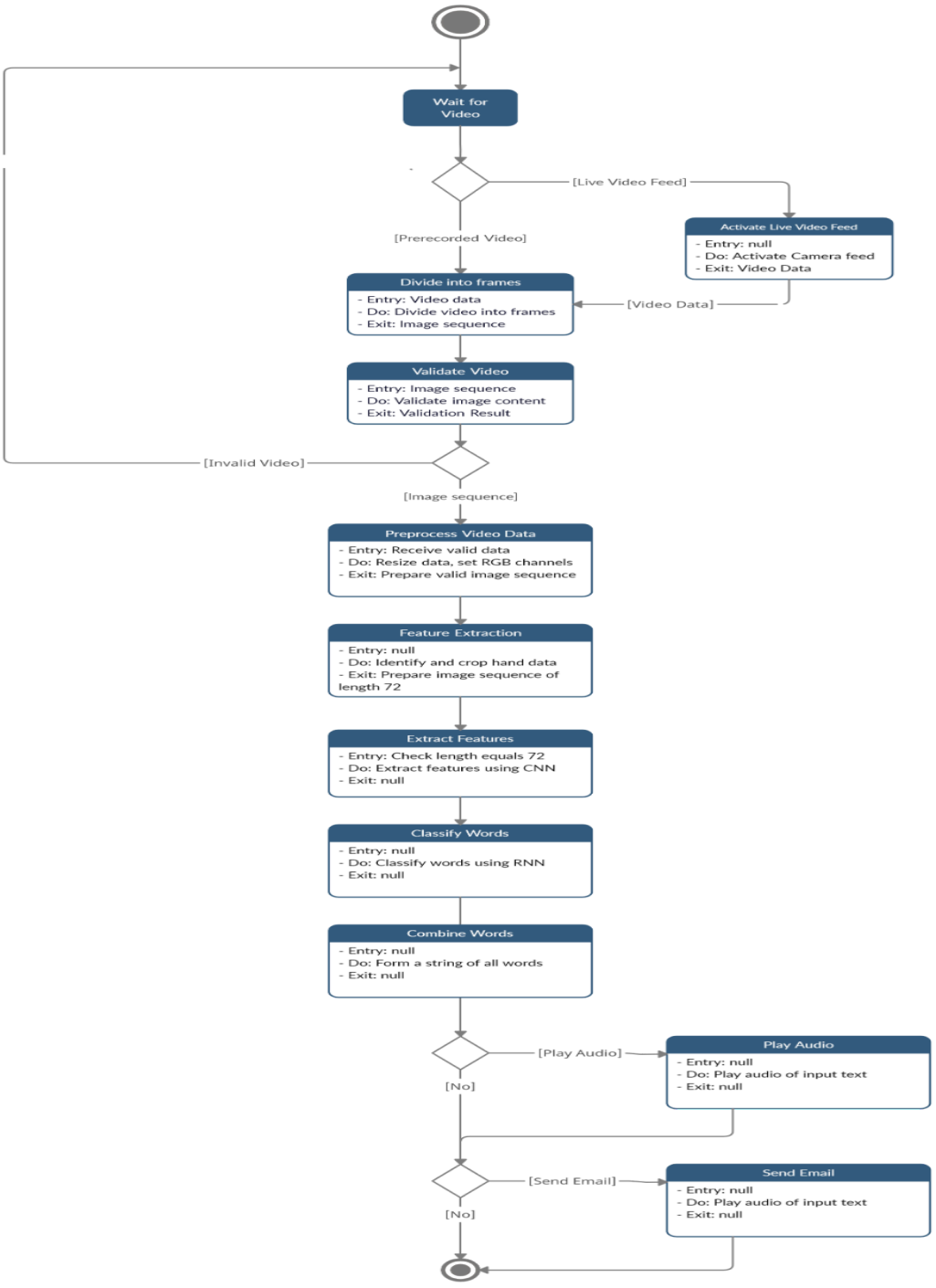

Figure 4.3.3: State Diagram

4.4 ALGORITHMS

- **Haar Cascade:** Once, the data is confirmed to be video, a face recognizer is applied on it to make sure that the video actually has a human being and is not some random data e.g. cat video. For this, a Haar Cascade classifier is used which classifies the video frames given to it as ones having human face and others as not. This is an extremely necessary step to verify that the data is actually valid and the model is not working on data that was either misplaced or was purposely given with malicious intent.
- **Hand Detection:** The video files, before being actually passed through the data generator and further processed by the neural network, is first run through a hand detection algorithm. Here, an inference graph, written in tensorflow and saved in a pickle file, is read into the module which efficiently detects hands in the video frames. Similarly, this algorithm is implemented for every frame of every video which is read into the module. The output of this module hence delivers a list of frames consisting of hand movements of the signer of size (64,64,3), which corresponds to the height, width and the number of channels of every frame. These frames are then passed through the data generator to increase the size of the dataset as well introducing variations in the angle, shear, brightness and zoom.
- **Transfer Learning (for feature extraction):** Transfer learning is a machine learning method where a model developed for a task is reused as the starting point for a model on a second task. Although it can be used as a model, as our problem statement is a video classification task, we used transfer learning as a tool for extracting features from the frames, for which we used the state-of-the-art VGG16 model. Transfer Learning proved to be a far better approach than our previous approach of using ConvLSTM layers which replaces the matrix multiplication operations within LSTM with the convolution operation and thus allows working with sequential data. We tried other state-of-the-art transfer learning models like VGG19, MobileNet, etc. however VGG16's performance was superior.
- **LSTM (Long Short Term Memory):** Long short-term memory is a recurrent neural network architecture frequently used in deep learning. LSTM has feedback connections

unlike conventional neural networks. We used LSTM for the prediction task as it can efficiently process sequences of data. A LSTM unit comprises an input gate, output gate, forget gate and a cell. The input and output gates control the information flow to and from the unit whereas the cell actually remembers that time series information. The forget gate is used to specify which information needs to be forgotten and which to be retained by the cell. We built a neural network using LSTM which was used for predicting the class i.e. the word being performed by the signer.

4.5 USER INTERFACE

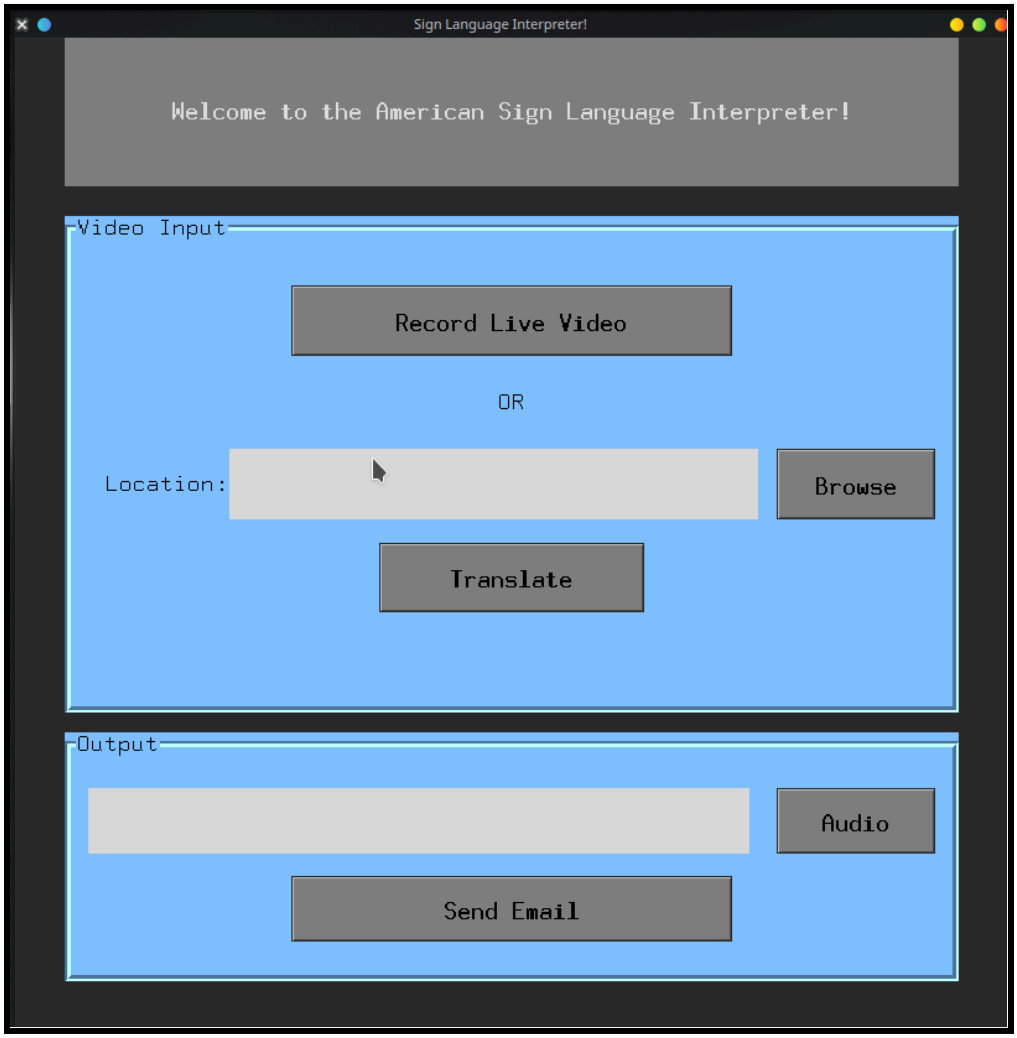

Fig. 4.5.1 User Interface

- The front-end of the application is a desktop application. We used Tkinter which is the standard Python binding to the Tk GUI Toolkit. Tkinter is inbuilt with all the leading Operating Systems like Linux, Mac and Windows and hence does not require any additional permissions or dependencies to work. As the main aim of this project is to help the disabled to communicate conveniently, the interface was kept simple and subtle.
- The user has 2 options for video data input : Record a live Video or upload a .mp4 file of a subject performing a Sign in American Sign Language from their local storage.
- After the video data has been selected, either recorded or uploaded , the User clicks translate. The system then runs the data through the Model to predict the signs performed.
- The predicted words are printed in the 'Output' in text format. The user can also click on the Audio button to hear the words in an audio format.
- In emergency situations, the speech-impaired cannot call or talk to the emergency authorities on the phone if there is no one near them to speak on the call. To overcome this pertinent challenge, we have added the 'Send Email' functionality, which enables the user to record their signs, which are translated by the model, and then send the translated text over Email to emergency authorities. This data is accompanied with the user's location and picture of the face, cropped out from the video data.

Actual Working Example

Following is an example of our team member Vedant using the application and performing 2 words: namely "Please" and "Help".

Fig 4.5.2: Video frame of "Please"

Fig 4.5.3: Video Frame of "Help"

The output of performing the live video above can be seen in the snapshot of the UI below:

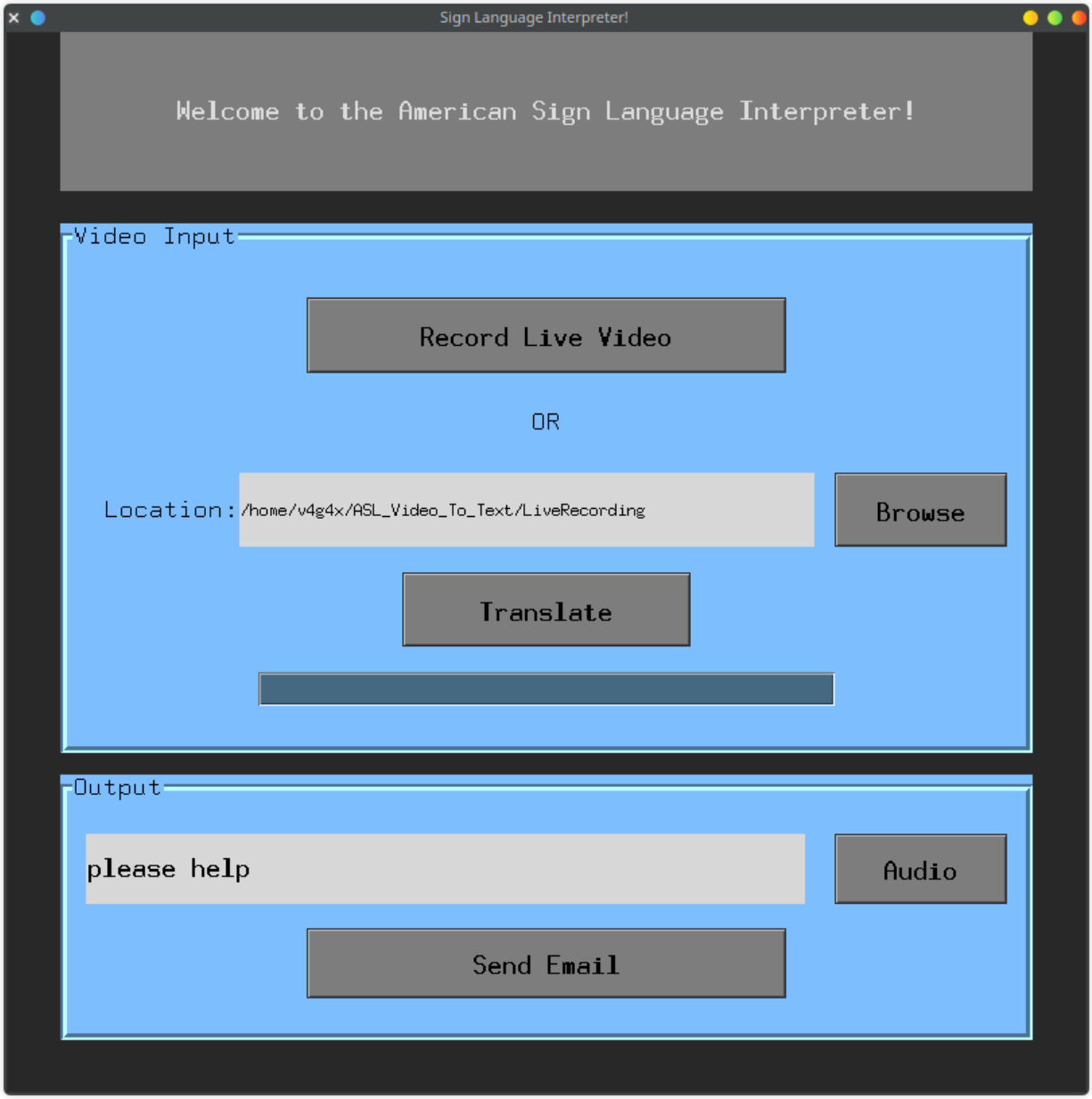

Fig. 4.5.4 User Interface Output

CHAPTER 5

IMPLEMENTATION

5.1 STAGES OF IMPLEMENTATION

5.1.1 PREPARATION OF DATA

5.1.1.1 Dataset Sources :

- WLASL (Word-Level American Sign Language) Dataset :
  WLASL is the largest video dataset for Word-Level American Sign Language (ASL) recognition, which features 2,000 common different words and 20000+ videos in ASL. The team carried out web-scraping by developing and deploying python scripts that pull official WLASL videos from YouTube and other sources into local storage. These videos are of varying lengths, quality and formats. The WLASL dataset acts as our primary reference dataset.
- **Self Recorded Videos :**
  The WLASL dataset, despite being one of the largest of its kind, has a variable number of videos per word. Hence we decided to record videos of our team members and their family members performing the signs for the following reasons :
  1) To balance the number of videos we had per word.
  2) To add variety and generalize the data.
  3) To boost the amount of training data we had to achieve better results.

5.1.1.2 Selecting words :

As the scope of our project is limited to only a small batch of words due to limitations on our computational resources we wanted to work on basic signs that would be used in emergencies situations by the speech impaired community. We decided to work in batches of words with increasing sizes to ensure that our approaches were scalable and robust. Initially working with 9 words, then 15 words and finally 20 words. Listed below are the words we decided to work with and the number of videos we had for each.

Word	**Number of Videos**
cold	37
crash	37
doctor	34
give	40
medicine	36
no	41
police	35
woman	39
yes	40
animal	37
child	37
danger	33
help	44
home	39
kill	35
please	40
rob	39
Send	33
sick	38
want	39

Table 5.1.1.2 Dataset Description

5.1.2 PREPROCESSING

5.1.2.1 Frame Duplication, Video Cropper and Resizing

For our RNN model to train and process our dataset, every video needs to have the same amount of frames. After considering all our signs and collected data, we decided that every video must have 72 frames i.e 3secs video at 24fps, with each frame being of 64*64 size.
As not every video is exactly 3 seconds long, they needed to either be cropped to 72 frames or have certain frames duplicated to make each video exactly 72 frames. Each video longer than 72 frames had a starting frame assigned to it , which signified the start of the section of the video that had the important gesture in it. For videos which had less than 72 frames, our scripts uniformly duplicated the frames till the video had exactly 72 frames. Each frame is resized to a 64*64 size.

5.1.2.2 Data Generator

The Data Generator performs combinations of scaling, shearing, rotation, and brightness adjustment on all frames of a video to produce similar videos as the original. This was done for the following purposes :
1) It boosts the amount of data the models had to train on.
2) To generalize the model towards variations in camera angles and environment changes.

5.2 Implementation Issues

5.2.1 Computational Resources

As none of the team members possessed a system with a powerful GPU, which was extremely essential for efficient and fast training of the models, the building, training and testing of the model was executed completely on Google Colab. Google Colab provides a GPU and a 12 GB RAM free of cost and hence the development of the model was possible. However, these resources were still not enough when we tried executing more complex architectures and would run into resource exhaustion problems. Upon availability of more computational resources, there was still some scope for betterment of results.

5.2.2 Storage Issues

All the videos, required to be processed by the model, were stored on Google Drive. Google Drive provides a storage space of maximum 15 GB to every individual. A fee needs to be charged for buying more storage. Hence, as a lot of storage was not available, the attempt of scaling the project further was halted as the data would not fit in the available space.

5.3 Techniques

5.3.1 Hand Detection:

The video files, before being actually passed through the data generator and further processed by the neural network, is first run through a hand detection algorithm. Here, an inference graph, written in tensorflow and saved in a pickle file, is read into the module which efficiently detects hands in the video frames. Similarly, this algorithm is implemented for every frame of every video which is read into the module. The output of this module hence delivers a list of frames consisting of hand movements of the signer of size (64,64,3), which corresponds to the height, width and the number of channels of every frame. These frames are then passed through the data

generator to increase the size of the dataset as well introducing variations in the angle, shear, brightness and zoom.

5.3.2 Transfer Learning (Feature Extraction):

Transfer learning is a machine learning method where a model developed for a task is reused as the starting point for a model on a second task. Although it can be used as a model, as our problem statement is a video classification task, we used transfer learning as a tool for extracting features from the frames, for which we used the state-of-the-art VGG16 model. Transfer Learning proved to be a far better approach than our previous approach of using ConvLSTM layers which replaces the matrix multiplication operations within LSTM with the convolution operation and thus allows working with sequential data. We tried other state-of-the-art transfer learning models like VGG19, MobileNet, etc. however VGG16's performance was superior.

5.3.3 LSTM (Long Short Term Memory):

Long short-term memory is a recurrent neural network architecture frequently used in deep learning. LSTM has feedback connections unlike conventional neural networks. We used LSTM for the prediction task as it can efficiently process sequences of data. An LSTM unit comprises an input gate, output gate, forget gate and a cell. The input and output gates control the information flow to and from the unit whereas the cell actually remembers that time series information. The forget gate is used to specify which information needs to be forgotten and which to be retained by the cell. We built a neural network using LSTM which was used for predicting the class i.e. the word being performed by the signer.

5.3.4 Speech Generation:

This module was provided as aid to the illiterate who cannot read or write. The words predicted by the LSTM model were then passed through a script written in Python which used the playsound library to convert the text to audio. The user can optionally execute this functionality by clicking on the play sound button provided on the user interface.

5.4 SOFTWARE TOOLS

- **Frontend:** The front-end of the application is a desktop application. We used Tkinter which is the standard Python binding to the Tk GUI Toolkit. Tkinter is inbuilt with all the leading Operating Systems like Linux, Mac and Windows and hence does not require any additional permissions or dependencies to work. As the main aim of this project is to help the disabled to communicate conveniently, the interface was kept simple and subtle.
- **Backend:** Python provides an extensive amount of support for a vast array of uses from application development to front-end development to machine learning and AI libraries and does so with minimal development time. We have used Python as the backend coding language that is used to record videos, read videos, perform frame extraction and then execute the deep learning models to get predictions. Keras, OpenCV and Numpy were used for building the functionality.
- **Data Storage:** All models during the development phase were built, trained and evaluated on Google Colab. Google Colab was used primarily to leverage the GPU capacity of the platform. Subsequently, Google Drive was used as the data storage for all the videos from where they were read into the Jupyter notebook to process them.

CHAPTER 6

RESULTS AND EVALUATION

6.1 EXPERIMENTS

6.1.1 Detailed Discussion of Experiments Carried Out

- **Convolutional Neural Network**

  The data that we obtained after the data generation model was first passed to through the VGG16 model, which is a state-of-the-art convolutional neural network used for image classification and feature extraction tasks. Our primary aim of using the VGG16 model was feature extraction as the VGG16 model itself is used for image classification while our problem required a sequential approach. We removed the last layer of the VGG16 model and replaced it with a Flatten layer that flattens the output to a vector of size 2048. We passed the frames of every video through the resultant model to get a 2048-sized vector from it. These vectors were subsequently used as data for training a stacked LSTM model for prediction of classes i.e. words.

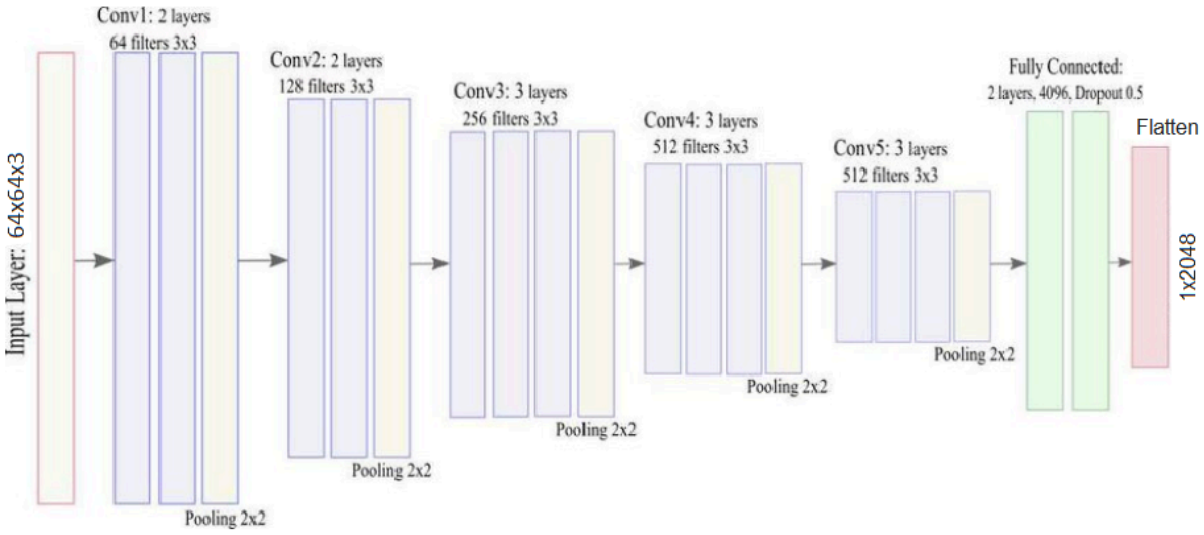

Fig. 6.1.1.1 VGG16 Model Architecture

- **Recurrent Neural Network**

We passed the output of the VGG16 model, which was a 2048-sized vector through a stacked LSTM architecture, consisting of 2 LSTM layers of 200 and 100 units each followed by a dense layer of 100 neurons. This neural network architecture culminated with a final dense layer of 20 neurons, each corresponding to a class in the gloss. The input shape given to this architecture was (72, 2048), where 72 corresponds to the number of frames in a video and 2048 is the size of the vector representation of each video frame. The LSTM model was trained for 50 epochs with a batch size of 8 using the Adam optimizer.

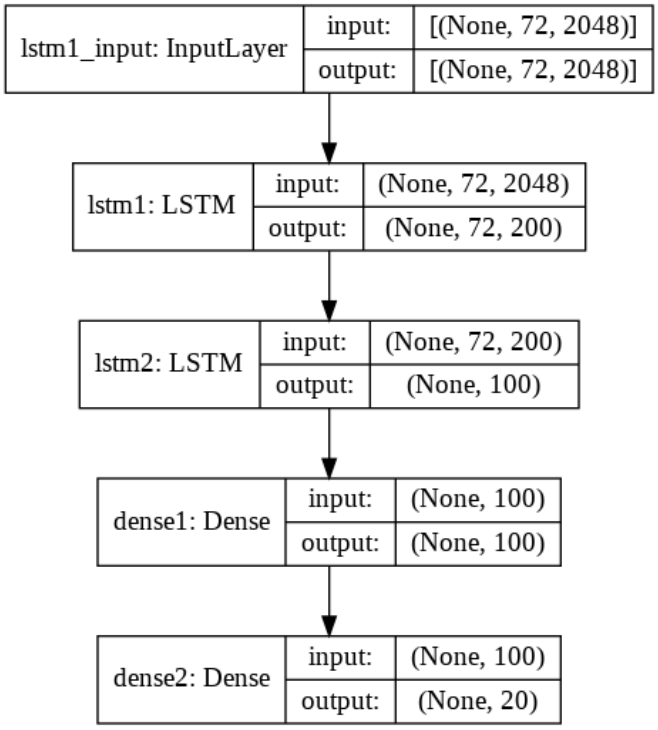

Fig. 6.1.1.2 LSTM Model Architecture

- **Varying number of Words**

Initially, we started working on 9 words that we thought to be the most important ones during times of distress for the disabled. Then we increased the count of words to 15 and ultimately we settled for 20 words. This approach followed to test the scalability of the project with the increase of data and the classes for prediction. Results obtained confirm

the fact that the project is in fact scalable and only limited by the availability of computational resources.

6.1.2 Results

The results of the experiments carried out have been summarized in the table below. We have provided the result of our deep learning model by using various metrics such as train, test and validation accuracy. Along with that a classification report with the precision, support, f1 score and support for each word has also been given.

Number of Words	**Train Accuracy**	**Validation Accuracy**	**Test Accuracy**
9	100%	93.06%	94%
15	100%	92.16%	91%
20	100%	90.11%	89%

Table 6.1.2.1 Results for Varying Number of Words

Although the training accuracy is 100%, the high values of the validation accuracy and test accuracy prove that overfitting has not occurred. As the accuracy values do not drop sharply after the increase in the number of classes, it can be stated that the model is pretty scalable.

The classification report for the model is as given below :

Word	**Precision**	**Recall**	**F1-Score**	**Support**
Cold	0.96	0.78	0.86	32
Crash	0.97	0.97	0.97	31
Doctor	0.81	0.95	0.88	22
Give	0.82	0.78	0.80	36
Medicine	0.92	0.89	0.91	38
No	0.83	0.94	0.88	36
Police	0.80	0.77	0.78	26
Woman	0.88	0.88	0.88	26
Yes	0.83	1.00	0.91	24
Animal	0.93	0.90	0.91	29
Child	0.92	0.85	0.88	26
Danger	0.90	1.00	0.95	28
Help	0.92	0.88	0.90	41
Home	0.96	0.92	0.94	24
Kill	0.85	0.79	0.81	28
Please	0.89	0.96	0.92	25
Rob	0.94	0.94	0.94	34
Send	0.82	0.88	0.85	26
Sick	0.94	1.00	0.97	30
Want	1.00	0.84	0.92	32

Table 6.1.2.2 Classification Report

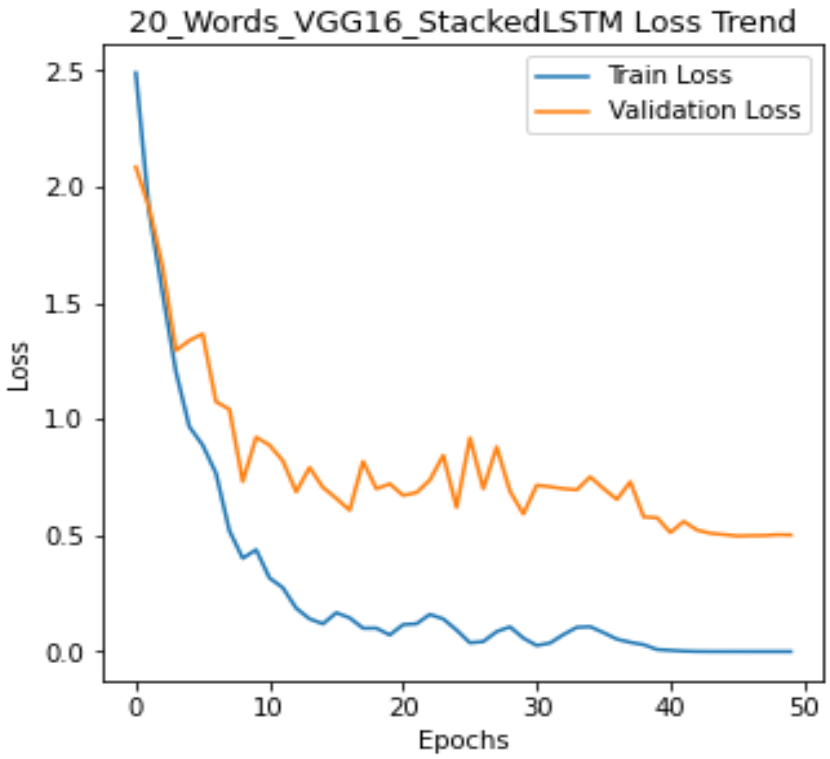

Fig. 6.1.2.1 Loss Trend

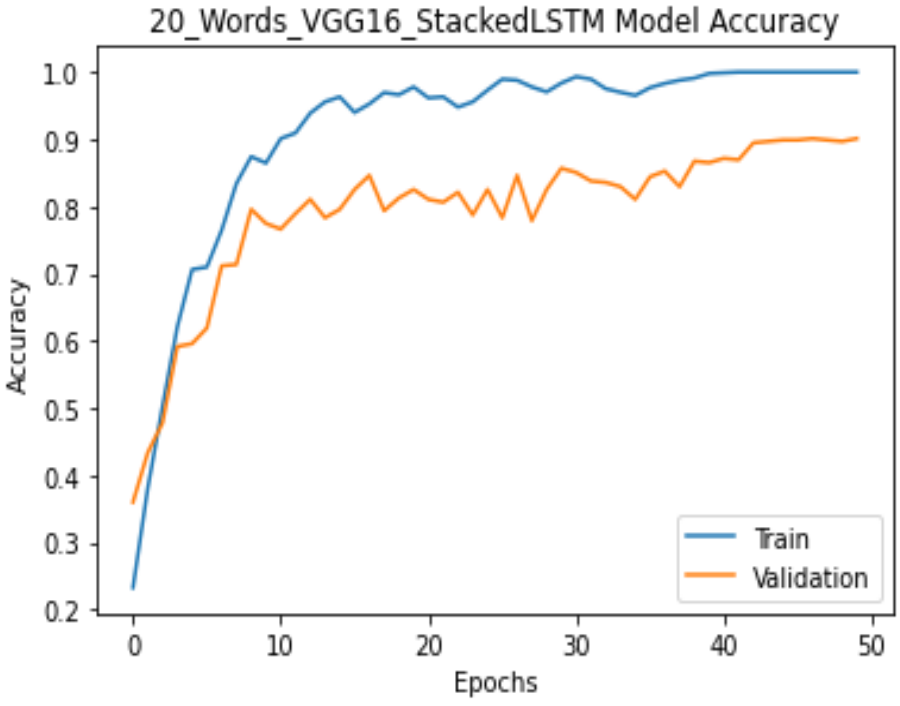

Fig. 6.1.2.2 Accuracy Trend

6.2 Testing

- **Checking the type of Uploaded File :**
  If the user chooses to upload a file from his/her local storage, the system must validate the type of the file selected. The system in its current form can only work with .mp4 files. Hence, if the user selects any other type of file, there is an error prompt to the user.

- **Checking for presence of a human face in the Video Data :**
  The Video data, either in the form of a live stream or .mp4 file selected from the local storage, must contain a human face for the entirety of the video. This ensures that a human is the subject of the video, and invalidates videos with incomprehensible subjects. It must be noted that the face detection is simply used to ensure the presence of a human, the model does not consider facial data in its processing as most of it is disregarded by the hand detection module. Failure to detect face is prompted to the user with an error message.

- **Checking for Hand Movement in the Video Data:**
  The Video data, either in the form of a live stream or .mp4 file selected from the local storage, must contain at least a single frame with hands visible in it. This ensures that only data with hands which is used to predict the sign is presented to the model. If hands are not detected for the entire video, the user is prompted with an error message.

CHAPTER 7

CONCLUSION

7.1 CONCLUSION

We have proposed a system for the deaf and mute who primarily communicate using sign languages with others. This system records a video of the signer, segregates the video into word videos, extracts frames from the videos, detects hand movements and then predicts the word being said by the signer by using a Convolutional Neural Network followed by LSTM RNN. A total of 20 words can be identified by the system. The system also allows the user to generate audio output of the final word sequence that is obtained as the output of the video of the signer.

7.2 LIMITATIONS

- Currently, the system will work only for the American Sign Language.
- Only 20 words can be successfully recognized by the system owing to the dearth of computational resources and data storage.
- The system facilitates only one-way communication - interpreting sign language and generating natural spoken language.

7.3 FUTURE SCOPE

- This project can further be extended to facilitate two-way communication between the Mute and the Society - sign language to spoken language and vice versa.
- All the words of the sign language can be inculcated to institute a general conversation.
- An all inclusive platform can be made for all sign languages spoken worldwide to provide a single solution for effective communication.

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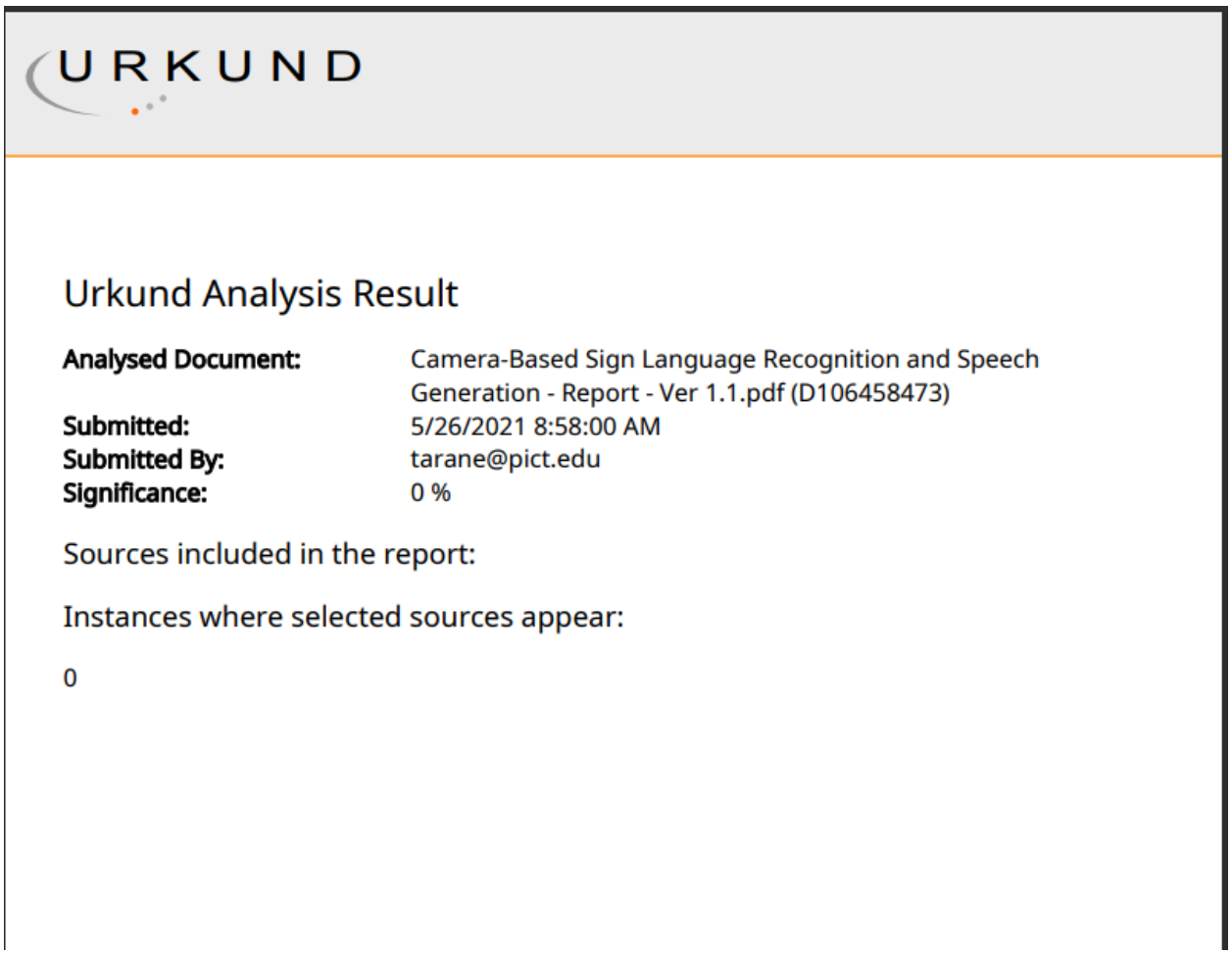
APPENDICES

Base Paper

S. Demidenko et al., "Developing Automatic Markerless Sign Language Gesture Tracking and Recognition System," 2019 IEEE International Symposium on Haptic, Audio and Visual Environments and Games (HAVE), Subang Jaya, Malaysia, 2019, pp. 1-6, doi: 10.1109/HAVE.2019.8921358.

Plagiarism Report



Review Sheets (Semester 7)

Project Review 1:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.
Department of Information Technology
PROJECT REVIEW – I

(Academic Year: 2020-21)

Group Id:	12			**Date: 11/9/2020**
Project Title:	Camera-Based Sign Language Recognition and Speech Generation			
Sr. No.	**Roll No.**	**Student Name**	**Contact Details**	**Internal Guide Details**
1	43107	Ayushi Patani	7744890841	Guide Name: Prof. T. A. Rane
2	43117	Varun Gawande	9619939148	
3	43118	Jash Gujarathi	7030548435	
4	43152	Vedant Puranik	9130096819	

REVIEW – I CHECKLIST: FINALIZATION OF SCOPE		**25 Marks**
PROJECT STATEMENT		
1.	Is the statement short and concise (10-20 words maximum)?	Y
2.	Does the statement give clear indication about what your project will accomplish?	Y
3.	Can a person who is not familiar with the project understand scope of the project by reading the problem statement?	Y

REQUIREMENT: SCOPE AND OBJECTIVES	
Does the Scope and Objectives establish the "context" for the proposed project by referencing to the following elements:	
a. Are all aspects of the requirements document (i.e., Functional Spec.) addressed in the design \	Y
b. Is the architecture / block diagram well defined and understood?	Y
c. The project's objective of study (what product, process, resource etc.) is being addressed?	Y
d. The project's purpose is the purpose of project addressed properly (why it's being pursued: to evaluate, reduce, increase, etc.)?	Y
e. The project's viewpoint: Is the project's viewpoint is understood? (Who is the project's end user)?	Y
f. Is the project goal statement in alignment with the sponsoring organization's business goals and mission?	Y

Savitribai Phule Pune University Faculty of Information Technology

ANALYSIS	
1. Is information domain analysis complete, consistent and accurate?	Y
2. Is problem statement categorized in identified area and targeted towards specific area therein?	Y
3. Are external and internal interfaces properly defined?	Y
4. Does the Use Case Model properly reflect the actors and their roles and responsibilities?	Y
5. Are all requirements traceable to system level?	Y
6. Is similar type of methodology / model is used for existing work?	N
7. Are requirements consistent with schedule, resources, and budget?	Y

Paper Publication Review:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.
Department of Information Technology
RESEARCH PUBLICATION REVIEW – I

(Academic Year: 2020-21)

Group Id: 12	**Date:** 23/10/2020
Project Title: Camera-Based Sign Language Recognition and Speech Generation	

Sr. No.	Roll No.	Student Name	Contact Details	Internal Guide Details
1	43107	Ayushi Patani	7744890841	Guide Name: Prof. T. A. Rane
2	43117	Varun Gawande	9619939148	
3	43118	Jash Gujarathi	7030548435	
4	43152	Vedant Puranik	9130096819	

RESEARCH PUBLICATION REVIEW – I CHECKLIST		**25 Marks**
Publication based on the Proposed Methodology		
1.	Is the Problem Clearly defined and concise? (Which Challenge / issue is addressed by this research?)	Y
2.	Is Abstract precisely written and are Keywords correctly identified?	Y
3.	Is motivation/significance of the research work is defined?	Y
4.	Is Literature Survey comprehensive, systematic?	Y
5.	Is comparative analysis demonstrated through implementation?	Y
6.	Is new methodology/algorithm proposed precisely?	Y
7.	Does the system architecture/ workflow diagram match the proposed methodology?	Y
8.	Is conclusion with future scope communicated effectively?	Y
9.	Is plagiarism checked?	Y
10.	Are the WoS /Scopus indexed and /or UGC listed international journals and/or Scopus indexed international conferences identified?	Y

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

Department of Information Technology

PROJECT REVIEW – I

(Academic Year: 2020-21)

STUDENT PERFORMANCE EVALUATION

Students' Contribution and Performance				
Particulars	**Marks(25M)**			
	Group Members			
	1	2	3	4
1. Background and Topic (4 M)	4	4	4	4
2. Project Scope and Objectives (4M)	4	4	4	4
3. Literature Survey (5 M)	3	3	3	3
4. Project Planning (4 M)	4	4	4	4
5. Presentation Skills (4 M)	4	4	4	4
6. Question and Answer (4 M)	4	4	4	4
Total(25M)	**23**	**23**	**23**	**23**
Comments (if any)				
1. Do some more detailed literature Survey. 2. Make comparative study of different methods.				

To be filled by internal guide & reviewer(s) only.

* Whether the presentation / evaluation is as per the schedule. : YES / NO (If NO mention the reasons for the same.)

Review – I: Deliverables

• Problem Statement / Title • Purpose, Scope, Objectives • Abstract (System Overview) • Introduction (Architecture and High-Level Design)	• H/W, S/W & other requirement, Test Environment/Tools • Literature Survey • References • Project Plan 1.0 (**Gantt Chart**)

Name & Signature of evaluation committee –

Prof. N. V. Buradkar	Prof. Vinay Thamke	Prof. Tushar A. Rane
Name of Reviewer 1	Name of Reviewer 2	Name of Internal Guide

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

Department of Information Technology

RESEARCH PUBLICATION REVIEW – I

(Academic Year: 2020-21)

STUDENT PERFORMANCE EVALUATION

Students' Contribution and Performance				
Particulars	**Marks(25M)**			
	Group Members			
	1	2	3	4
1. System Architecture & Literature Survey (Review-I)	Y	Y	Y	Y
2. Precise Title, Abstract and Keywords (2 M)	2	2	2	2
3. Motivation and scope of research work (2 M)	2	2	2	2
4. Literature Survey and identification of research gap (5 M)	4	4	4	4
5. Proposed Methodology /Algorithm/System Architecture (5M)	4	4	4	4
6. Effective Conclusion and Future Scope (2 M)	2	2	2	2
7. Relevant References (3 M)	3	3	3	3
8. Effective Technical Writing and Presentation Skills (4 M)	3	3	3	3
9. Originality (Plagiarism <20%) (2M)	2	2	2	2
10. Identification of quality journals/international conferences	Y	Y	Y	Y
Total(25M)	22	22	22	22
Comments (if any)				

To be filled by internal guide & reviewer(s) only.

* Whether the presentation / evaluation is as per the schedule. : YES / NO (If NO mention the reasons for the same.)

Research Publication Review – I: Deliverables

• Paper Title, Abstract and keywords • Introduction • Literature Survey • Proposed Methodology/ Algorithm • System Architecture/ Workflow Diagram	• Conclusion and Future Scope • References • Identified WoS /Scopus indexed and /or UGC listed international journals and/or Scopus indexed international conferences.

Name & Signature of evaluation committee –

Prof. N. V. Buradkar	Prof. Vinay Thamke	Prof. Tushar A. Rane
Name of Reviewer 1	Name of Reviewer 2	Name of Internal Guide

Project Review 2:

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.
Department of Information Technology
PROJECT REVIEW – II

(Academic Year: 2020-21)

Group Id:	12			Date: 10/12/2020
Project Title:	Camera-Based Sign Language Recognition and Speech Generation			
Sr. No.	**Roll No.**	**Student Name**	**Contact Details**	**Internal / External Guide Details**
1	43107	Ayushi Patani	7744890841	Guide Name: Prof. T. A. Rane
2	43117	Varun Gawande	9619939148	
3	43118	Jash Gujarathi	7030548435	
4	43152	Vedant Puranik	9130096819	

REVIEW – II CHECKLIST: DESIGN		**25 Marks**
DESIGN		
1.	Are requirements reflected in the system architecture?	Y
2.	Does the design support both project (product) and project goals?	Y
3.	Does the design address all the issues from the requirements?	Y
4.	Is effective modularity achieved and modules are functionally independent?	Y
5.	Are structural diagrams (Class, Object, etc.) well defined and understood?	Y
6.	Are all class associations clearly defined and understood? (Is it clear which classes provide which services)?	Y
7.	Are the classes in the class diagram clear? (What they represent in the architecture design document?	Y
8.	Is inheritance appropriately used?	NA
9.	Are the multiplicities in the use case diagram depicted in the class diagram?	Y
10.	Are behavioral diagrams (use case, sequence, activity, etc.) well defined and understood?	Y
11.	Is aggregation/containment (if used) clearly defined and understood?	Y
12.	Does each case have clearly defined actors and input/output?	Y
13.	Is all concurrent processing (if used) clearly understood and reflected in the sequence diagrams?	Y
14.	Are all objects used in sequence diagram?	Y
15.	Does the sequence diagram match class diagram?	Y
16.	Are the symbols used in all diagrams correspond to UML standards?	Y

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

Department of Information Technology

PROJECT REVIEW – II

(Academic Year: 2020-21)

STUDENT PERFORMANCE EVALUATION

Students' Contribution and Performance				
Particulars	**Marks(25M)**			
	Group Members			
	1	2	3	4
1. System Architecture & Literature Survey (Review-I)	Y	Y	Y	Y
2. Project Design (5 M)	5	5	5	5
3. Methodology /Algorithms and Project Features (5 M)	5	5	5	5
4. Project Planning (2 M)	2	2	2	2
5. Basic details of Implementation (5 M)	4	4	4	4
6. Presentation Skills (4 M)	4	4	4	4
7. Question and Answer (4 M)	4	4	4	4
8. Summarization of ultimate findings of the Project	Y	Y	Y	Y
Total(25M)	24	24	24	24
Comments (if any)				

To be filled by internal guide & reviewer(s) only.

* Whether the presentation / evaluation is as per the schedule. : YES / NO (If NO mention the reasons for the same.)

Review – II: Deliverables

• Problem Statement / Title • Abstract • Introduction • Literature Survey (comparison with existing system) • Methodology • Design / algorithms / techniques used	• Modules Split-up • Proposed System • Software Tools / Technologies to be used • Proposed Outcomes • Partial Report (Semester – I) • Project Plan 2.0 (Gantt Chart)

Name & Signature of evaluation committee -

Prof. N. V. Buradkar	Prof. Vinay Thamke	Prof. Tushar A. Rane
Name of Reviewer 1	Name of Reviewer 2	Name of Internal Guide

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

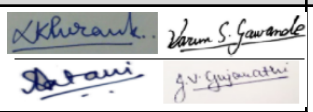
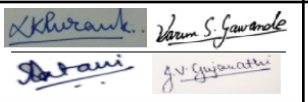
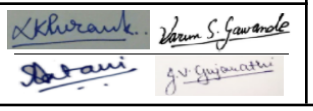
Department of Information Technology

(Academic Year: 2020-21)

Semester – I

Monthly Planning Sheet

Academic Year: 2020-2021

Week No.	Activity Planned	Activity Completed Status	Student Signature	Guide Signature
Week 1	To select project domain	Completed		
Week 2	To approach companies for sponsorship	Completed		
Week 3	To decide problem statement and its scope	Completed		
Week 4	To deliver Project-Review 1	Completed		
Week 5	To collect project-related research papers	Completed		
Week 6	To learn basic Python	Completed		
Week 7	To deliver Research-Publication Review 1	Completed		
Week 8	To gather information from all research papers	Completed		
Week 9	To identify necessary technologies	Completed		
Week 10	To implement web scraping to collect data	Completed		
Week 11	To write a survey paper based on the project topic	Completed		
Week 12	To deliver Project-Review 2	Completed		

Review Sheets (Semester 8)

Project Review 3:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

Department of Information Technology

PROJECT REVIEW – III

(Academic Year: 2020-21)

Group Id:	12			Date: 27/02/2021
Project Title: Camera-based Sign Language Recognition and Speech Generation				
Sr.No.	**Roll No.**	**Student Name**	**Contact Details**	**Internal / External Guide Details**
1	43107	Ayushi Patani	7744890841	Guide Name: Prof. T. A. Rane
2	43117	Jash Gujarathi	9619939148	
3	43118	Varun Gawande	7030548435	
4	43152	Vedant Puranik	9130096819	

REVIEW – III : IMPLEMENTATION — **25 Marks**

IMPLEMENTATION (SOURCE CODE REVIEW CHECKLIST)	
a. Structure	
1. Does the code completely and correctly implement the design?	Y
2. Does the code comply with the Coding Standards?	Y
3. Is the code well-structured, consistent in style, and consistently formatted?	Y
4. Does the implementation match the design?	Y
5. Are all functions in the design coded?	Y
b. Documentation	
1. Is the code clearly and adequately documented?	Y
2. Are all comments consistent with the code?	Y

Project Review 3 Performance Evaluation:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.
Department of Information Technology
PROJECT REVIEW – III
(Academic Year: 2020-21)

STUDENT PERFORMANCE EVALUATION

Students' Contribution and Performance				
Particulars	Marks(25M)			
	Group Members			
	1	2	3	4
1. Architecture / System Design (if any modification)	N	N	N	N
2. 60 % Implementation (10 M)	10	10	10	10
3. Partial results obtained (7 M)	6	6	6	6
4. Presentation skills (4 M)	3	3	3	3
5. Question and Answer (4 M)	4	4	4	4
6. Summarize the methodologies / Algorithms implemented / to be implemented	Y	Y	Y	Y
Total(25M)	23	23	23	23
Comments (if any)				

To be filled by internal guide & reviewer(s) only.
* Whether the presentation / evaluation is as per the schedule : YES / NO (If NO mention the reasons for the same.)

Review – III: Deliverables

- Detailed Design (if any deviation)
- 60% of code implementation
- Some Experimental Results
- Project Plan 3.0

Name & Signature of evaluation committee –

Prof. N. V. Buradkar	Prof. Vinay Thamke	Prof. T. A. Rane
Name of Reviewer 1	Name of Reviewer 2	Name of Internal Guide

Project Review 4:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.
Department of Information Technology
PROJECT REVIEW – IV
(Academic Year: 2020-21)

Group Id:	12			Date: 29/05/2021
Project Title: Camera-based Sign Language Recognition and Speech Generation				
Sr.No.	Roll No.	Student Name	Contact Details	Internal / External Guide Details
1	43107	Ayushi Patani	7744890841	Guide Name: Prof. T. A. Rane
2	43117	Jash Gujarathi	9619939148	
3	43118	Varun Gawande	7030548435	
4	43152	Vedant Puranik	9130096819	

REVIEW – IV: (25 Marks)

IMPLEMENTATION AND TESTING	
1. Is every feature tested?	Y
2. Are all functions, user screens and navigation tested? (e.g. module, object, integration, usability, system)	Y
3. Are test cases designed? (manual and automated)	Y
4. Is testing tool used?	Y
5. Is result analysis done properly and appropriate conclusion drawn?	Y
6. Implementation status (code completion in percentage)	100
7. Final thesis status (in percentage)	100

FILL IN BRIEF

Final results are known or not? : Known
Quality of Presentation : Very Good
List the chapter numbers of final report : Introduction, Literature Review, Requirement Specification and Analysis, System Analysis and Design, Implementation, Results and Evaluation, Conclusion
Project Completion Date : 21/05/2021
Final Report Submission Date : 03/06/2021

General

Is the LOG BOOK of project up-to-date and signed?: Yes

Project Review 4 Performance Evaluation:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.
Department of Information Technology
PROJECT REVIEW – IV
(Academic Year: 2020-21)

STUDENT PERFORMANCE EVALUATION

Students' Contribution and Performance				
Particulars	Marks(25M)			
	Group Members			
	1	2	3	4
1. Implementation (100%) (5 M)	5	5	5	5
2. Testing, Results and Performance Evaluation (5 M)	5	5	5	5
3. Final Project Report (5 M)	5	5	5	5
4. Publications (2 M)	2	2	2	2
5. Presentation skills (4 M)	3	3	3	3
6. Question and Answer (4 M)	4	4	4	4
Total(25M)	24	24	24	24
Comments (if any)				

To be filled by internal guide & reviewer(s) only.
* Whether the presentation/evaluation is as per the schedule.: YES / NO (If NO mention the reasons for the same.)

Review – IV: Deliverables

- Detailed Design
- 100% of code implementation
- Experimental Results
- Performance Evaluation
- Test Cases
- Result Analysis and Conclusion
- Final Thesis
- Project Plan 4.0

Name & Signature of evaluation committee -

Prof. N. V. Buradkar	Prof. Vinay Thamke	Prof. T. A. Rane
Name of Reviewer 1	Name of Reviewer 2	Name of Internal Guide

Research Publication Review 2:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

Department of Information Technology

RESEARCH PUBLICATION REVIEW – II

(Academic Year: 2020-21)

Group Id :	12			Date: 29/05/2021
Project Title : Camera-based Sign Language Recognition and Speech Generation				
Sr. No.	**Roll No.**	**Student Name**	**Contact Details**	**Internal / External Guide Details**
1	43107	Ayushi Patani	7744890841	Guide Name: Prof. T. A. Rane
2	43117	Jash Gujarathi	9619939148	
3	43118	Varun Gawande	7030548435	
4	43152	Vedant Puranik	9130096819	

RESEARCH PUBLICATION REVIEW – II CHECKLIST	**25 Marks**
Publication based on the Experimentation Results	
1. Is the Problem Clearly defined and concise? (Which Challenge / issue is addressed by this research?)	Y
2. Is Abstract precisely written and are Keywords correctly identified?	Y
3. Is motivation/significance of the research work is defined?	Y
4. Is Literature Survey comprehensive, systematic?	Y
5. Is contribution of the research work is clearly described?	Y
6. Is new methodology/algorithm proposed precisely?	Y
7. Does the system architecture/ workflow diagram match the proposed methodology?	Y
8. Are the experimentation setup and results discussed systematically?	Y
9. Is the empirical study compares the results with the state-of-the-art algorithms?	Y
10. Is conclusion with future scope communicated effectively?	Y
11. Is plagiarism checked?	Y
12. Are the WoS /Scopus indexed and /or UGC listed international journals and/or Scopus indexed international conferences identified?	Y

Research Publication Review 2 Student Performance Evaluation:

Savitribai Phule Pune University — Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.
Department of Information Technology
RESEARCH PUBLICATION REVIEW – II
(Academic Year: 2020-21)

STUDENT PERFORMANCE EVALUATION

Students' Contribution and Performance				
Particulars	**Marks(25M)**			
	Group Members			
	1	2	3	4
1. Implementation (Review-III)	Y	Y	Y	Y
2. Precise Title, Abstract and Keywords (2 M)	2	2	2	2
3. Motivation and contribution of research work (2 M)	2	2	2	2
4. Literature Survey and identification of research gap (2M)	2	2	2	2
5. Proposed Methodology /Algorithm/System Architecture (4M)	4	4	4	4
6. Experimentation Results and Empirical Analysis (5M)	4	4	4	4
6. Effective Conclusion and Future Scope (2 M)	2	2	2	2
7. Relevant References (2 M)	2	2	2	2
8. Effective Technical Writing and Presentation Skills (4 M)	4	4	4	4
9. Originality (Plagiarism <20%) (2M)	2	2	2	2
10. Identification of quality journals/international conferences	Y	Y	Y	Y
Total(25M)	24	24	24	24
Comments (if any)				

To be filled by internal guide & reviewer(s) only.
* Whether the presentation / evaluation is as per the schedule: YES / NO (If NO mention the reasons for the same.)

Research Publication Review – II: Deliverables

• Paper Title, Abstract and keywords • Introduction • Literature Survey • Proposed Methodology/ Algorithm • System Architecture/ Workflow Diagram	• Experimentation Results and Empirical Analysis • Conclusion and Future Scope • References • Identified WoS /Scopus indexed and /or UGC listed international journals and/or Scopus indexed international conferences.

Name & Signature of evaluation committee –

Prof. N. V. Buradkar	Prof. Vinay Thamke	Prof. T. A. Rane
Name of Reviewer 1	Name of Reviewer 2	Name of Internal Guide

Savitribai Phule Pune University Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, Pune.

Department of Information Technology

(Academic Year : 2020-21)

Semester - II

Monthly Planning Sheet

Academic Year:

Week No.	Activity Planned	Activity Completed Status	Student Signature	Guide Signature
Week 1	Data Exploration	Completed		
Week 2	Data Preprocessing and Frame Extraction	Completed		
Week 3	Hand Recognition	Completed		
Week 4	Data augmentation and further preprocessing	Completed		
Week 5	Exploring different architectures for classification	Completed		
Week 6	Architecture exploration and implementation	Completed		
Week 7	Obtaining and comparing primitive results	Completed		
Week 8	Hyperparameter tuning of model	Completed		
Week 9	UI and backend coding	Completed		
Week 10	Integration and backend coding	Completed		
Week 11	Testing	Completed		
Week 12	Documentation and Review 4	Completed		

Project Coordinator Internal Guide

Summary of Project Work:

Savitribai Phule Pune University — Faculty of Information Technology

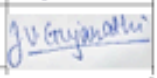
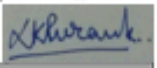
PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

Department of Information Technology

PROJECT REVIEW – I to IV

(Academic Year: 2020-21)

Summary of Project Work Evaluation Sheet

Sr. No.	Roll No. / Exam. No.	Name of the Student	I	II	III	IV	Total	Student Signature
1	43107	Ayushi Patani	23	24	23	24	94	
2	43117	Jash Gujarathi	23	24	23	24	94	
3	43118	Varun Gawande	23	24	23	24	94	
4	43152	Vedant Puranik	23	24	23	24	94	

Overall Remarks or Comments (if any)

Prof. N. V. Buradkar	Prof. Vinay Thamke	Prof. T. A. Rane
Name of Reviewer 1	Name of Reviewer 2	Name of Internal Guide

Achievements:

Savitribai Phule Pune University — Faculty of Information Technology

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Department of Information Technology

ACHIEVEMENTS

(Academic Year: 2020-21 Semester-II)

Group Id:	12			Date: 06/05/2021
Project Title: Camera-based Sign Language Recognition and Speech Generation				
Sr.No.	Roll No.	Student Name	Contact Details	Internal / External Guide Details
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2	43117	Jash Gujarathi	9619939148	
3	43118	Varun Gawande	7030548435	
4	43152	Vedant Puranik	9130096819	

Project Competition/ Exhibition

Sr.No.	Name & Place of Project Competition/ Exhibition	Organizer & Place of Project Competition/ Exhibition	Date of the Competition / Exhibition	Prizes won (if any) or Participation	State / National/ International Level

Savitribai Phule Pune University Faculty of Information Technology

PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE.

Department of Information Technology

Paper Publication/ Presentation

Sr. No.	Paper Title	Authors	Journal/ Conference Name	National / International)	Volume/ No.	Page No.	Date of Publication	DOI	Indexing
1	Methodologies for sign language recognition: A survey	Ayushi N. Patani, Varun S. Gawande, Jash V. Gujarathi, Vedant K. Puranik, Prof. Tushar A. Rane	International Journal of Innovative Science and Research Technology	International	6		April 2021	https://www.ijisrt.com/methodologies-for-sign-language-recognition-a-survey	

Prof. T. A. Rane

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