Sign Language Recognition using Deep Learning Model

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report titled **"SIGN LANGUAGE RECOGNITION USING DEEP LEARNING"** is the bonafide work of "**RAHUL NIHALANI (21MIM10002), SHWETANK THAKUR (21MIM10003), DEVANSH MITTAL (21MIM10058), JAI VADULA(21MIM10066), SANDEEPAN CHAKRABORTY (21MIM10072)"** who carried out the project work under my supervision. Certified further that to the best of my knowledge the work reported at this time does not form part of any other project/research work based on which a degree or award was conferred on an earlier occasion on this or any other candidate.

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LIST OF ABBREVIATIONS

1. **SLR-SIGN LANGUAGE RECOGNITION**
2. **LSTM – LONG SHORT-TERM MEMORY**
3. **ISL- INDIAN SIGN LANGUAGE**
4. **RNN- RECURRING NEURAL NETWORK**
5. **GRU-GATED RECURRENT UNIT**
6. **CNN-CONVOLUTIONAL NEURAL NETWORK**
7. **HGR-HAND GESTURE RECOGNITION**

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ABSTRACT

Sign Language Recognition (SLR) is a task which computer performs for sign and hand gesture recognition by humans. Main purpose of the sign language is to help the mute and deaf people who are not able to communicate with the normal people. It works as a bridge of communication between the physically abled and normal people. In this project, LSTM Model is used, also dataset of 8 subjects has been taken and from each subject 22,500 images have been taken which combinedly gives us 180k images.

With the help of following database and model, accuracy of 94% achieved with loss of 0.4 .

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CHAPTER – 1
PROJECT DESCRIPTION AND OUTLINE

1.1 Introduction

Sign Language Recognition (SLR) is a task that a computer performs to recognize the signs or hand gesture by humans. This concept came into existence so that the physically impaired people like mute and deaf can communicate with each other and to normal people. SLR acts a bridge for communication.

1.2 Motivation for the work

Motivation to do this project came into our mind when we saw a person in the market, who was trying to ask for some food from a confectionary shop, but was unable to communicate as he was mute. Then we thought, why don't we create a system which can bridge communication between normal people and physically impaired people.

1.3 About Introduction to the project including techniques

In our project, to create a sign language recognition model, there are five basic requirements or techniques: Image Acquisition, Image Pre-processing, Segmentation, Feature extraction and classification. If all the above techniques are implemented, we can increase the efficiency and accuracy of our model.

1.4 Problem statement

Mute/Deaf people use hand signs to communicate with each other, hence normal people find it difficult recognizing the sign languages made by them.

We need to create an algorithm, which can act as a bridge for communication between normal people and physically impaired people in a real time environment

1.5 Objective of the work

Our objective is to make a system which efficient and accurate enough to recognize the hand sign language and convert it into either text or voice or maybe both. What this will do is that, it will reduce the communication gap between normal people and physically impaired people. This will also reduce the need for interpreter for physically impaired people.

1.6 Organization of the project

At first, all the group members researched about the topic Sign Language Recognition and gathered as much information as we can. Then we divided our group into a coding group, execution group and the data gathering group. Each person was assigned the task and work was done under a group leader which was multilaterally selected. Our group was doing the work under the directions/supervision of a mentor/guide.

1.7 Summary

In all, our project aims to create a bridge for communication between normal people and physically impaired people. We can create a bridge by designing an algorithm which fast, efficient and accurate enough to reduce communication gap. The project needs to be in a real-time environment, for which we need to create a deep-learning model train it with multiple data. More data means more efficiency and more accuracy.

CHAPTER - 2

Related work and Investigation

2.1 Introduction

The Sign Language Recognition Model is a real-time vision-based system whose purpose is to recognize the Indian sign language numerical from 0 to 9. The purpose of the Model was to test and select hand features that could be used with Deep learning algorithms allowing their application in any real-time sign language recognition systems. For that, the person must be positioned in front of the camera, doing the sign language gestures, that will be interpreted by the system and their classification will be displayed on the system.

2.2 Existing Approaches/Methods

RNN combined with LSTM approach:

We apply CNN to detect the position of the hands and RNN to detect patterns of the signs through time. The hand tracking is done with the Mediapipe. This is a framework that provides real-time computer vision technologies such as hand detection, hand tracking, face detection or object detection. The mediapipe detects the hand using the two RNN models: Palm detection and finger detection. First Mediapipe detects the palm, if the palm doesn't change position, palm detection is not required again, which improves efficiency. The finger detection is done only on the area of the palm previously detected, this way, false finger detection is avoided. The RNN built with Keras takes the first 50 frames of each sign. The signs have different time lengths depending on the gesture and the person executing it. We have recognized 0 to 9 numerical signs with a training accuracy of 94 percent and testing accuracy of 89 percent.

2.3 Pros and cons of RNN approach

Pros:

- RNN can process inputs of any length.
- Even if the input size is larger, the model size does not increase.
- The weights can be shared across the time steps.

Cons:

- Due to its recurrent nature, the computation is slow.
- Training of RNN models can be difficult.
- Prone to problems such as exploding and gradient vanishing.

2.4 Summary

Hand gestures are a powerful way for human communication. In this work, we have gone through a numerical sign language gesture recognition system in real-time, using different tools. There's still a lot of scope for possible future work.

CHAPTER – 3
REQUIREMENT ARTIFACTS

3.1 Introduction

In our project, we have used a deep learning model which requires heavy demand of hardware components. As per our understanding a medium-high end pc is required to run the model seamlessly. Higher the quality of pc, the lesser the time it will take train the model and load it.

3.2 Hardware and Software requirements

Below is the list of minimum and maximum hardware requirements:

i. Minimum requirements:
   a. CPU: i5 7th gen laptop
   b. GPU: Integrated
   c. RAM: 8GB
   d. Storage: HDD
   e. OS: Windows 10
   f. Webcam: Integrated or Dedicated

ii. Recommended requirements:
   a. CPU: i5 11th gen laptop or above
   b. GPU: GTX 1650 laptop or above
   c. RAM: 16GB or above
   d. Storage: SSD or above
   e. OS: Windows 10/11
   f. Webcam: Integrated or Dedicated

iii. Hardware used:
   a. CPU: Ryzen 7 5800H laptop
   b. GPU: RTX 3050/3070 laptop
   c. RAM: 16/32GB
   d. Storage: M.2 nvme
   e. OS: Windows 10/11
   f. Webcam: Integrated or Dedicate

Below is the list of Software requirements:

a. VS Code
b. Python
c. Nvidia cuda
d. Nvidia cudnn

3.3 Specific Project Requirements

3.3.1 Data requirement

We need a dataset, with decent number of images which is used to train our model. More the number and variety of images, more will be the accuracy.

3.3.2 Functions requirement

The actions which are recognized by the Deep Learning model should be displayed on the screen or in the form of voice. There should be a pre-defined action for which the model will search and give the output accordingly.

3.3.3 Performance and security requirement

For the model to function/work properly, the train and validation accuracy should be above 85% and the recommended value is above 90%. If the mentioned value is achieved, then the model should work properly and give us the desired output.

3.3.4 Look and feel requirement

The recognition screen should contain all the action which the model can recognize. There should be output section on the screen which shows the actions detected by the model. The screen should not be bulky or filled with unnecessary things, otherwise the user will feel overwhelmed.

3.4 Summary

Overall, the system on which the model is to be trained and run should be a medium to high end pc. More is quality of PC, the better it will perform. Talking about the performance, model should be able to detect the signs accurately with accuracy of at least 85-90%. To increase accuracy, model should be trained with large set and variety of data. The interface should be clean and should only contain the required information.

CHAPTER – 4
DESIGN METHODOLOGY AND ITS NOVELTY

4.1 Methodology and goal

Our project aims to capture sign language performed by signers in a real-time environment and interpret the language to produce textual and audio output for the physically impaired people. 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. This video will then be processed by our application. The video would be divided into a number of frames which will convert the video into a raw image sequence.

4.2 Functional Modules design and analysis

a.) OpenCV – It is a great tool for image processing and performing computer vision tasks.
b.) Mediapipe – It is a framework for building machine learning pipelines for processing time-series data like video, audio, etc.
c.) TensorFlow– It is an open-source framework developed by google researchers to run ML, DL and other statistical and predictive analytics.
d.) Keras API – It minimizes the number of user actions required for common use cases and also provide clear and actionable error messages.
e.) NumPy – This library is used for working with arrays.
f.) sklearn – This library is focused on ML tools such as mathematical, statistical and general-purpose algorithms.

4.3 Software and architectural designs

The system design of our Indian Sign Language is like that the data taken from subjects are divided into many image sequences. It consists of many modules as mentioned above. This design describes the top-level architecture of ISLR. A Recurrent Neural Network model is developed for the recognition of gestures using the features computed from the image sequences.

4.4 User Interface Designs

The interface design consists of a frame where user can see itself. Interface contains the actions which the model can recognize and the output. Landmarks are recognized as soon as the user comes into the view of camera and the model starts recognizing the gesture. The interface created using OpenCV.

4.5 Summary

Variety of modules are used, each having its significance. The sequential data is used to train RNN model and for recognition in real-time environment. The interface is not much overwhelming and the normal people can communicate with physically impaired people without any difficulty.

CHAPTER – 5
TECHNICAL IMPLEMENTAION AND ANALYSIS

5.1 Technical coding and code solutions

To solve this problem, we tried using multiple codes and models. After comparing many models, we finally decided the deep learning LSTM model[Figure 1]. Basically, three main files are there for capturing images for dataset, training the model and recognition.

5.2 Working layout of Forms

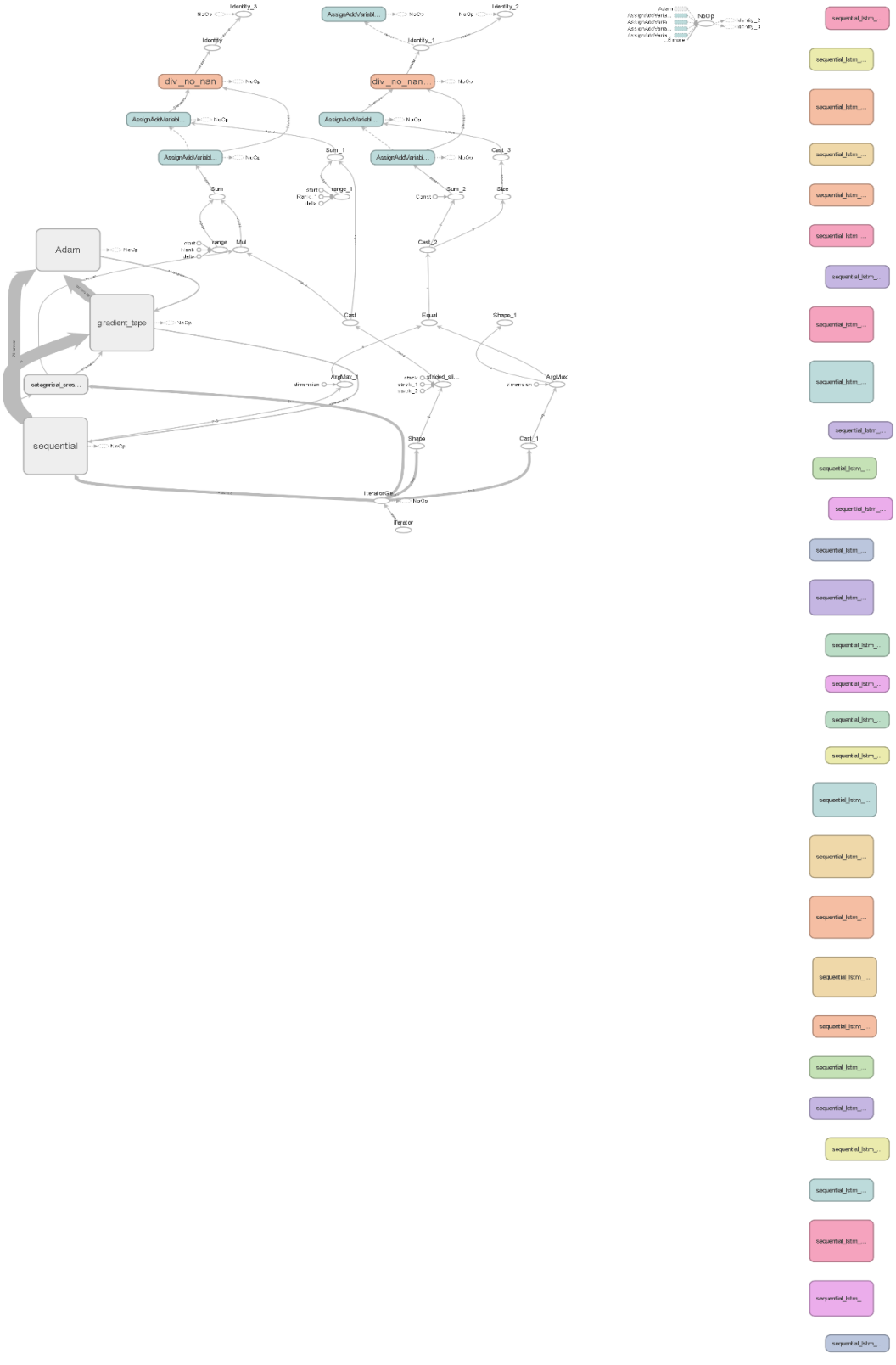
At first dataset was created with help of 8 subjects, which was pre-processed and saved in the form of NumPy Array in sequences. After data collection, model was trained on different parameters. The trained model was saved in form of '.h5' file extension. Summary[Figure 2] was generated and finally recognition was done successfully with expected output.

5.3 Test and Validation

The custom dataset was divided in 30:70 ratio. 70% data was used for training purpose and 30% for testing purpose. To get the best results, fine tuning of model was done[Table 1].

5.4 Performance analysis

The performance which we got from our model was as per our expectations. We got train accuracy of 19approx.. 94% and validation accuracy of 19approx.. 89%[Graph 1]. Train loss is around 0.15 and validation loss is around 0.44[Graph 2].


Identity_3
Identity_2
Identity
Identity_1
div_no_nan
div_no_nan_...
Sum_1
Cast_3
Sum
range_1
Sum_2
Size
Adam
range
Mul
Cast_2
gradient_tape
Cast
Equal
Shape_1
categorical_cross...
ArgMax_1
ArgMax
sequential
Shape
Cast_1
IteratorGe...
Iterator

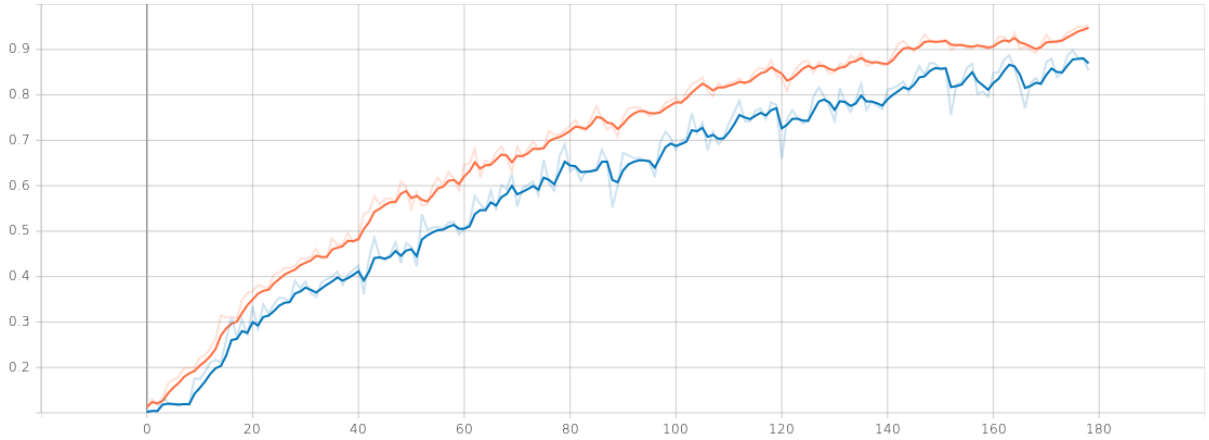
(Figure 1.)

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 lstm (LSTM)                 (None, 100, 16)           9152
 lstm_1 (LSTM)               (None, 100, 32)           6272
 dropout (Dropout)           (None, 100, 32)           0
 lstm_2 (LSTM)               (None, 100, 16)           3136
 dropout_1 (Dropout)         (None, 100, 16)           0
 lstm_3 (LSTM)               (None, 100, 16)           2112
 dropout_2 (Dropout)         (None, 100, 16)           0
 lstm_4 (LSTM)               (None, 100, 8)            800
 dropout_3 (Dropout)         (None, 100, 8)            0
 flatten (Flatten)           (None, 800)               0
 dense (Dense)               (None, 2048)              1640448
 dense_1 (Dense)             (None, 1536)              3147264
 dense_2 (Dense)             (None, 1024)              1573888
 dense_3 (Dense)             (None, 9)                 9225
=================================================================
Total params: 6,392,297
Trainable params: 6,392,297
Non-trainable params: 0
_________________________________________________________________
40/40 [==============================] - 2s 23ms/step
Train Accuracy :->
90.39682539682539
17/17 [==============================] - 0s 22ms/step
Test Accuracy :->
91.2962962962963
```

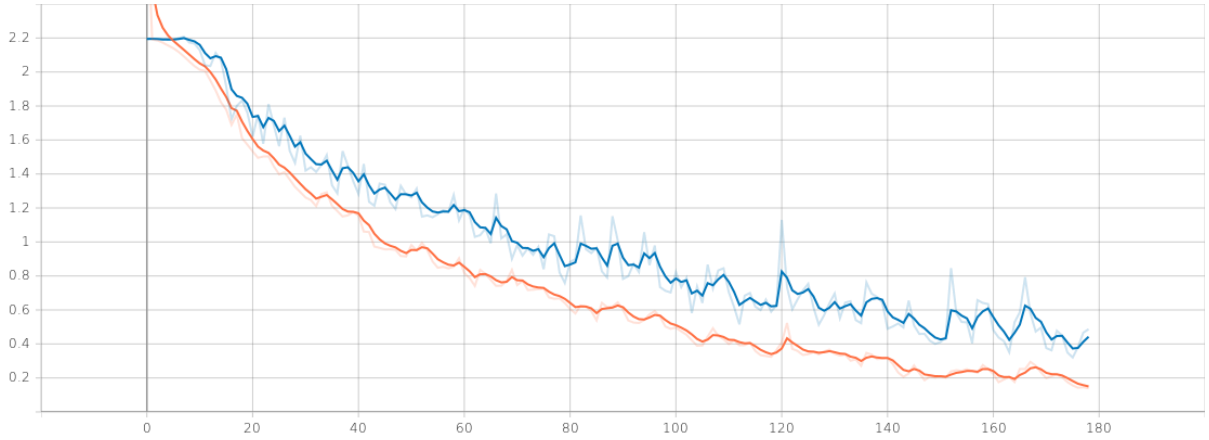
Figure 2.

Table 1:->

S.No.	Parameters	Value
1	Learning Rate	0.001
2	Epoch	300
3	Batch Size	256
4	Optimizer	Adam
5	Loss Calculation	categorical_crossentropy
6	Metrics	accuracy
7	Activation	relu



Graph 1



Graph 2

5.5 Summary

The performance which we got from the model was satisfying. Train and validation accuracy of 94% and 89% (respectively) is pretty good at the start which can be improved further on.

CHAPTER – 6

PROJECT OUTCOME AND APPLICABILITY

6.1 Key implementations outline of the System

The key implementation of sign language recognition is to provide an efficient and accurate method of translating sign language into text or speech to assist the hearing impaired. SLR helps in conveying meaningful information through gestures , careful selection and extraction of features is a very important aspect to consider for giving an appropriate result. Hand Gesture is a powerful form of communication and has many potential applications in human-computer interaction. Vision-based gesture recognition technology has many proven advantages over traditional devices.

6.2 Significant project outcome

We managed to make our system recognize numbers from 0 to 9. Our program would recognize the signs which is based on numbers from 0-9 and then will display what number the user wants to show.

6.3 Project applicability on Real-world applications

The sign language recognition systems facilitate communication between signers and non-signers. A recent area of research aims to focus on efficient character recognition under computational power constraints. Our program would recognize the signs made by the deaf/dumb person and would help the normal person to understand what the person wants to communicate.

CHAPTER - 7

CONCLUTIONS AND RECOMMENDATION

7.1 Outline

- Our system is mainly focused on numerical.
- We have used our own dataset.
- Sign language recognition systems should adopt data acquisition in any situation.
- Standard dataset is not available for all countries/ subcontinents/ languages.
- The system is performing recognition tasks in a convenient and faster manner.

7.2 Limitation/Constraints of the System

The drawbacks include its high cost and challenging commercial use. Additionally, classification techniques vary from researcher to researcher. Researchers frequently build their theories on techniques that are effective in recognizing sign language. The Sign Language Recognition (SLR) system has a difficult time identifying signals in continuous video sequences because of the system's enormous vocabulary.

7.3 Future Enhancements

We can create a model for ISL word and sentence level recognition. A system that can recognize changes in temporal space will be needed for this. By creating a comprehensive offering, we can bridge the communication gap for persons who are deaf or hard of hearing.

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