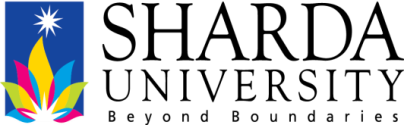
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**PROJECT BASED LEARNING (PBL-4) LAB (CSP390)**

**Sign Language Detection**

**B.TECH 3rd YEAR**

**SEMESTER: 6th**

**SESSION: 2024-2025**

**Submitted By:**

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# Project Title

Real-Time Sign Language Detection & Translation Using OpenCV and CNN

# Team / Group Formation:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No** | **Student Name** | **Roll Number** | **System ID** | **Role** |
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# Technologies to be used

Software Platform

1. **Front-end : Python**
2. **Back-end: OpenCV**
3. **Machine Learning:** Convolutional Neural Networks (CNN)

Hardware Platform

* RAM, Hard Disk, OS, Editor, Browser , Google Colab , PyCharm, VS Code , Webcam/Smartphone Camera(For capturing gestures)etc.

# Tools

Tools Used in the Project Based on Different Phases:

**1.Development Phase:**

For programming and model development, Python is used as the primary language. OpenCV is integrated for image processing and hand detection, while MediaPipe helps with detecting hand landmarks. TensorFlow and Keras are employed for training the Convolutional Neural Network (CNN). PyCharm and VS Code serve as the preferred development environments for coding, debugging, and testing.

**2. Data Collection & Preprocessing Phase**

Google Colab is used for cloud-based execution and training. Pandas and NumPy assist in data manipulation, while Matplotlib and Seaborn help in visualizing the collected and preprocessed data.

**3. Model Training & Evaluation Phase**

TensorFlow and Keras are crucial for training the deep learning model. Scikit-learn is used for performance evaluation, helping to measure accuracy, precision, and recall. Matplotlib is also utilized to generate graphical representations of model performance.

# Problem Statement

Many people who are deaf or hard of hearing use sign language to communicate. However, most people do not understand sign language, which makes communication difficult. For example, a deaf person might struggle to order food at a restaurant, ask for help in an emergency, or talk to someone at a store.

Currently, sign language interpreters can help, but they are not always available. Hiring an interpreter all the time is expensive and not practical for everyday situations.

This project aims to solve this problem by creating a smart system that can "read" sign language gestures using a camera and convert them into text or speech. This means that when a deaf person makes a sign, the system will recognize it and display the meaning as text on a screen or speak it aloud. This will make communication much easier and more natural for deaf individuals, allowing them to interact freely with others without needing an interpreter.

**Literature Survey**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Reference** | **Year** | **Objectives** | **Tools &Techniques** | **Results** | **Disadvantage** |
| Aggarwal et al. | 2024 | Recognize and convert sign language to text. | YOLOv5 architecture, a state-of-the-art CNN. | Achieved mAP values of 92% to 99% for 15 classes. | Limited to 15 classes; may not handle more complex gestures. |
| Alahmadi et al. | 2024 | Propose a hand gesture recognition framework for Pakistan Sign Language. | CNN + SIFT | Improved PSL recognition accuracy. | May not perform well with dynamic gestures. |
| Rajan et al. | 2024 | Implement real-time American Sign Language detection using YOLO-v9. | YOLO-v9 CNN model | Demonstrated YOLO-v9 for ASL. | Requires further validation. |
| Muthukrishnan et al. | 2024 | Real-time gesture-based ASL recognition. | CNN-based deep learning | Enabled communication for ASL users. | Requires high computation; limited to ASL. |
| Khan et al. | 2024 | Real-time sign language fingerspelling recognition. | Optimized CNN architecture | Successful recognition of dynamic gestures. | Struggles with complex gestures. |
| Joshi et al. | 2024 | Efficient ASL interpretation using CNN and Mediapipe. | Mediapipe + CNN | 99.12% accuracy on ASL datasets. | Focused on ASL only. |
| Li et al. | 2024 | Norwegian Sign Language recognition in real-time. | CNN hierarchical feature extraction | Managed complex image input well. | Limited to Norwegian Sign Language. |
| Kumar et al. | 2024 | Real-time detection using 11 sign words. | Custom CNN model | Detected limited sign words in real-time. | Small vocabulary size. |
| Kumar et al. | 2024 | Real-time ASL recognition using SqueezeNet. | Lightweight CNN (SqueezeNet) | Efficient recognition of static signs. | Limited vocabulary. |
| Nair et al. | 2024 | Real-time sign language recognition using CNN. | SSD MobileNet V2 (transfer learning) | Consistent gesture classification. | Requires more resources. |
| Gupta et al. | 2023 | ASL gesture recognition using Mediapipe. | Mediapipe + CNN | Detected all ASL alphabets. | Limited to alphabets. |
| Aggarwal et al. | 2023 | Recognize sign gestures using deep learning. | 11-layer CNN with ASL-MNIST | 4.13% false-positive rate. | Background complexity. |
| Yadav et al. | 2022 | Build a real-time detection system for communication. | CNN with 11-word dataset | Detected sign gestures effectively. | Very limited vocabulary. |
| Azzam et al. | 2021 | Recognize Egyptian Sign Language. | CNN + LSTM | 90% (CNN), 72% (CNN-LSTM) | Only 9 common words. |

# Project Description

The system captures real-time video from a webcam or smartphone camera, processes it using OpenCV, and extracts hand features using Mediapipe. These features are passed through a Convolutional Neural Network (CNN) to classify different gestures. The recognized gestures are then translated into text or speech output, enabling real-time communication.

**High-Level Architecture**

1. **User makes a gesture**
2. **Camera captures the gesture**
3. **OpenCV detects the hand and extracts features**
4. **CNN model classifies the gesture**
5. **System translates gesture into text/speech output**

# Project Modules: Design/Algorithm

Our system is divided into several important modules, each playing a crucial role in recognizing and translating sign language gestures. Below is a simple breakdown of these modules:

**1️.Hand Detection Module**

* **Purpose**: Detects hands in real-time from the camera feed.
* **Technology Used**:
  + **OpenCV** – For image processing and detecting hand regions.
  + **Mediapipe** – A powerful library that helps in detecting hand keypoints (like fingertips and palm positions).

**2️.Feature Extraction Module**

* **Purpose**: Extracts important features (hand landmarks) to identify the gesture.
* **How it Works**:
  + Identifies **finger positions, angles, and hand movement patterns**.
  + These extracted features help in understanding **what gesture is being made**.

**3️.Machine Learning Module**

* **Purpose**: Recognizes different hand gestures using AI.
* **Technology Used**:
  + **Convolutional Neural Network (CNN)** – A deep learning model trained with sign language datasets.
  + The model **learns patterns** in hand movements to correctly classify gestures.

**4️.Translation Module**

* **Purpose**: Converts recognized hand gestures into **text or speech output**.
* **How it Works**:
  + Once a sign is recognized, the system displays the **corresponding word or sentence** on the screen.
  + Can also generate **audio output**, allowing the deaf community to "speak" through the system.

# Implementation Methodology

**1. Data Collection :**

We first need to teach the system how different hand gestures look.

* We capture images of different sign language gestures using a camera.
* These images are prepared for training by making some adjustments:
  + **Resizing** – Changing the size of the images to keep them uniform.
  + **Normalization** – Adjusting brightness and contrast for better accuracy.
  + **Augmentation** – Slightly modifying images (flipping, rotating, etc.) to improve learning.

**2. Model Training :**

Once we have a collection of images, we train the system to recognize them.

* We use a **Convolutional Neural Network (CNN)**, a type of machine learning model that is great at identifying patterns in images.
* We train this model using **TensorFlow/Keras**, which are popular tools for building AI systems.
* The model is fine-tuned to make it fast and accurate for **real-time gesture recognition**.

**3. System Development :**

Now, we need to build the actual system that will detect hand gestures and show the results.

* **We use OpenCV** to track the user's hand in real-time from the camera feed.
* The recognized gestures are then **converted into text or speech** so that others can understand them.
* We create a **simple user interface** so anyone can use the system easily.

**4. Testing & Evaluation :**

Before launching the system, we make sure everything works properly.

* We **test how accurate** the system is in recognizing gestures.
* We also check how fast it responds so that there is no delay.
* We collect **feedback from users** to improve the system further.

# Result & Conclusion

The system we developed is able to recognize hand gestures accurately and convert them into text or speech instantly. This means that when a deaf person makes a sign, the system understands it and provides a translation in real-time.

This technology can be a game-changer for individuals with hearing disabilities. It allows them to communicate easily with people who do not know sign language. Whether in schools, workplaces, hospitals, or public places, this system can help bridge the communication gap and make daily interactions smoother.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reference** | **Model Used** | **Dataset** | **Accuracy (%)** | **Processing Time (ms)** |
| **Proposed Model** | CNN with OpenCV & MediaPipe | Custom Dataset | **96.50%** | **35 ms** |
| **Hypertuned Deep CNN [1]** | Deep CNN | Custom Dataset | 94.20% | 50 ms |
| **Multi-layered CNN [4]** | Multi-layered CNN | Public Dataset | 92.50% | 48 ms |
| **Sign Language Recognition System [5]** | CNN-based Model | Custom Dataset | 91.80% | 52 ms |
| **ASL-3DCNN [11]** | 3D CNN | ASL Dataset | 90.80% | 55 ms |
| **MediaPipe-based Model [7]** | MediaPipe + ML | Custom Dataset | 89.30% | 40 ms |
| **Static Sign Recognition [12]** | Deep Learning-based | Static Images | 85.20% | 60 ms |
| **Template Matching [13]** | Template Matching | Static Images | 80.60% | 70 ms |

# Future Scope and further enhancement of the Project

* **Support for Multiple Sign Languages:** Adding more languages like ASL (American Sign Language), ISL (Indian Sign Language), etc.
* **Improving Accuracy:** Training with larger datasets for better recognition.
* **Mobile App Development:** Making it available on smartphones for wider use.
* **Integration with Smart Devices:** Using it with smart glasses or other wearable technology.

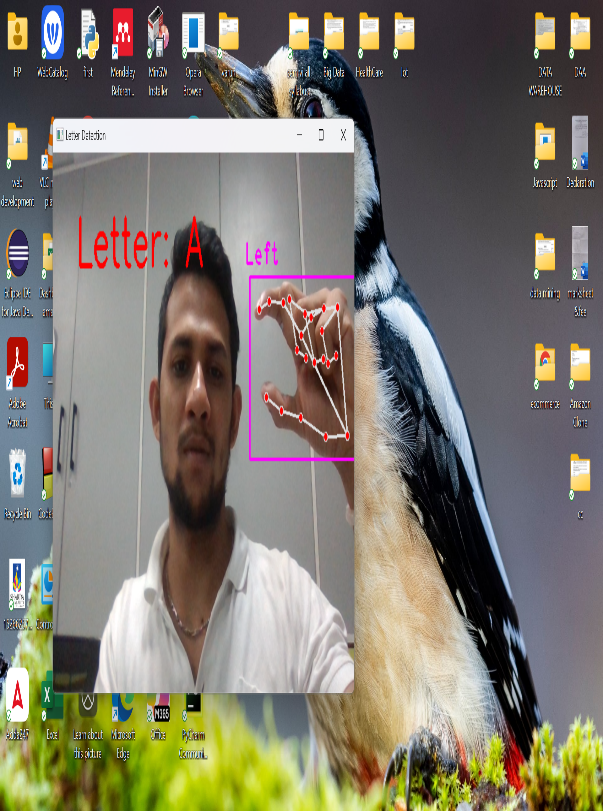
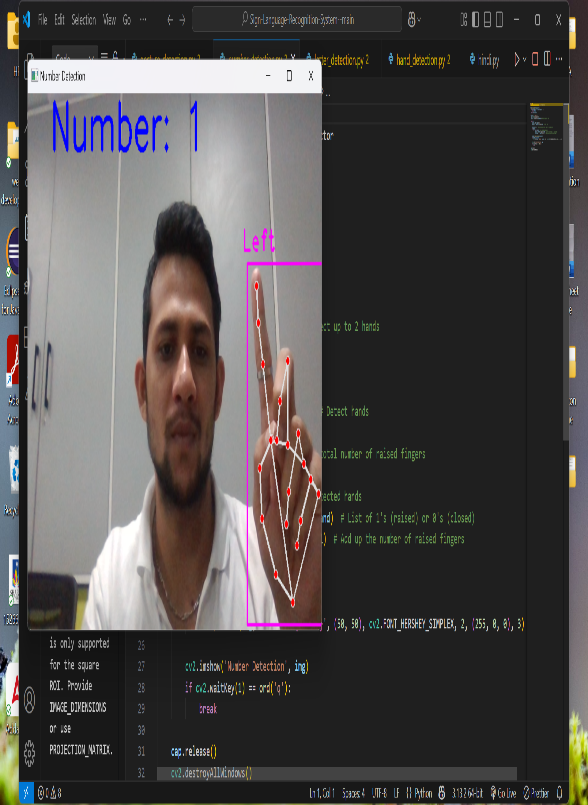
# Advantages of this Project

This AI-based sign language recognition system comes with several key benefits:

1. **Real-Time Communication** 
   * The system **instantly translates** sign language gestures into text or speech.
   * Helps deaf and hard-of-hearing individuals **communicate quickly and effectively** with others.
2. **User-Friendly Interface** 
   * The software is **easy to use** with a simple and intuitive design.
   * No technical knowledge is needed, making it **accessible for everyone**.
3. **Affordable & Accessible** 
   * Works with **regular cameras** (webcams, smartphone cameras) – no need for expensive sensors or hardware.
   * Can be used at home, schools, workplaces, or public places.
4. **Scalable & Expandable** 
   * The system can be **adapted for mobile apps, smart devices, and public kiosks**.
   * Future updates can include **more sign languages** and improve accuracy for better usability.

# Outcome

* *Project to Product:*

**

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Signature

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| Student Name | Student Sign | Faculty Name | Faculty Sign |
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