Empowering Deaf With Indian Sign Language Interpreter

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Contents

Introduction

- Hearing impaired people use sign language to express thoughts, emotions and fluent conversations.
- "Empowering Deaf with Indian Sign Language Interpreter" aims to detect and understand significant hand motions for effective communication.

There is Gun Stop I am Good Sorry

Figure: Deaf communication.

Problem Statement

- To develop a Indian Sign Language recognition system using deep learning and OpenCV to identify sign language gestures in real-time and convert sign to text based on detected gestures to enhance communication experiences for deaf individuals.

Objectives

- To create a curated dataset of Indian Sign Langugae.
- To create a real-time system translating short sign to text.
- To bridge communication gap between deaf people and normal people.

Architecture

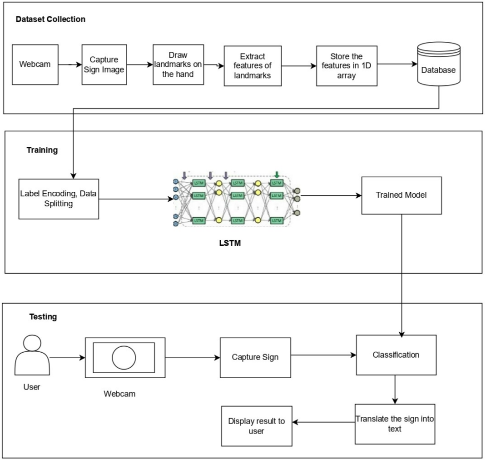

Figure: System Architecture

Dataset Link

Click here to visit dataset

Mathematical Modeling

Mathematical Model use in LSTM model to build the system is as follow:
Here LSTM layer($i = 1,2,3$)
X=input
1.Input Gate(i_i)

$$i_t^{(i)} = \sigma(W_i^{(i)} \cdot [h_{(t-1)}^{(i)}, x_t] + b_i^{(i)}) \tag{1}$$

- $W_{(i)}$ is weight and $b_{(i)}$is biases for input gate.
- σ is Sigmoid activation.
- h^{t-1} preceding hidden state

2.Forget Gate(f_t)

$$f_t^{(i)} = \sigma(W_f^{(i)} \cdot [h_{(t-1)}^{(i)}, x_t] + b_f^{(i)}) \tag{2}$$

3.Cell State(C_t)Update:

$$C_t^{(i)} = f_t^{(i)} \cdot C_{(t-1)}^{(i)} + i_i^{(i)} \cdot \overline{C} \tag{3}$$

$$\overline{C} = ReLU(W_c^{(i)} \cdot [h_{(t-1)}^{(i)}, x_t] + b_c^{(i)}) \tag{4}$$

- $\overline{C}$ - Candidate cell state

4.Output Gate(O_t)

$$O_t^{(i)} = \sigma(W_O^{(i)} \cdot [h_{(t-1)}^{(i)}, x_t] + b_O^{(i)}) \tag{5}$$

5. Hidden State(h_t):

$$h_t^{(i)} = O_t^{(i)} \cdot ReLU(C_t) \tag{6}$$

Here Dense layer($j = 1,2$)

6. Dense Layer 1 and 2:
input:$(O^{(3)})$ =$[h_1^{(3)}$,$h_1^{(3)}$,......$h_{numtimesteps}^{(3)}]$
Forward Pass: for t = 1,2,....,$numtimesteps$:

$$Z_t^{(j)} = W^{(j)} \cdot O_t^{(j)} + b^{(1)} \tag{7}$$

$$A_t^{(j)} = ReLU(Z_t^{(j)}) \tag{8}$$

7. Output layer:
input:$(A^{(2)})$ =$[A_1^{(2)}$,$A_1^{(2)}$,......$A_{num_t ime_s teps}^{(3)}]$
Forward Pass: for t = 1,2,....,num-time-steps:

$$Z_t^{(3)} = W^{(3)} \cdot A_t^{(2)} + b^{(2)} \tag{9}$$

$$Y_t^{(3)} = Softmax(Z_t^{(3)}) \tag{10}$$

Output gives the results of sign with text.

Algorithm:
Input: Array of features extracted from landmarks present on the hand.
Output: Sign Detection
Training Phase: LSTM

for epoch = 0 **to** epochs = 150 **do**
    img_array ← Sequential model();
    for i = 0 to 2
        img_array ←LSTM array with 64 unit and
        return_sequences=True;
    end
        img_array ←LSTM array with 128 unit and
        return_sequences=True;
        img_array ←LSTM array with 64 unit and
        return_sequences=False;
        img_array ←Dense layer with softmax activation;
Output()←img_array;

Testing Phase;
Image processing(image):
output image $\leftarrow$ Sign Language Detection(image);
Hand-Landmarks[ ] $\leftarrow$ Feature Extraction(Output_image);
for $i = 0$ **to** size(Hand-Landmarks) **do**
    output text += Classify Sign with Trained Model(Hand-Landmarks[i]);
end

System Implementation Phase:
trained model $\leftarrow$ LSTM-Based sequential Model(dataset);
Sign Language Detection $\leftarrow$ image processing(image);
display(text);

SRS Diagram

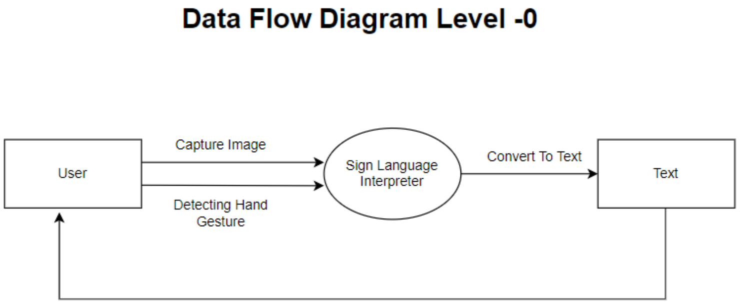

Figure: DFD0

SRS Diagram

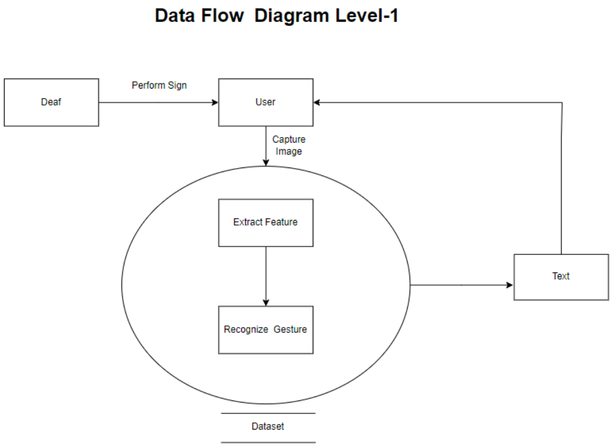

Figure: DFD Level 1

SRS Diagram

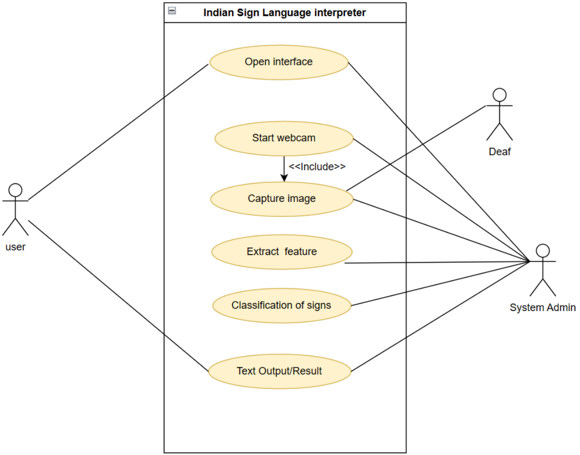

Figure: Use case Diagram

SRS Diagram

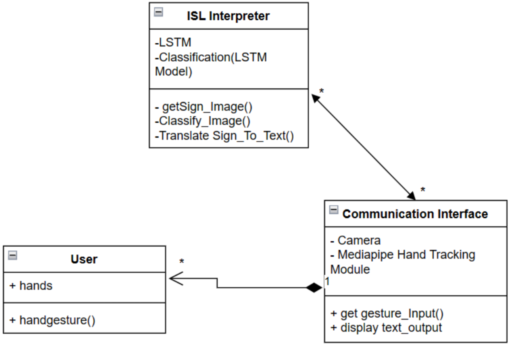

Figure: Class Diagram

SRS Diagram

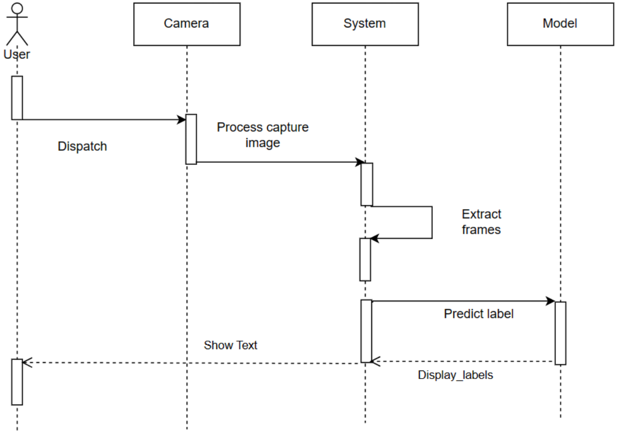

Figure: Sequence Diagram

SRS Diagram

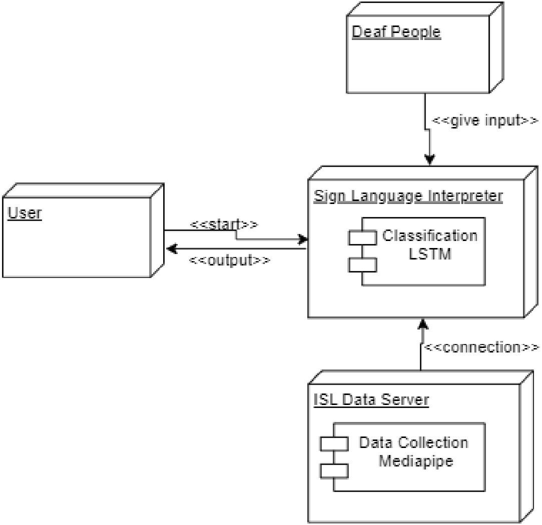

Figure: Deployment Diagram

Implementation

Click here to visit implementation.

Accuracy Graph: The graph shows that model's accuracy improves and stabilizes over epochs, indicating effective learning and good performance on both training and validation data.

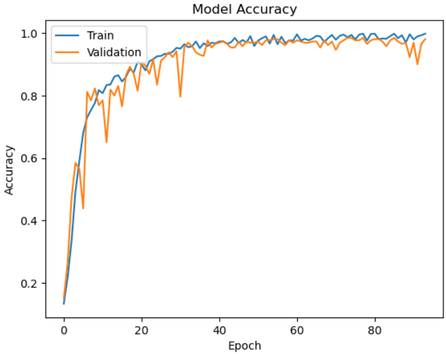

Figure: Model Accuracy

Loss Graph: The loss graph shows that the model's error decreases and stabilizes over epochs, reflecting improved accuracy in predictions.

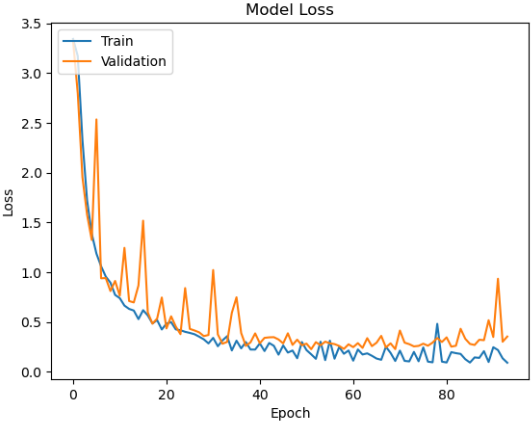

Figure: Loss

Figure: Results

Experimental Results

Figure: Results

Performance Evaluation

Signs	Precision	Recall	F1-score	Support
Alone	1.00	0.92	0.96	13
Call	1.00	1.00	1.00	13
Flower	1.00	1.00	1.00	11
Food	1.00	0.86	0.92	7
I am Good	1.00	0.88	0.93	8
Ok Fine	1.00	1.00	1.00	10
Stop	0.62	1.00	0.77	5
There is Gun	1.00	1.00	1.00	13

Table: Classification Report

Performance Evaluation

Algorithm	LSTM
Accuracy	0.9625
Precision	0.98
Recall	0.96
F1 Score	0.97

Table: Performance Evaluation of LSTM

Future Scope

- The project can improve by adding more words and phrases in dataset.
- Include Facial Expressions and Body Movements.
- Develop Mobile and Wearable Apps

Conclusion

- The dataset consists of 8 classes for different signs.
- An LSTM model is employed for classification tasks, exhibiting encouraging outcomes in converting concise sign language gestures into text.
- Project overcomes the objective which was reducing communication barrier between normal people and deaf people.
- The proposed system gives the accuracy 96.25%.

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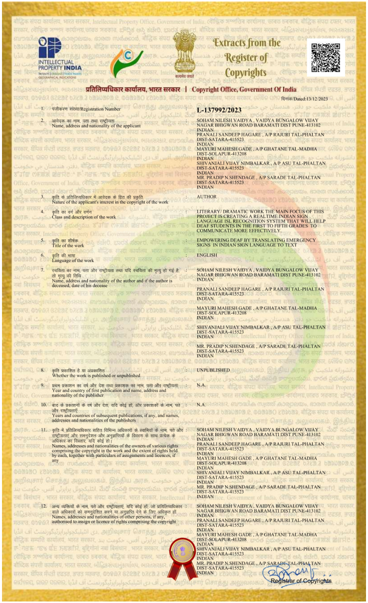

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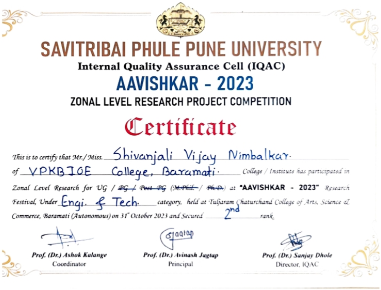

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