A PROJECT REPORT

on

SIGN LANGUAGE DETECTION USING ACTION RECOGNITION WITH VOICE OUTPUT

Submitted to

KIIT Deemed to be University

In Partial Fulfilment of the Requirement for the Award of

BACHELOR'S DEGREE IN
INFORMATION TECHNOLOGY

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CERTIFICATE

This is certify that the project entitled

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is a record of bonafide work carried out by them, in the partial fulfillment of the requirement for the award of Degree of Bachelor of Engineering (Computer Science & Engineering OR Information Technology) at KIIT Deemed to be university, Bhubaneswar. This work is done during year 2024-2025, under our guidance.

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Project Guide
(Mrs. Chandani Kumari)

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ABSTRACT

This project presents the development of a real-time sign language recognition system aimed at enhancing human-computer interaction for individuals with hearing or speech impairments. The system utilizes a webcam to capture hand gestures, which are then processed using the MediaPipe framework to extract landmark coordinates. These features are input into a trained machine learning model to classify the gestures accurately. Upon recognition, the system provides immediate audio feedback by playing a corresponding pre-recorded audio file, thereby facilitating effective two-way communication.

The solution is implemented using Python for backend processing, with frontend interfaces developed using HTML, CSS, and Flutter to ensure a responsive, user-friendly experience across platforms. This project emphasizes inclusivity, accessibility, and responsiveness—key principles in the field of human-computer interaction. By integrating gesture recognition with audio output, the system demonstrates how multimodal communication can bridge gaps in accessibility and promote more natural interactions between users and digital systems.

Here are five key keywords:

1. Human-Computer Interaction
2. Gesture Recognition
3. Inclusive Design
4. Multimodal Interface
5. Assistive Technology

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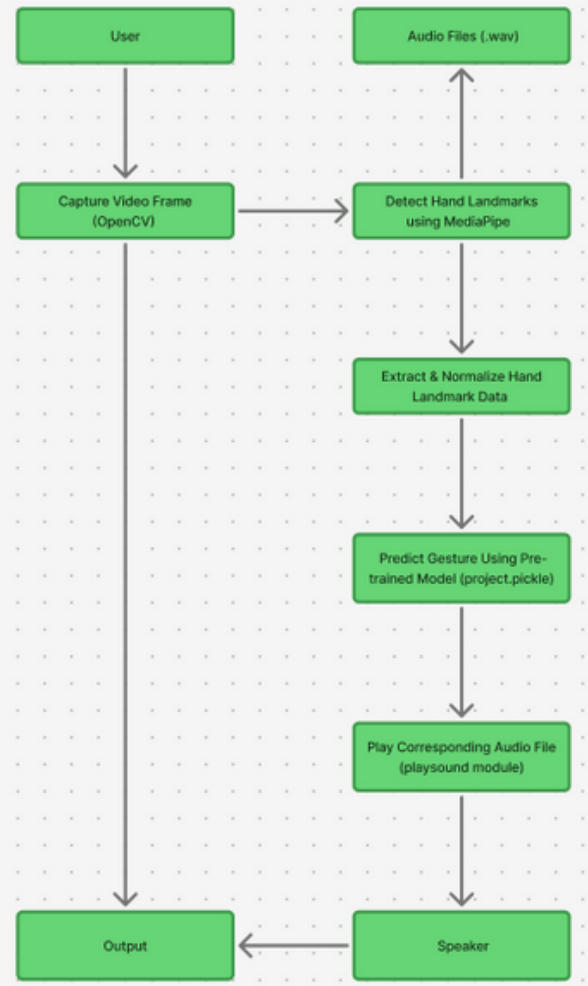
Chapter 1

Introduction

Sign language plays a vital role in helping individuals who are deaf or hard of hearing communicate and connect with the world around them. However, for those who don't understand sign language, it can be difficult to engage in meaningful conversations, which often leads to communication gaps. To bridge this divide, technology has started playing a powerful role—particularly through sign language recognition systems that aim to make interaction smoother and more inclusive.



1.1 Data Flow Diagram

With advancements in deep learning, it's now possible to create smart systems that can understand sign language with impressive accuracy. These models are great at picking up the natural flow and rhythm of hand movements, making them ideal for recognizing gestures in real-time.

In this project, we built a real-time sign language detection system using Python. It starts by capturing video from a webcam, then uses MediaPipe to track hand landmarks. These points are turned into meaningful features and sent to a trained model that identifies the gesture. Once detected, the system instantly plays a voice message that matches the sign making the interaction feel smooth, fast, and more like a spoken conversation.

To make the system user-friendly and accessible, we've built a clean, cross-platform interface using HTML, CSS, and Flutter. The goal is to make the experience simple and effective for users across different devices, while helping improve everyday communication for the hearing impaired.
The rest of the report is organized as follows: Section II explains the system's design and the algorithms behind it; Section III outlines the experiments and results; and Section IV wraps up with the conclusions and future improvements.

Chapter 2 Basic Concepts/ Literature Review

The developed model comprises two primary components, a facial recognition classifier and a person identification system, with integration into a web-based interface for accessibility and usability.

2.1 Face Recognition

- **Face Categorization**: The face recognition model assigns images to predefined identity categories, facilitating applications such as security and personalized user experiences.
- **Data Source**: A curated set of labeled facial images is used to train the model, enabling accurate identification across different lighting conditions, angles, and backgrounds.
- **Model and Feature Extraction**: The system utilizes a pre-trained Convolutional Neural Network (CNN) that is specifically designed for hand recognition tasks, ensuring efficient extraction of crucial hand signs.

- **Fine-Tuning**: The model is fine-tuned by adjusting key parameters like learning rate, batch size, and epochs to optimize its performance in identifying individuals with high accuracy.
- **Image Preprocessing**: The preprocessing pipeline standardizes image quality and format, addressing variations such as lighting, scaling, and facial landmark alignment to ensure consistency and reliability during recognition.

2.2 Person Identification

- **Model Selection**: To identify individuals, the system employs a Support Vector Machine (SVM) classifier, which differentiates between various identities by analyzing the extracted facial features.
- **Data Collection**: A diverse set of facial images is gathered, ensuring representation across various expressions, angles, and lighting conditions. This helps the model perform robustly in different real-world scenarios.

- **Feature Engineering**: Important facial features, such as the distances between key facial landmarks and texture patterns, are extracted to enhance the model's ability to distinguish between different individuals.
- **Confidence Scoring**: A confidence score is assigned to each identified face, reflecting both the similarity to known identities and the quality of the image. This score helps improve the reliability of the recognition process.

2.3 Web Integration:

The web integration enhances the accessibility and user experience of the face recognition and person identification system, making it suitable for a wide range of real-time applications. Below are some key points:

- **Real-Time Interaction**: The web interface facilitates real-time interaction with the face recognition system, enabling users to instantly upload images or video streams for immediate identification.

- **User-Friendly Interface**: Designed with HTML, CSS, and JavaScript, the interface provides a seamless and intuitive platform, ensuring easy navigation and minimal user effort to access the system's features.
- **Responsive Design**: The interface is fully responsive, ensuring that it performs effectively across a wide range of devices, including desktops, tablets, and smartphones, making it versatile and accessible.
- **Security and Personalization**: Users can securely upload and manage their facial data for personalized experiences, such as customized security alerts or access controls. The system can be integrated into various security applications, enhancing user-specific functionalities.
- **Integration with Databases:** The web interface can be connected to a backend database to store and retrieve known user profiles, allowing for dynamic person identification and seamless updates to user records.

- **Demo and Visualization:** The interface includes features like demo videos, which visually demonstrate the real-time face recognition process, making it more engaging and informative for the users.
- **Scalability:** The system is designed to scale effortlessly, allowing easy expansion to accommodate multiple users or additional functionalities, such as integrating with other security systems or adding more features like driver monitoring.
- **Continuous Feedback and Monitoring:** Users can receive live feedback on their actions, such as successful or unsuccessful identification attempts, which adds transparency and encourages interaction.
- **Cross-Platform Support:** The interface is compatible across different browsers, ensuring a wide reach and making the system easily accessible to anyone with internet access.

Chapter 3
Problem Statement / Requirement Specifications

3.1 **Project Planning**: The objective of this project is to build a real-time sign language detection system that can recognize hand gestures and provide audio feedback using voice output. This system helps bridge communication gaps between individuals with hearing impairments and the rest of the world. The following are the major components of the project:

1. **Data Collection:**

- A custom dataset of sign language gestures was created. The dataset included various letters and phrases like "A", "HELLO", "THANK YOU", "YES", "NO", etc. Multiple recordings were taken under different lighting conditions and from different hand orientations to improve the model's generalization.

2. **Data Preprocessing:**
   - Captured video frames were processed using OpenCV and MediaPipe. Key steps included:
     - Hand landmark detection using MediaPipe.
     - Normalization of coordinates relative to hand position.
     - Padding for missing landmarks when only one hand is detected.
     - Frame filtering to ensure only valid inputs (with 84 features) are passed to the model.

3. **Model Selection & Training:**
   - A machine learning model was trained using preprocessed hand landmarks. The model was loaded via a .pkl file. Feature vectors were generated from the coordinates of 21 landmarks (per hand), totaling 84 features. A supervised classifier was used to classify these features into gesture labels.

4. **Gesture Recognition with Audio Output:**
   - Implement a classification approach, such as k-Nearest Neighbors (k-NN) or Support Vector Machine (SVM), to match the extracted facial features to known identities. A confidence score is calculated for each face recognition result to reflect the certainty of identification, helping to ensure reliability in real-world applications.

5. **Evaluation & Testing:**

- The model was tested in real time with a variety of signs. System performance was validated by checking:
- Prediction accuracy
- Speed of detection
- Smoothness of audio output Special attention was given to minimizing latency and ensuring
- that false predictions were filtered out by checking feature lengths and adding a cooldown timer to avoid repeated audio triggers.

3.2 Project Analysis

1. **Data Quality:**

- Accurate recognition depended on the consistency and precision of the hand landmarks. Any blurring or misalignment during webcam capture affected the prediction. Proper lighting and hand visibility improved data quality.

2. **Real-time Gesture Ambiguity:**
   - Gesture similarity (e.g., "V" vs "W") posed challenges. The system handled this by requiring high-confidence predictions before audio output. Using both hands (42 points each) gave better accuracy than single-hand-only models.
3. **External Factors:**
   - Factors like background noise in audio files, hand occlusion, or quick gesture movement impacted recognition. The system was made robust by implementing real-time frame filtering and only accepting frames with exactly 84 features.

3.3.1 Design Constraints

1. **Software:**
   - Python was used along with OpenCV, MediaPipe, NumPy, and Playsound. Model loading was done using pickle.

2. **Hardware:**
   - A webcam and a system with good CPU performance were required to ensure smooth real-time gesture detection and audio output.

3. **Audio Dependency:**
   - A folder containing **.wav** files for each gesture was essential for the voice output.

3.3.2 System Architecture

- The architecture is modular:
  - **Input Layer**: Webcam capture
  - **Preprocessing Layer**: Hand landmark extraction
  - **Model Layer**: Gesture prediction using trained **.pkl** model
  - **Output Layer**: Audio playback and display of predicted sign on the screen

  Each component was developed and tested independently, enabling smooth integration and easy debugging during the real-time execution phase.

Chapter 4 Implementation

The paper titled "Sign Language Detection Using Action Recognition with Voice Output" presents an innovative approach to real-time sign language recognition by utilizing action recognition techniques. The primary objective of this project is to build a reliable and efficient system capable of interpreting sign language gestures, thereby bridging the communication gap between individuals with hearing impairments and those unfamiliar with sign language. The system processes live video input, extracts meaningful gesture features, and provides both visual and audio feedback, enabling smoother and more inclusive interactions.

Key elements of the system include:

- **Data Acquisition**: A diverse dataset of various sign language gestures is collected, ensuring a broad range of sign types and scenarios.

- **Data Preprocessing**: Video frames are enhanced using techniques such as noise reduction, frame segmentation, and normalization to ensure consistent, high-quality input for gesture recognition. These steps help minimize background interference and lighting inconsistencies during real-time detection.

- **Feature Extraction**: Advanced methods, such as optical flow and pre-trained Convolutional Neural Networks (CNNs), are used to extract both motion-based and high-level features from the sign language gestures.

- **Model Evaluation**: The system's effectiveness is assessed through performance latency, recall and F1-score, to ensure the model is performing optimally.

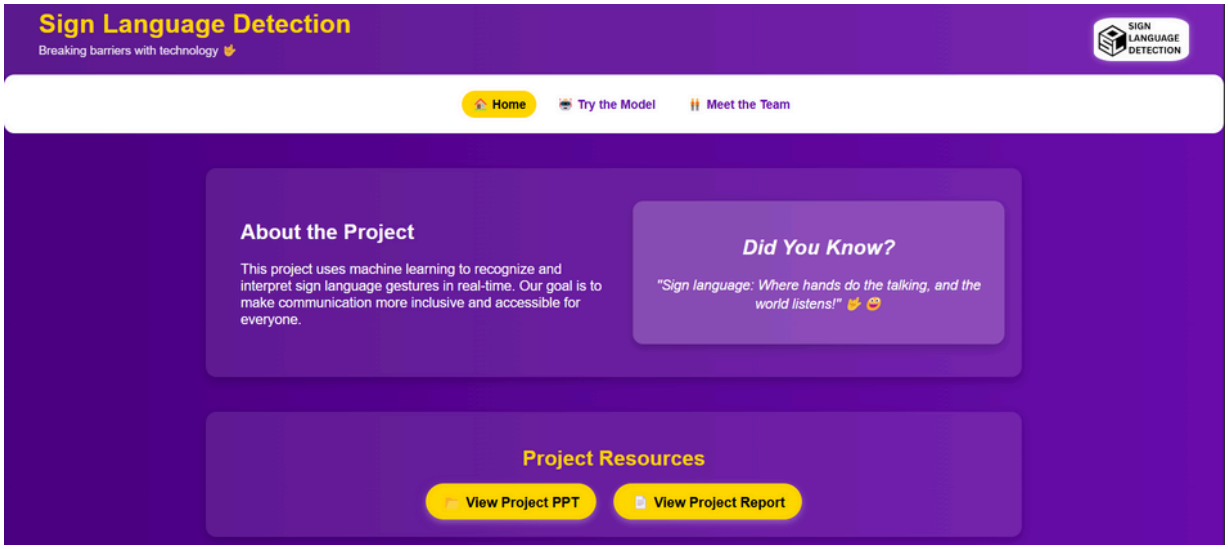
- **Real-Time Detection**: After training, the model is deployed for real-time gesture recognition, showcasing its ability to accurately interpret sign language gestures in live environments.

- The system is integrated with a web interface developed using HTML, CSS allowing users to easily interact with the real-time sign language detection system through an online platform.

- By combining deep learning with web technology, the project offers an inclusive and accessible tool for communication, making it practical for a wide audience, especially for individuals with hearing impairments.

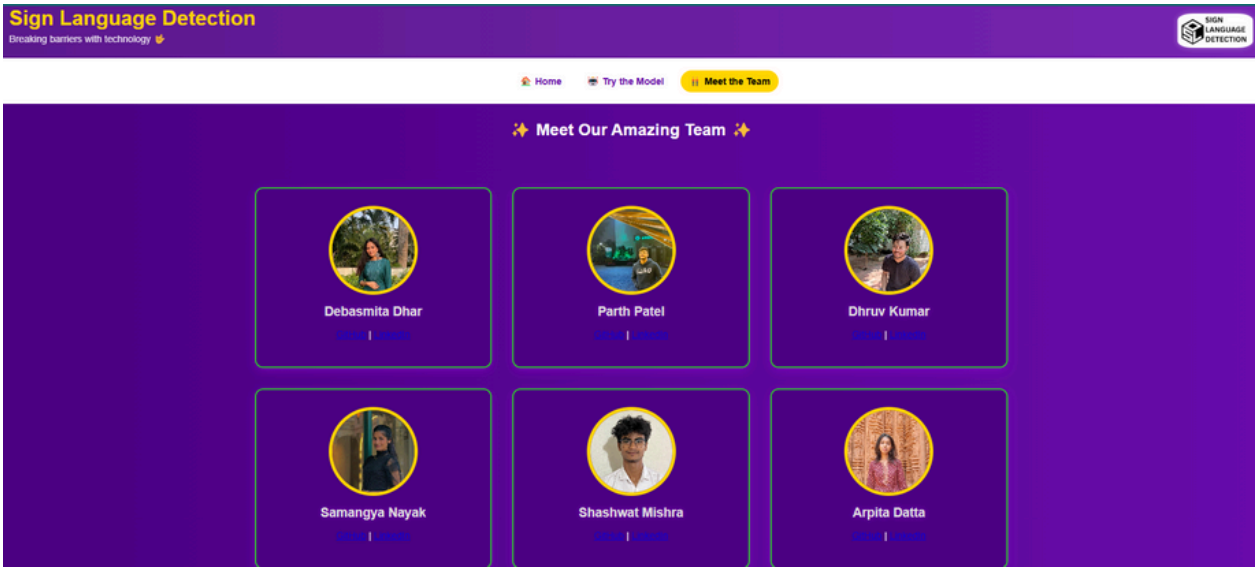
4.2 Website Designs:

Home: The homepage serves as an introduction to the face recognition project, outlining its goals and features.



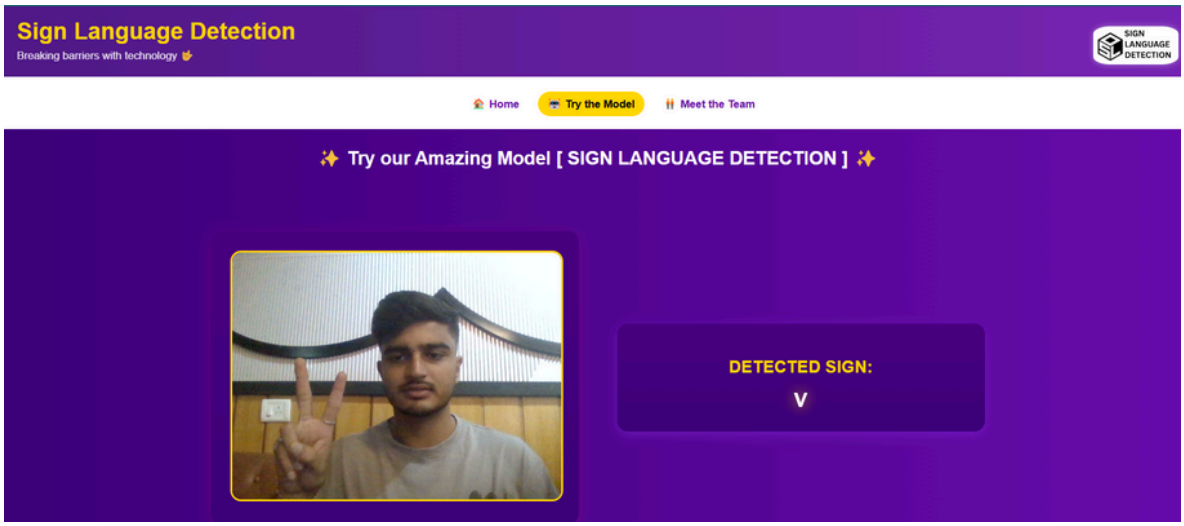
4.2.1 Web Home Page Design

Meet The Team: This section displays each team member's photo, name, and role in the project. It briefly highlights their contributions.Below each profile, clickable links to their LinkedIn and GitHub accounts are provided, allowing viewers to explore their professional profiles and project work



4.2.2 Web Meet The Team Section Design

Face Recognition Interface: The main feature of the website, this section allows users to interact with the face recognition system. It provides real-time face detection and person identification capabilities, enabling easy testing of the system's functionality.The website also includes audio feedback,you can hear the signs that appear, making the interaction more intuitive and accessible.



4.2.3 Web Sign Detection Interface

4.3 Model Integration

The trained model was connected to the web interface using Flask. A live webcam feed was added so users could perform gestures directly on the site. Once detected, the system displayed the predicted letter or word on-screen and used text-to-speech to play the audio, making the tool more interactive and inclusive.

4.3.1 **Website Execution**: To launch the website, the virtual environment with all necessary dependencies was activated through the command line. The user navigated to the project directory and ran the main Flask script. This started a local development server, generating a local host URL that could be opened in any browser. The entire system, camera feed, gesture recognition, and audio output was accessible through the website, offering a smooth and interactive real-time experience.

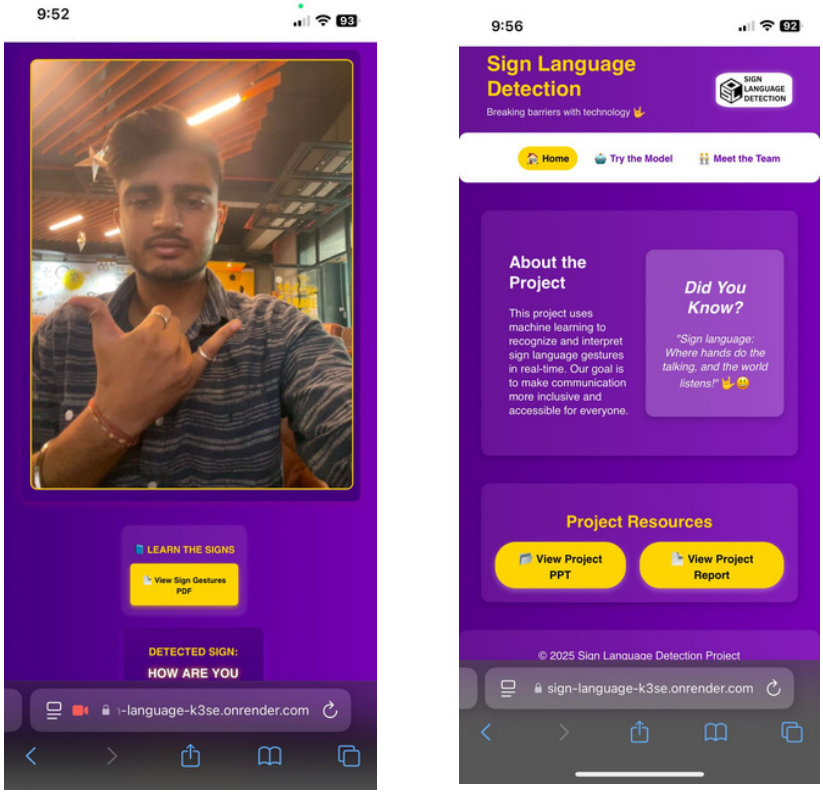
```
C:\Users\KIIT>myenv\Scripts\activate

(myenv) C:\Users\KIIT>cd C:\Users\KIIT\Desktop\major 8th

(myenv) C:\Users\KIIT\Desktop\major 8th>python app.py
```

4.4 Testing OR Verification Plan

After the completion of the project, it is essential to establish verification criteria to assess whether the project's objectives have been met effectively. Testing or verification ensures that the system delivers reliable and accurate results. Below are sample test cases for verification tailored to your sign language detection project:

1. **Test Case Title: Real-Time Gesture Detection Performance**

- Test Condition: Live input through a webcam with real-time sign language gestures.
- System Behavior: The system's ability to process and interpret gestures in real-time with minimal latency.
- Expected Result: Smooth, real-time gesture detection with accurate results and no significant delay in interpretation.



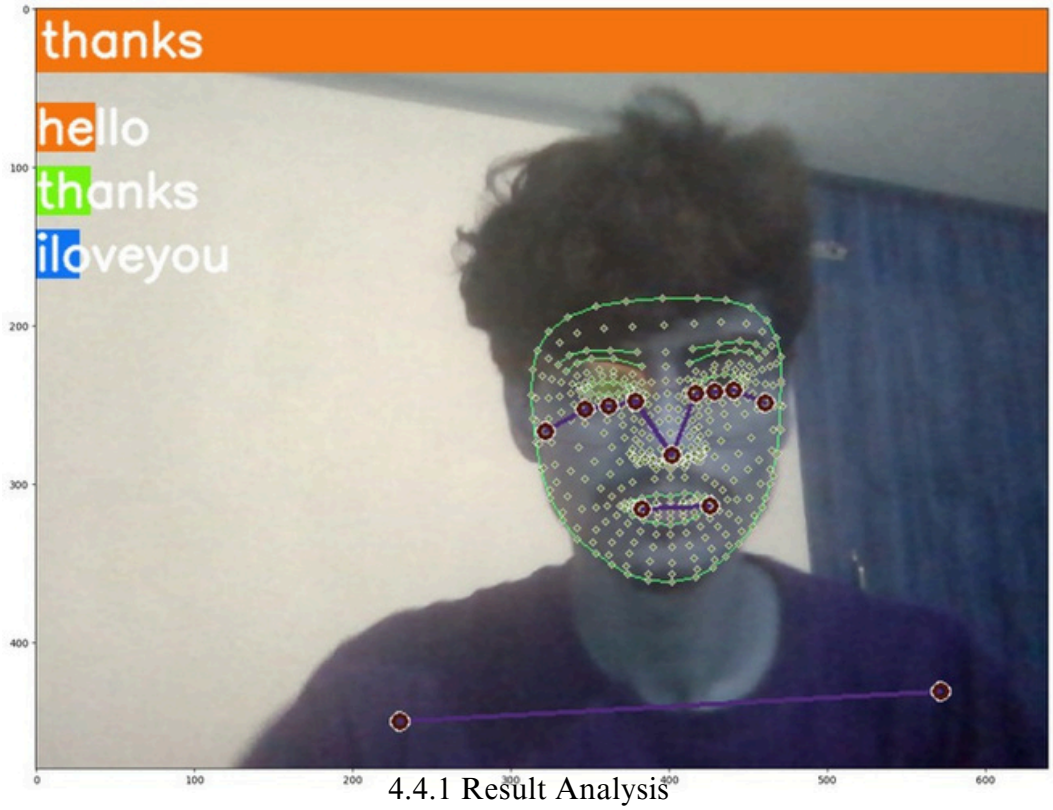
4.3.1 Real Time Guesture Detection

2. **Test Case Title: Model Evaluation Metrics**
   - Test Condition: Dataset with a variety of sign language gestures (with labels).
   - System Behavior: Evaluation of the model using metrics like accuracy, precision, recall, and F1-score.
   - Expected Result: High performance across the evaluation metrics, demonstrating that the system's predictions are reliable and consistent.

```
# 2. Prediction logic
keypoints = extract_keypoints(results)
sequence.append(keypoints)
sequence = sequence[-30:]  # Keep only the latest 30 frames

if len(sequence) == 30:
    # Predict using the model
    res = model.predict(np.expand_dims(sequence, axis=0))[0]
    print(actions[np.argmax(res)])  # Print predicted action
    predictions.append(np.argmax(res))

    # 3. Viz logic
    if np.unique(predictions[-10:])[0]==np.argmax(res):
        if res[np.argmax(res)] > threshold:  # Only append if the probability is above the threshold
            if len(sentence) > 0:
                if actions[np.argmax(res)] != sentence[-1]:  # Avoid duplicate actions in sentence
                    sentence.append(actions[np.argmax(res)])
            else:
                sentence.append(actions[np.argmax(res)])
```

4.5 Result Analysis OR Screenshots

The result analysis of the face recognition and identification system focuses on evaluating the performance of the model across various metrics, such as accuracy, precision, recall, and F1-score. The system's effectiveness in recognizing faces under different conditions (lighting, angles, and occlusions) is carefully assessed. Additionally, the confidence scores for each identification provide insight into the model's reliability and accuracy in real-world scenarios. Performance is also analyzed based on the model's ability to generalize across diverse datasets, ensuring robustness. Results are visualized through performance charts and matrices, allowing for easy identification of areas for improvement. The web interface's real-time performance is also evaluated for responsiveness and user interaction.



4.4.1 Result Analysis

4.6 Quality Assurance

The Quality Assurance process ensures that the sign language gesture detection system meets the established quality guidelines. The system is developed with attention to detail and accuracy, ensuring reliable gesture recognition and real-time interpretation. This rigorous approach aims to provide an effective tool for real-time sign language communication, enhancing accessibility and promoting inclusivity for the hearing-impaired community. The system's performance and usability are thoroughly tested to ensure it delivers valuable results in both practical and real-world applications.

4.6.1 Performance Improvements:

Latency was reduced for faster gesture detection, and the site layout was made responsive for use on phones and tablets. The text-to-speech output was refined for clearer audio. File sizes were optimized to speed up loading times and reduce unnecessary resource usage.

Chapter- 5
Voice Integration

5.1 Voice Feedback-

The playsound module is integrated into the system to provide real-time audio feedback. When a gesture is recognized by the trained model, the system maps the predicted label to a corresponding audio file stored in the system directory and plays it back using the playsound() function. This auditory feedback enhances user experience, especially for users with visual impairments or for scenarios where immediate confirmation of the detected gesture is essential.

The audio files used are in the .wav (Waveform Audio File Format). .wav is a standard digital audio file format developed by IBM and Microsoft. It is commonly used for storing uncompressed audio data, which makes it ideal for applications that require high audio quality and low processing overhead. Key characteristics of .wav files include: Uncompressed Format: Unlike formats like .mp3, .wav files typically store raw PCM (Pulse-Code Modulation) audio data without compression, preserving original sound quality.

Fast Playback: Because there is no need for decompression, .wav files can be played instantly, which is particularly useful for real-time applications like gesture-based audio feedback.
Wide Compatibility: The format is supported across all major platforms and programming environments, including Python, making it a reliable choice for cross-platform audio playback.
Customizability: Developers can easily create, edit, or replace .wav files to update the audio response for each gesture.
By using .wav files, the system ensures clear and immediate auditory responses, crucial for an interactive sign language recognition application.

WAV Audio File Format

The WAV (Waveform Audio File Format) is a standard audio file format developed jointly by IBM and Microsoft. It is one of the most widely used formats for storing high-quality audio on Windows-based systems.

5.2 - Key Features of WAV Files:

Uncompressed Audio:

WAV files typically store raw audio in the form of PCM (Pulse Code Modulation). This means the audio is stored exactly as recorded, without any loss of quality due to compression.

High Quality:

Because the format is uncompressed, it offers superior sound quality, making it suitable for applications where clarity and precision are important—such as professional audio recording, broadcasting, and speech-based systems.

Fast Playback:

WAV files do not require decompression before playback. This allows for instant and seamless audio playback, which is ideal for real-time applications like gesture recognition feedback.

Usage of playsound in the Project

In this sign language recognition project, the playsound library is integrated to provide audio feedback whenever a gesture is recognized by the trained machine learning model. Here's how it's used:

Gesture Detection:

The system uses MediaPipe and OpenCV to detect hand gestures in real time from webcam input.

Gesture Classification:

A trained model classifies the hand gesture and assigns it a corresponding label (e.g., “HELLO”, “YES”, “NO”).

Audio Playback:

Once the gesture is identified, the program constructs the path to a corresponding .wav file (e.g., HELLO.wav) stored in a designated audio directory.

```
audio_path = os.path.join(audio_directory, f"{predicted_character}.wav")
if os.path.exists(audio_path):
    playsound(audio_path)
```

- This plays the audio message that matches the recognized gesture, giving instant auditory feedback to the user.
- Improving Accessibility and Interaction:
- This use of playsound makes the system more interactive and accessible, especially for users with hearing or speech difficulties, by turning sign language into spoken output.

Larger File Size:

Since there is no compression, WAV files are significantly larger than formats like MP3 or AAC. This is a trade-off for maintaining audio fidelity.

Widely Supported:

WAV is supported across all major operating systems and audio players, and it integrates easily with programming languages like Python, especially when using libraries like playsound or pygame.

Usage in This Project:

In the context of the sign language recognition system, WAV files are used to store the audio output corresponding to recognized gestures. When a user performs a gesture, the model identifies it and triggers the playback of the respective .wav file (e.g., "HELLO.wav" or "THANKYOU.wav"). This provides clear and immediate audio feedback, enhancing both usability and accessibility

5.3 - Playsound Library

The playsound library is a simple, cross-platform Python module used to play audio files. It is lightweight and easy to implement, requiring minimal setup and no additional dependencies for basic playback.

Key Features of playsound:

Cross-Platform Compatibility:

Works on Windows, macOS, and Linux, making it suitable for most development environments.

Simplicity:

The library has a very simple interface—you only need one line of code to play an audio file:

```
from playsound import playsound
playsound('path_to_audio.wav')
```

Supports WAV and MP3 Files:

Although .wav files are recomme
nded for better compatibility, playsound can also play .mp3 files, provided the system has the proper media support.

Synchronous Playback:

The default behavior is synchronous, meaning the script will wait until the audio finishes playing before continuing. However, this can be managed using multithreading if non-blocking behavior is needed.

Chapter 6 Standards

Adopted

6.1 Design Standards 6.1.1

IEEE Standards:

- **IEEE 730** - Standard for Software Quality Assurance Plans: Defines the essential components of a quality assurance plan, covering all project aspects such as data collection, image preprocessing, face detection, and model evaluation.
- **IEEE 830** - Recommended Practice for Software Requirements Specifications: Guides in documenting system requirements, including the functional requirements needed for the face recognition process.

6.1.2 ISO Standards:

- **ISO/IEC 25010** - Systems and Software Engineering - Systems and Software Quality Requirements and Evaluation (SQUARE): Defines quality models and metrics to evaluate the effectiveness, accuracy, and performance of the face recognition system.
- **ISO 9126** - Software Engineering - Product Quality: Outlines quality attributes and metrics to guide the design toward producing a high-quality face recognition system, focusing on attributes like reliability, efficiency, and usability.

6.2 Coding Standards

- **Naming Conventions:** Use descriptive names for variables (e.g., face_coordinates, detection_confidence) and functions (e.g., detect_face, recognize_person).
- **Modularization:** Divide code into logical modules and functions, each with a single responsibility (e.g., face detection, feature extraction, model training).
- **Classes:** Encapsulate related functionality in classes and follow object-oriented design principles to create reusable, maintainable code.
- **Comments and Documentation:** Use comments to explain complex logic, and include docstrings for modules, classes, and functions.
- **Exception Handling:** Use try-except blocks for robust handling of errors, such as file loading issues or model prediction failures.
- **Data Handling:** Use best practices for data handling, such as managing missing or corrupted images, standardizing image sizes, and ensuring data consistency.
- **Documentation:** Maintain a clear project structure and document key aspects of the code and functionality.

6.3 Testing Standards

6.3.1 IEEE Standards:

- **IEEE 829** - Standard for Software Test Documentation: Provides templates for documenting various testing aspects, including test plans, test design specifications, test cases, and test procedures. **IEEE 1012** - Standard for Software
- Verification and Validation: Ensures that the face recognition system meets specified requirements through verification and validation processes, such as checking model performance and system accuracy.

6.3.2 ISO Standards:

- **ISO 29119** - Software and Systems Engineering - Software Testing: A multipart standard providing guidelines for the testing process, test documentation, and test techniques. **ISO**
- **25051** - Software Engineering - Software Product Quality Requirements and Evaluation (SQuaRE): Although focused on Commercial Off-The-Shelf (COTS) software, it provides principles useful for testing the reliability and effectiveness of face recognition systems.

Chapter 7 Conclusion and Future Scope

The "Sign Language Detection Using Action Recognition with Voice Output" project successfully demonstrates the use of deep learning and action recognition techniques to interpret sign language gestures. Key stages included data collection, preprocessing, feature extraction, and real-time detection. By enhancing input quality and effectively capturing motion-based features, the system achieved accurate and responsive performance, making it a valuable tool for improving communication between individuals with hearing impairments and the wider community.

This project advances sign language detection by using deep learning and action recognition techniques to understand the flow and patterns of hand gestures. Future improvements may include fine-tuning the system with specialized sign language datasets, leveraging transfer learning, and expanding the gesture vocabulary. Overall, this work emphasizes the role of technology in promoting inclusivity and improving communication for individuals with hearing impairments.

7.2 Future Scope

1. Deployment in Real-World Security Applications: The system could be deployed in public spaces like airports or offices to enhance security protocols, automate attendance tracking, or offer personalized experiences.

2. Expanding Vocabulary: Increasing the number of signs in the system's database would allow users to communicate a wider array of words and phrases, making the tool more useful and flexible in everyday conversations.

3. Driver Speed Monitoring and Warning System: The face recognition system could be integrated with a driver monitoring system to detect the driver's facial expressions and alertness. By analyzing signs of fatigue or distraction, it could trigger a warning if the driver is about to exceed speed limits, enhancing road safety and preventing accidents. This feature could be further expanded to track driving behavior and improve overall traffic management systems.

4. Exploring Advanced Models: Experimenting with newer, more advanced architectures such as Transformers or 3D CNNs could help the system gain a better understanding of the nuances in sign language gestures, leading to even higher recognition precision.

5. Mobile and Web App Development: Creating a mobile or web-based version of the system would make real-time sign language recognition easily accessible on smartphones and computers, broadening its reach and enabling communication in a variety of contexts.

6. Supporting Multiple Sign Languages: Incorporating additional sign languages into the system would ensure that users from different regions and cultural backgrounds could benefit from it, promoting inclusivity and cross-cultural communication.

7. Optimizing for Real-Time Performance: Improving the system's processing speed would enable smoother, more natural conversations, even on devices with lower computational power, such as smartphones. This would make real-time sign language recognition more practical in daily interactions.

8.Integrate an AI chatbot for real-time responses: enhance the system's interactivity and usability, an AI chatbot can be integrated to provide real-time conversational responses. Once a gesture is recognized and converted into text, this text can be passed as input to an AI-powered chatbot, such as one built using OpenAI's GPT API or a custom-trained NLP model.

9.In the future, this system can be implemented in public spaces like metros, airports, and government offices to assist the hearing-impaired. Users can perform gestures to ask questions, and the system will respond with real-time voice output.

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SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

SIGN LANGUAGE DETECTION USING ACTION RECOGNITION WITH VOICE OUTPUT

DEBASMITA	DHAR	2105117
PARTH	PATEL	21052512
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SAMANGYA	NAYAK	21052526
SHASHWAT	MISHRA	21053356
ARPITA	DATTA	21053382

Abstract:

This study presents a real-time sign language detection system developed using Python and action recognition techniques. The system captures and interprets hand gestures through a process that includes video input, preprocessing, feature extraction, and gesture classification. Methods like optical flow are used to enhance motion-based feature quality. Evaluated using metrics such as accuracy and F1-score, the system demonstrates strong performance, highlighting its potential as a practical tool for real-time sign language interpretation.

Individual contribution and Findings:

Model Evaluation & Performance Testing:
(Debasmita Dhar [2105117])

This member was responsible for evaluating the overall performance of the trained gesture recognition model. They designed test cases and conducted real-time trials to assess how accurately the system detected and classified hand gestures under varying conditions, such as different lighting, hand speeds, and angles.

They measured and documented key performance metrics, including accuracy, precision, recall, and F1-score, to ensure the reliability of the model. In addition, they monitored latency to confirm the system could operate in real-time without lag. Their analysis helped identify areas of improvement and supported decisions related to cooldown timing, audio synchronization, and frame skipping, contributing to a smoother and more stable user experience.

Video Capture, Hand Landmark Detection & Audio Playback Integration:
(Samangya Nayak [21052526])

This member was responsible for setting up the real-time video feed using OpenCV and integrating the MediaPipe library for accurate detection of hand landmarks. Their work involved ensuring smooth webcam functionality, stable frame capture, and reliable tracking of hand gestures. They implemented the drawing of landmarks and bounding boxes around detected hands, contributing to real-time visual feedback. In addition to the visual system, they also worked on the audio playback component of the project using the Pygame library. This included configuring Pygame's mixer module to play gesture-based .wav files, avoiding overlapping sounds, and ensuring seamless voice output that synchronized with gesture detection.

Feature Extraction, Data Formatting & Audio Logic Handling:
(Dhruv Kumar [21052513])

This member focused on processing the hand landmark data captured through MediaPipe. They handled the normalization and feature extraction, transforming landmark coordinates into structured vectors suitable for model input (84 values for two hands). They also managed padding logic to account for cases where only one hand was visible. Alongside this, they contributed to the audio functionality by building the logic that mapped each predicted gesture to its corresponding audio file. They implemented mechanisms to prevent repeated audio playback for the same gesture and added error handling to manage missing or misnamed audio files, ensuring a smooth user experience.

Gesture Prediction & Output Display:
(**Shashwat Mishra [21053356])**

This member led the integration of the machine learning model used for gesture recognition. They loaded the pre-trained model from a .pickle file and implemented the logic for making predictions based on the processed input features. They were also responsible for ensuring that the system displayed the correct gesture label on the screen in real time, along with the bounding boxes provided by the landmark detection module. Additionally, this member worked on refining model performance, testing the system under various conditions, and improving prediction stability and reliability across different hand gestures.

Homepage Design & Website Integration:
(Arpita Datta [21053382])

This member was responsible for designing and implementing the homepage of the website. Using HTML and CSS, they created an engaging and user-friendly layout featuring a welcome animation, project introduction, and resource download section. The homepage was styled with custom fonts, gradient backgrounds, and smooth animations to enhance visual appeal. Navigation links to other parts of the site were also implemented to ensure intuitive flow. Additionally, they managed the integration of the homepage with Flask to ensure it rendered correctly when the web server was run.

Try Model Interface, Model Integration, & Meet the Team Section:
(Parth Patel [21052512])

This member worked on building the model interaction page and the team introduction section. In the “Try the Model” page, they integrated a live camera feed interface using JavaScript and HTML, allowing users to test the gesture recognition model in real time. They also ensured the predictions were displayed clearly with styled output boxes. For the “Meet the Team” section, they created profile cards with member photos, names, roles, and clickable GitHub and LinkedIn links, all arranged with responsive design using CSS. The layout was interactive, visually consistent, and optimized for various devices.

Full Signature of Supervisor: Full signature of the student:

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