PROJECT REPORT

On

SignSpeak

Submitted by

Palak Parikh (IU2141231213)
Pranav Sondagar (IU2141230280)

In fulfillment for the award of the degree

Of

BACHELOR OF TECHNOLOGY

In

COMPUTER SCIENCE & ENGINEERING

INSTITUTE OF TECHNOLOGY AND ENGINEERING

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AT

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In the partial fulfillment of the requirement
for the degree of
Bachelor of Technology
in
Computer Science & Engineering

PREPARED BY

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UNDER GUIDANCE OF

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SUBMITTED TO

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CANDIDATE’S DECLARATION

We declare that 7th semester report entitled “**SignSpeak**” is our own work conducted under the supervision of the guide Dipali Jitiya

We further declare that to the best of our knowledge, the report for B.Tech 7th semester does not contain part of the work which has been submitted for the award of B.Tech Degree either in this university or any other university without proper citation.

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INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
COMPUTER ENGINEERING
2024 -2025

CERTIFICATE

Date: 18 - 10 - 2024

This is to certify that the project work entitled “**SIGNSPEAK”** has been carried out by **PALAK PARIKH** under my guidance in partial fulfillment of degree of Bachelor of Technology in **COMPUTER SCIENCE & ENGINEERING (Final Year)** of Indus University, Ahmedabad during the academic year 2024 – 2025.

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ABSTRACT

This project focuses on the development of a real-time system for the conversion of sign language into text and speech, and vice-versa, to facilitate seamless communication between individuals with hearing impairments and those without. The proposed system integrates advanced technologies such as Convolutional Neural Networks (CNN), LSTM, image processing is to achieve accurate and efficient translation between sign language and spoken language. The use of LSTM plays a pivotal role in the recognition of sign language gestures from video input.

The model is trained on a diverse dataset of sign language gestures, allowing it to learn and generalize the intricate hand movements and expressions inherent in sign language communication. This deep learning approach enhances the system's ability to recognize a wide range of gestures with high accuracy.

Image processing techniques are employed to preprocess the video input, extracting relevant features and reducing noise to enhance the overall performance of the system. The integration of image processing not only contributes to the accuracy of gesture recognition but also ensures robustness in varying lighting conditions and background environments.

The real-time nature of the system ensures minimal latency in the translation process, enabling instantaneous communication between individuals using sign language and those relying on spoken language. The proposed solution holds promise in breaking down communication barriers and fostering inclusivity in various social and professional settings.

Sign language is a vital form of communication used by millions of people worldwide, particularly within the deaf and hard-of-hearing communities. Despite its importance, there remains a significant communication barrier between sign language users and non-signers in everyday situations, such as social interactions, public services, and workplaces.

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ABBREVIATION

Abbreviations used throughout this whole document for SignSpeak report are:

CNN	Convolutional Neural Network
LSTM	Long Short Term Memory
SLR	Sign Language Recognition
RGB	Red, Green, Blue (color model used in image processing)
AI	Artificial Intelligence
ML	Machine Learning
CV	Computer Vision
FPS	Frames Per Second
IoU	Intersection over Union (for gesture detection accuracy)
UI	User Interface
Mediapipe	A library for real time hand detection
GPU	Graphics Processing Unit
NLP	Natural Language Processing

CHAPTER 1

INTRODUCTION

- **Project Summary**
- **Project Purpose**
- **Project Scope**
- **Objective**
- **Synopsis**

1.1 PROJECT SUMMARY

The goal of our project is to develop novel approaches that help Deaf and hearing people communicate with each other. Our goals are very clear: we want to create technologies that can smoothly translate spoken language into sign language and vice versa. We outline the parameters of our work, lay out our approach, and strive to offer workable, immediate solutions that improve these communities' inclusivity and communication.The project aims to create a real-time system that transforms sign language movements into readable text, enabling seamless communication in a variety of social and professional settings.

The system was created utilizing computer vision and machine learning algorithms. It employs a camera to collect hand motions, then processes the images to identify and isolate the gestures before recognizing and classifying them with a convolutional neural network (CNN). The neural network is trained on a vast dataset of sign language motions to ensure accuracy and robustness under a variety of situations, including lighting, hand position, and shape. In continuous signing, Long Short-Term Memory (LSTM) models are used to process sequential gestures and convert them into meaningful text or words.

The text generated by identified gestures is presented in real time on a user-friendly interface. The system's potential applications include real-time communication assistance for public services, educational tools for learning sign language, and interaction with mobile apps or wearables. By providing an easy, scalable, and customizable solution, this initiative helps to create a more inclusive environment for sign language users.

1.2 PROJECT PURPOSE

The purpose of the Sign Language to Text Conversion project is to bridge the communication gap between individuals who rely on sign language and those who do not. Sign language is the primary mode of communication for many deaf and hard-of-hearing individuals, but it often presents challenges in interacting with the broader population who may not understand it.

This project seeks to provide an accessible and efficient solution by developing a system that can accurately convert sign language gestures into readable text in real-time. By leveraging computer vision and machine learning techniques, the system aims to recognize sign language gestures, translate them into text, and even convert that text into speech, enabling smoother and more effective communication.

The goal is to enhance inclusivity and accessibility in various social, educational, and professional environments, ensuring that sign language users can interact seamlessly with others. This system can serve as an essential tool in public services, educational institutions, workplaces, and other settings where communication barriers exist, promoting better understanding and interaction for all parties involved.

1.3 PROJECT SCOPE

The **scope of the Sign Language to Text Conversion project** focuses on creating a robust and scalable system that can bridge communication gaps between sign language users and non-sign language users. It employs a combination of **computer vision** and **machine learning** techniques to convert hand gestures into readable text in real time. The project's scope includes both technical and societal aspects.

Technically, the system is designed to function across various environments, handling challenges such as changes in lighting conditions, variations in hand shapes, and different hand orientations. **Convolutional Neural Networks (CNNs)** are employed to accurately detect and classify gestures, while **Long Short-Term Memory (LSTM)** models manage the sequential nature of gestures in continuous signing. This makes the system flexible and capable of recognizing not only individual signs but also complex phrases, ensuring its applicability in real-world situations.

The system is adaptable for integration with multiple platforms such as **mobile applications**, **wearables**, and **desktop interfaces**, broadening its scope to serve a wide range of use cases. It could be used in personal communication tools for individuals, as well as in **public services**, **educational settings**, and **workplaces**.

From a societal perspective, the project plays a critical role in enhancing **inclusivity** and **accessibility**. It aims to improve communication between the **deaf and hearing communities** in various professional, educational, and social environments. The system's application extends beyond personal interactions, allowing sign language users to participate more fully in public services and professional spaces, ultimately contributing to greater inclusivity and accessibility for all.

1.4 OBJECTIVE

The primary objective of the "Sign Language to Text Conversion" system is to develop an efficient and user-friendly application that bridges the communication gap between individuals who are deaf or hard of hearing and those who do not understand sign language. The system aims to recognize and translate sign language gestures into written text in real-time, allowing for seamless and inclusive communication in various settings such as education, workplaces, public services, and social interactions.

- ➔ Implement advanced gesture recognition technology, utilizing machine learning and computer vision techniques, to accurately identify a wide range of sign language gestures.
- ➔ Ensure that the system can process and translate gestures into text in real time with minimal delay, allowing for smooth and natural conversations.
- ➔ Design an intuitive and accessible user interface that can be easily used by individuals with varying levels of technical expertise, including both sign language users and non-users.
- ➔ Allow the system to operate without an active internet connection for better usability in remote or low-connectivity areas.
- ➔ Promote social inclusion by enabling non-signers to communicate effectively with sign language users, fostering better understanding and collaboration in diverse environments.

1.5 SYNOPSIS

The **Sign Language to Text Conversion project** aims to develop a system that allows for the real-time translation of sign language gestures into readable text. This solution employs **Convolutional Neural Networks (CNNs)** to accurately detect hand gestures and **Long Short-Term Memory (LSTM)** models to process sequential signs, ensuring continuous and fluid sign language recognition. The system captures gestures through a camera, processes them using machine learning, and outputs text in real-time, making communication more accessible for individuals who rely on sign language.

The project is designed to facilitate communication between **deaf individuals** and those who do not understand sign language by providing an intuitive, user-friendly interface. Its applications span various sectors, including **public services**, **education**, and **workplaces**, offering a scalable and adaptable solution for real-world use. By addressing communication gaps and promoting inclusivity, the project contributes to a more accessible environment for sign language users.

In addition to its core functionality, this project also emphasizes the adaptability of its system to various languages and environments. By incorporating a flexible design, the project allows for the training of the model on different sign language datasets, making it applicable across diverse regions and cultures. This customization potential ensures that the system can evolve to meet the needs of various communities, providing an inclusive solution that breaks down communication barriers not only for specific languages but also across multiple sign language variations worldwide.

CHAPTER 2

LITERATURE SURVEY

Sign language recognition and its conversion to text represent a multifaceted research area that integrates computer vision, machine learning, natural language processing, and human-computer interaction. This literature survey provides an overview of significant advancements and existing challenges in the field.

Initially, many systems concentrated on recognizing static gestures, such as hand shapes and positions. However, recent studies have shifted towards dynamic gestures that involve continuous signing. For instance, Fang et al. (2007) introduced a method utilizing data gloves to capture finger movements and hand shapes. Although this approach achieved high accuracy, its practicality was hindered by the need for specialized hardware, limiting its everyday usability.

Recent developments in computer vision and machine learning, particularly through deep learning techniques, have greatly enhanced sign language recognition capabilities. Li et al. (2020) improved gesture recognition by integrating Convolutional Neural Networks (CNNs) with Recurrent Neural Networks (RNNs), specifically Long Short-Term Memory (LSTM) networks. This combination effectively captured both spatial and temporal features of dynamic sign language gestures, leading to improved performance in continuous recognition tasks.

Real-time gesture recognition is crucial for the practical implementation of sign language recognition systems. Several approaches have been developed to optimize these systems for speed and accuracy, addressing the need for immediate translation in communication contexts.

Despite these advancements, several challenges persist in the development of effective sign language to text conversion systems. One major challenge is the complexity inherent in continuous signing; unlike spoken languages, sign languages are highly dynamic and involve not only hand gestures but also facial expressions and body postures. The ability to recognize transitions between signs (co-articulation) remains difficult, as systems adept at static gestures often struggle with continuous signing. Additionally, the scarcity of large, annotated datasets for training machine learning models poses a significant hurdle. Collecting and annotating sign language data demands specialized expertise and resources, complicating efforts to train models on diverse sign languages.

In conclusion, the literature on sign language recognition and conversion reveals substantial progress in both hardware and software solutions. Early systems relied heavily on specialized equipment for static gesture recognition, while modern methodologies leverage deep learning and computer vision technologies to facilitate real-time recognition of continuous gestures. Nonetheless, challenges related to continuous signing recognition, multilingual support, and dataset availability remain critical areas for future research. The "Sign Language to Text Conversion" project aims to build a comprehensive real-time translation system that accommodates various sign languages. This survey serves as a foundation for understanding the current state of research in sign language recognition and its application to text conversion while highlighting ongoing challenges that must be addressed for broader adoption.

CHAPTER 3

SIGNSPEAK

- **Introduction**
- **Why SignSpeak?**
- **Features**
- **Technology and Tools used**

3.1 INTRODUCTION

Communication is a fundamental human need, yet millions of people worldwide face barriers due to hearing impairments. Sign language serves as a primary mode of communication for the deaf and hard-of-hearing communities. However, a large portion of the population does not understand sign language, creating a significant communication gap. SignSpeak aims to bridge this gap by developing an innovative system that translates sign language gestures into written text in real-time.

Fig 3.1.1 Product Logo

The SignSpeak system leverages advanced technologies such as computer vision, machine learning, and natural language processing to recognize hand gestures, and movements. It then converts these elements into accurate, readable text, facilitating communication between sign language users and non-signers. By offering a seamless, real-time translation solution, SignSpeak promotes inclusivity in various social, educational, and professional settings, enabling easier interaction and understanding between communities.

The inspiration behind SignSpeak stems from the growing need for accessible technologies that promote inclusivity for people with hearing impairments. Traditionally, interpreters are required to facilitate communication between deaf individuals and non-signers, but this solution is not always feasible or available in everyday situations. SignSpeak offers a technological alternative by automatically translating sign language into written text without the need for human intermediaries, enabling more independent communication for deaf individuals.

The core goal of SignSpeak is to make communication effortless and accessible, allowing people who use sign language to converse naturally with those who do not, breaking down barriers and fostering a more inclusive society.

Real-Time Translation: The system processes sign language gestures captured via a camera and instantly translates them into text that can be displayed on a screen, ensuring fluid conversations without significant delays.

Customization and Learning: Train the system to recognize personalized signs or unique gestures, improving accuracy and adapting to individual signing styles.

SignSpeak aims to revolutionize the way people with hearing impairments interact with the world. By providing an accessible and user-friendly platform for real-time sign language translation, SignSpeak empowers individuals to communicate independently in a variety of settings—from everyday conversations to professional environments. The system not only promotes inclusivity but also paves the way for a future where communication barriers between the deaf and hearing communities are significantly reduced.

SignSpeak is more than a technological innovation—it is a step toward a more inclusive society where language differences, whether spoken or signed, do not stand in the way of meaningful communication.

3.2 Why SignSpeak?

The SignSpeak project, a real-time sign language to text conversion system, is essential for several reasons. These reasons highlight the need to bridge the communication gap between the deaf or hard-of-hearing community and the broader population who do not understand sign language. Here are the key explanations and reasons:

1. **Lack of Widespread Knowledge of Sign Language**

   Despite sign language being a crucial form of communication for millions of people with hearing impairments worldwide, very few hearing individuals are proficient in it. In most social, educational, and professional settings, people without knowledge of sign language struggle to communicate effectively with those who rely on it. This language barrier creates challenges for deaf or hard-of-hearing individuals to participate fully in day-to-day activities.

   - **Reason:** SignSpeak addresses this gap by automatically converting sign language gestures into readable text, ensuring that people who do not understand sign language can still engage in meaningful communication with deaf individuals without the need for prior knowledge of the language

2. **Limited Availability of Human Interpreters**
   Professional sign language interpreters are commonly used to facilitate communication in critical settings, such as hospitals, courts, or educational institutions. However, interpreters are not always available, especially in spontaneous or less formal situations like casual conversations, customer service interactions, or social events. Additionally, relying on interpreters can sometimes be costly or impractical in everyday scenarios.

   - **Reason:** SignSpeak offers a cost-effective, always-available alternative to human interpreters. By using technology to translate sign language into text, individuals who are deaf or hard of hearing can communicate independently, reducing their reliance on human interpreters.

3. **Promoting Social Inclusion and Equal Opportunities**

   People with hearing impairments often face social isolation due to their inability to communicate with hearing individuals. This communication gap can limit their access to opportunities in education, employment, and social interaction, leading to feelings of exclusion. In professional settings, deaf individuals might miss out on key discussions or find it challenging to interact with colleagues who do not know sign language.

   - **Reason:**Byfacilitating real-time communication, SignSpeak can promote social inclusion and help level the playing field for deaf individuals. In environments like classrooms or workplaces, SignSpeak empowers users to engage in conversations, participate in group discussions, and access information without facing communication barriers. This, in turn, fosters equal opportunities and allows for greater inclusion in society.

4. **Educational Benefits**

   Educational environments are one of the key areas where communication barriers between sign language users and non-users can be detrimental. Deaf students in mainstream educational settings often face difficulties accessing the same level of instruction as their hearing peers due to the language gap. While interpreters and captioning services help, they may not always be sufficient or timely.

   - **Reason:**With SignSpeak, deaf students can actively participate in class discussions by signing their questions or comments and having them translated into text instantly. This can improve the educational experience by fostering more interactive and inclusive learning environments.

3.3 FEATURES

The SignSpeak project for sign language to text conversion incorporates several key features designed to enhance its usability, accuracy, and effectiveness. Here's a detailed overview of these features:

1. **Real-Time Gesture Recognition**
   - **Functionality:** SignSpeak captures sign language gestures using a camera (e.g., a smartphone or webcam) and translates them into text instantly.
   - **Technology Used:** The system employs advanced computer vision techniques, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs), particularly Long Short-Term Memory (LSTM) units, to analyze video frames and identify gestures.
   - **Importance:** This feature ensures that conversations flow naturally without significant delays, allowing for smoother interactions.

2. **Static and Dynamic Gesture Recognition**
   - **Static Gesture Recognition:** Recognizes individual signs or hand shapes (e.g., letters of the alphabet) that are typically held in a fixed position.
   - **DynamicGesture Recognition:** Captures movements that represent words or phrases, which involve transitioning between different signs and include facial expressions and body movements.
   - **Technology Used:** The integration of CNNs for spatial feature extraction and LSTMs for temporal analysis allows the system to distinguish between static and dynamic gestures effectively.
   - **Importance:** This capability enhances the system's accuracy by recognizing a broader range of signs and expressions

3. **Data Collection**
   - **Model Training:** To train the machine learning algorithms that power SignSpeak, a diverse and extensive dataset of sign language gestures is required. This dataset helps the system learn to recognize and interpret various signs accurately.

- **Performance Improvement:** Continuous data collection allows the system to improve its recognition accuracy over time, adapting to the unique signing styles of users and variations in different sign languages.

4. **User-Friendly Interface**
   - **Design:** SignSpeak incorporates an intuitive and accessible interface that makes it easy for both sign language users and non-signers to navigate.
   - **Display Options:** The translated text can be displayed in proper formats and can also integrate voice output for an inclusive experience.
   - **Importance:** A user-friendly interface is essential for ensuring that users of all technical skill levels can effectively utilize the system.

5. **Offline Functionality**
   - **Capability:** SignSpeak aims to provide offline functionality, allowing users to access the system without needing an active internet connection.
   - **Technology Used:** The models are designed to be lightweight and efficient, enabling them to run on local devices.
   - **Importance:** This feature is particularly valuable in areas with limited internet connectivity, ensuring that users can communicate anytime and anywhere.

6. **Security and Privacy Measures**
   - **DataProtection:** SignSpeak incorporates security features to protect user data and privacy, especially when capturing video input.
   - **UserControl:** Users have control over their data, including options to anonymize inputs or delete stored data.
   - **Importance:** Ensuring the security and privacy of users is crucial for building trust and encouraging the adoption of the technology.

3.4 Technology and Tools used:

Programming Language:

- Python

Libraries and Frameworks:

- TensorFlow/Keras
- OpenCV
- MediaPipe
- Seaborn
- Scikit-learn (sklearn)
- Matplotlib

Data Handling:

- NumPy

Data Storage:

- Google Drive

Development Environment:

- Jupyter Notebook/Anaconda
- VS Code
- Google Colab

User Interface:

- CustomTkinter

Hardware:

- Webcam
- Laptop

CHAPTER 4

PROJECT MANAGEMENT

- **Project Planning Objectives**
- **Project Scheduling**
- **Risk Management**

4.1 PROJECT PLANNING OBJECTIVES

The project planning objectives for the Sign Language to Text Conversion are:

1. **Define the project scope and requirements:** The first objective is to clearly define the scope and requirements of the project, including the features and functionality of the sign language to text conversion system, the target users (such as individuals with hearing impairments), and the expected outcomes.

2. **Develop a project timeline:** The second objective is to create a project timeline that includes key milestones, deliverables, and deadlines for each stage of the project, from research and design to implementation and testing.

3. **Assign roles and responsibilities:** The third objective is to allocate roles and responsibilities to team members, such as project managers, developers, designers, testers, and any other relevant stakeholders involved in the project's success.

4. **Identify and mitigate risks:** The fourth objective is to identify potential risks that could affect the project's progress, such as technical challenges or resource constraints, and develop strategies to minimize or mitigate those risk

5. **Develop a budget:** The fifth objective is to establish a budget that covers all aspects of the project, including costs related to development, testing, deployment, and maintenance of the sign language to text conversion system.

6. **Monitor and evaluate progress:** The sixth objective is to continuously monitor and assess the project's progress, using key performance indicators (KPIs) to ensure the project stays on schedule and within budget.

By meeting these objectives, the project team can ensure that the sign language to text conversion system is developed efficiently, meets the needs of the target users, and is delivered within the planned resources and timeline.

4.1.1 Resources

The development of the Sign Language to Text Conversion system will require a variety of resources across several categories to ensure the project's success. Below is a description of each type of resource:

1. **Human Resources:** Human resources are the people who will be involved in designing, developing, and testing the system. They include, the project manager oversees the entire Sign Language to Text Conversion project, ensuring it stays on track in terms of time, scope, and budget. Software developers, including specialists in artificial intelligence, machine learning, and computer vision, are responsible for writing the code and building the system's core functionality. UX/UI designers focus on creating a user-friendly interface that is accessible to all users, particularly individuals with hearing impairments. Data scientists play a key role in training the machine learning models by analyzing and processing large datasets of sign language gestures. Testers and quality assurance professionals conduct thorough testing to ensure that the system accurately interprets sign language and converts it to text with minimal errors.

2. **Hardware Resources**: Hardware resources are the physical tools and devices required for development and testing. These include high-quality cameras to capture detailed images and videos of sign language gestures, ensuring precise recognition of hand movements. High-performance computers and servers are essential for running complex machine learning algorithms, processing large volumes of video data, and storing extensive datasets used for training and testing.

3. **Software Resources**: Software resources are the tools and platforms needed for development, testing, and deployment. These include programming languages like Python will be used to build the system, particularly for implementing machine learning and deep learning models. Machine learning frameworks such as TensorFlow or OpenCV will be essential for training neural networks to recognize and classify sign language gestures. The development process will utilize Integrated Development Environments (IDEs) like Visual Studio for coding and debugging. Version control tools like GitHub or GitLab will manage code versions and facilitate team collaboration, while testing and debugging tools will be employed for unit testing,

integration testing, and debugging to ensure smooth and accurate functionality of the system.

4. **Data Resources**

Data resources are essential for training the system to recognize and convert sign language gestures to text. These include, large datasets of annotated sign language gestures, user input data, and language models for accurate text translation. The development team will need to ensure that they have access to relevant data sources to train the system effectively, ensuring accurate and real-time sign language recognition and conversion for users.

Fig. No. 4.1.1 Current dataset

4.1.2 Project Development Approach

The development approach for the Sign Language to Text Conversion project will follow the **Incremental Development Approach**, which emphasizes building the system in smaller, manageable parts or increments. This approach allows the project to be developed step by step, where each new feature or component is integrated and tested as it is completed. Incremental development ensures that key functionalities are delivered early and continuously, allowing for regular feedback, evaluation, and improvements. This approach helps reduce risks by catching and fixing issues early, and it provides flexibility to adjust as new requirements emerge during development. As each part of the system is refined, it contributes to a final product that meets user needs and maintains high performance and accuracy.

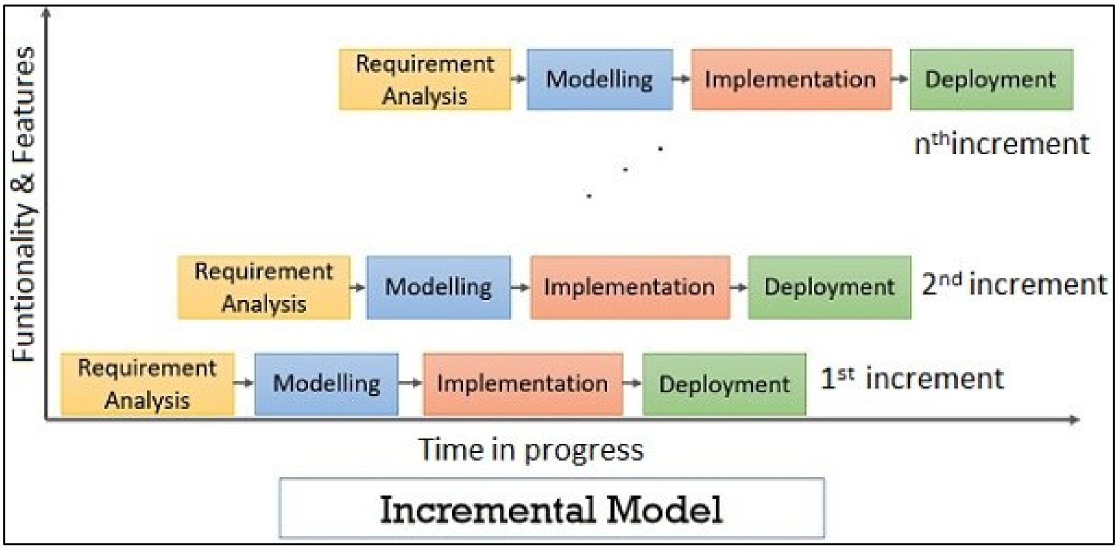


Fig. No. 4.1.2 Incremental Model

The Incremental Model process for SignSpeak will include the following stages:

1. **Requirements Gathering**

   In this step, the team works to understand the basic requirements of the project. Instead of trying to figure out every detail at the start, they outline the main goals and leave room to adjust or add requirements later. This flexibility is helpful when everything isn't clear from the beginning.

2. **Planning**

   Next, the project is broken down into smaller, manageable tasks. Each task is planned out, and the team decides which parts to work on first. The goal is to develop the project step by step, tackling one feature or component at a time instead of building everything all at once.

3. **Design**

   During this phase, the team creates initial designs and plans for how the project will work. Unlike traditional methods where everything is fully designed upfront, this approach allows the design to be adjusted and improved as the project progresses and new needs or ideas emerge.

4. **Implementation**

   Now, the team starts coding and building the project in small pieces. Each piece (like a feature or function) is developed on its own and then tested to make sure it works. The project grows over time as new parts are added with each iteration.

5. **Testing**

   After each part is built, it's tested right away. This helps the team catch any issues early and make sure everything works well together. Instead of waiting until the end to test the entire project, testing happens regularly throughout the process.

6. **Feedback and Refinement**

   At the end of each cycle, the team and other stakeholders review what has been built. They provide feedback, which is used to make improvements or adjustments. This feedback loop is key to ensuring the project meets expectations and functions as needed.

7. **Integration**

   As each new piece is developed, it's added to the existing system. This allows the team to make sure all parts of the project work well together. Any issues with how the different parts connect can be spotted and fixed early, rather than waiting until everything is built.

8. **Deployment**

   The project doesn't have to wait until everything is done before it's used. Early versions of the project can be deployed for testing or use by stakeholders. This allows for real-world feedback, which can then guide future improvements.

9. **Maintenance**

   Once the project is up and running, it doesn't stop there. As new needs come up or bugs are found, the team continues to make updates and improvements. This ensures the project stays useful and up to date over time.

4.2 PROJECT SCHEDULING

Project scheduling is a critical component in the successful delivery of the Sign Language to Text Conversion project, which aims to provide real-time translation of sign language gestures into text. It involves breaking down the project into smaller, manageable tasks and creating a timeline for completing each. The project manager must ensure the project stays within the agreed timeframe and budget, while making sure every team member is clear on their roles and responsibilities.

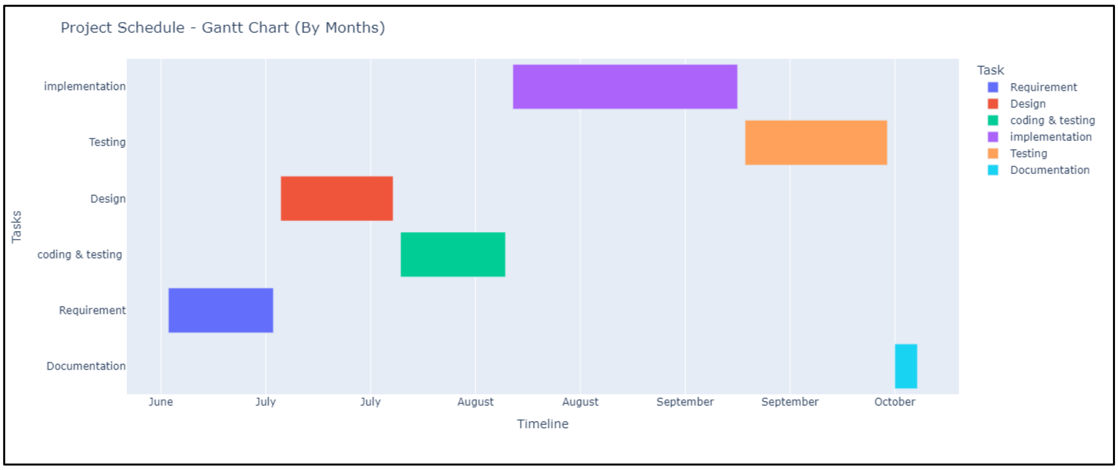


Fig. No. 4.2.1 Project Schedule

To schedule the Sign Language to Text Conversion project, we began by identifying the key deliverables and milestones such as designing the user interface, developing the gesture recognition algorithm, training the machine learning model, and testing the system for accuracy. These deliverables were divided into smaller, more specific tasks, with an estimated time for each task's completion. This approach helped us create a more accurate and realistic project timeline.

We also identified task dependencies to ensure that the team understands the sequence in which tasks should be completed. For example, data collection and annotation must be completed before training the machine learning model. Recognizing these dependencies allowed us to adjust the schedule as needed, ensuring a smooth progression of the project.

Once the timeline was established, team members were assigned tasks based on their expertise and availability. This optimized resource allocation, ensuring that the right people were working on the most appropriate tasks at the right time.

Overall, the scheduling process was essential for ensuring the successful delivery of the Sign Language to Text Conversion project. By breaking the project into smaller tasks and setting clear timelines, we managed the project efficiently, ensuring that it remained on track and within budget. The project management plan, along with the Gantt chart, provided a structured framework for tracking progress. Regular communication with the team ensured everyone was aligned with the project's goals. The project scheduling diagram for the Sign Language to Text Conversion system would typically include the following stages:

1. **Project initiation:** Identifying the project goals, scope, stakeholders, and risks, along with establishing a project charter and assembling the team.

2. **Requirements gathering:** Identifying the necessary features and functionalities through user research and interviews, with a focus on accuracy, usability, and accessibility.

3. **Design:** Creating wireframes, prototypes, and visual designs for the user interface, while defining the system architecture for gesture recognition and text conversion.

4. **Development:** Writing the code, integrating machine learning models, training the system using annotated datasets, and testing the recognition functionality.

5. **Quality assurance:** Conducting tests to identify bugs, errors, and usability issues. The system is tested for its ability to accurately convert sign language gestures into text, ensuring that it meets project requirements and user expectations.

6. **Deployment:** Releasing the system in a live environment, potentially starting with a beta version for initial user feedback. This includes setting up the necessary infrastructure for hosting and data processing.

7. **Maintenance and support:** Providing ongoing support by addressing bugs, improving system performance, and implementing user feedback for feature updates.

The scheduling diagram will also include key milestones, deadlines, and resource allocations such as team members and budget. This diagram provides a clear, visual representation of the project timeline, ensuring the system is developed on time and within budget.

Here are some important points related to project scheduling for the Sign Language to Text Conversion project:

1. **Task Breakdown:** The project is divided into smaller, manageable tasks such as data collection, algorithm development, user interface design, and testing. This granular approach helps in better time estimation and resource allocation.

2. **Milestones and Deadlines:** Key milestones such as model training completion, user interface prototype design, and testing phases are set with clear deadlines to track progress.

3. **Task Dependencies:** Critical dependencies are identified, such as the need for data collection before machine learning training or algorithm development before UI testing. Understanding these ensures smooth task transitions.

4. **Time Estimation:** Each task is given an estimated duration, based on its complexity. Tasks like model training and testing may require longer periods due to iterative improvements.

5. **Resource Allocation:** Team members, including developers, data scientists, and testers, are assigned tasks based on their skills and availability, ensuring efficient resource use.

6. **Continuous Testing and Feedback:** Testing and quality assurance occur throughout the development process, ensuring early detection of errors and continuous improvements to the system.

7. **Risk Management**: Potential delays due to issues like data quality or algorithm accuracy are accounted for in the schedule, with contingency plans to address these risks.

8. **Flexibility and Adaptability:** The project schedule remains flexible to accommodate adjustments based on user feedback, changes in requirements, or any unforeseen challenges.

9. **Regular Reviews:** Progress is reviewed regularly against the schedule, allowing for quick identification of delays or areas needing more focus, ensuring the project stays on track.

4.3 RISK MANAGEMENT

Risk management is a critical aspect of the Sign Language to Text Conversion project to ensure potential challenges are identified, analyzed, and mitigated proactively. For a project that involves machine learning, gesture recognition, and real-time text conversion, several risks need to be addressed:

1. **Data Quality and Availability Risks**
   - **Risk:** The project relies heavily on high-quality datasets of sign language gestures for training machine learning models. Inaccurate, insufficient, or biased data could affect the system's ability to accurately interpret gestures.
   - **Mitigation:** Ensure diverse and comprehensive datasets are collected and labeled properly. Collaborating with sign language experts and using open-source data can help reduce data quality issues.

2. **Algorithm Accuracy Risks**
   - **Risk:** The core of the system lies in recognizing sign language gestures accurately. There is a risk that the machine learning model may not achieve the desired accuracy, leading to incorrect or missed translations.
   - **Mitigation:** Implement multiple iterations of model training, validation, and testing with various algorithms and neural network architectures.

3. **Complex Gesture Recognition Risks**
   - **Risk:** Sign languages often involve complex gestures,like hand movements. The system may struggle with recognizing gestures in different lighting conditions, from various angles, or when gestures are made at different speeds.
   - **Mitigation:** Use advanced computer vision techniques, such as 3D motion tracking and multi-angle cameras, to capture gestures more accurately.

4. **Technology and Integration Risks**
   - **Risk:** Integration with different hardware or software environments may pose a challenge

- **Mitigation:** Use standardized APIs and modular code that allows easy integration across platforms.

5. **User Acceptance and Usability Risks**
   - **Risk:** There's a risk that the user interface or the system's overall usability may not meet the needs of the target audience, such as individuals with hearing impairments, resulting in poor adoption.
   - **Mitigation:** Involve users (especially from the deaf or hard-of-hearing community) throughout the design and testing phases. Conduct usability testing to ensure the interface is intuitive and accessible.

6. **Performance and Scalability Risks**
   - **Risk:** The system may not perform efficiently in real-time, especially when processing gestures with large datasets or running on devices with lower computational power.
   - **Mitigation:** Optimize the system for real-time processing by using efficient algorithms and hardware acceleration techniques (e.g., GPU usage). Design the system to be scalable, allowing it to handle more users and data as needed.

7. **Budget and Resource Risks**
   - **Risk:** The project could face budget overruns or delays due to unforeseen technical issues, additional resources needed, or extended development time.
   - **Mitigation:** Maintain a detailed and realistic budget and timeline, with buffer periods for unexpected delays.

8. **Team and Collaboration Risks**
   - **Risk:** Miscommunication, lack of clarity in roles, or insufficient collaboration between developers, data scientists, and stakeholders could delay progress.
   - **Mitigation:** Use Agile project management techniques to promote frequent communication and feedback loops. Hold regular team meetings to review progress, clarify roles, and adjust goals if needed.

CHAPTER 5

SYSTEM REQUIREMENTS

- **User Characteristics**
- **Functional Requirement**
- **Non-Functional Requirement**
- **Hardware and Software Requirement**

5.1 USER CHARACTERISTICS

When designing a Sign Language to Text Conversion system, it is crucial to consider the characteristics of the target audience. The success of the system will largely depend on how well it meets the needs of its users, particularly individuals who rely on sign language for communication.

The primary users of the Sign Language to Text Conversion system are individuals who are deaf or hard of hearing and use sign language as their primary mode of communication. These users need a solution that allows them to communicate easily with individuals who do not understand sign language. The system should be user-friendly and accessible, catering to a wide range of sign language users with varying levels of technical literacy.

In addition to direct users, the system may also be used by hearing individuals who need to communicate with those who use sign language, such as teachers, healthcare providers, and service personnel. These users are looking for an efficient way to understand sign language gestures and improve communication in educational, healthcare, or service environments.

The system may also appeal to researchers and developers in the fields of linguistics, accessibility, and assistive technology, as they seek tools for studying or improving communication for the deaf and hard-of-hearing community. For these users, accuracy and the ability to handle complex gestures in a variety of sign languages are key factors.

The users of this system value real-time translation, accuracy, and efficiency. Many may be busy individuals who need a solution that works reliably in everyday interactions, whether in personal, educational, or professional settings. For tourists or visitors in new regions, the system could also assist with communication across different sign languages.

It’s essential to consider that users may have different expectations and needs based on their demographics, location, and cultural background. Similarly, users may expect different levels of accuracy and real-time responsiveness based on the context in which they use the system (e.g., casual vs. professional settings).

In summary, the primary users of the Sign Language to Text Conversion system are individuals who rely on sign language and those who interact with them. These users value convenience, real-time translation, accuracy, and accessibility. Therefore, it is critical to consider the diverse user characteristics during the design and development phases to ensure the system effectively meets the needs and preferences of its target audience.

5.2 FUNCTIONAL REQUIREMENTS

The functional requirements for the Sign Language to Text conversion project define the system's essential behaviors, actions, and functions that it must perform to meet its goals. These requirements focus on how the system interacts with users and other systems to produce the desired outcome (i.e., converting sign language gestures into text). Here's a breakdown of the key functional requirements:

1. **Gesture Recognition**
   - Capture Hand Movements: The system must be able to capture hand gestures made by the user in real-time using a camera or motion-sensing technology.
   - Identify and Classify Gestures: The system must recognize specific hand gestures (i.e., signs) and classify them into corresponding sign language symbols. It should support a predefined set of sign language gestures.

2. **Text Conversion**
   - Map Gestures to Text: Once a gesture is recognized, the system must convert it into the corresponding text in the target language (e.g., English).
   - Display the Text: The converted text should be displayed in a text box or output area that the user can easily view and read.
   - Real-Time Text Output: The system should provide real-time conversion and display of text as the gestures are performed, without significant delays.

3. **System Integration**
   - Camera or Sensor Integration: The system should be able to access and use the device’s camera or an external sensor for gesture recognition.

4. **Performance Requirements**
   - Real-Time Processing: The system must process gestures and convert them to text within an acceptable response time (e.g., less than 1 second delay).
   - Low Latency: Gesture recognition and conversion should occur with minimal delay to ensure a fluid user experience.

5. **Security and Privacy**
   - Access Control: If the system supports multiple users, there should be proper authentication and authorization mechanisms to ensure data privacy for individual users.
   - Legal Compliance: The system must comply with any relevant local or international standards, such as data protection laws (e.g., GDPR) to ensure that user data is handled responsibly and ethically.
   - Industry Standards: The system should follow industry best practices for machine learning, AI ethics, and software development, especially in sensitive areas such as accessibility.

5.3 NON-FUNCTIONAL REQUIREMENTS

Non-functional requirements (NFRs) describe the system's performance characteristics, usability, security, and other aspects that are not related to specific functionalities but are critical for overall user satisfaction and system reliability. Here are the key non-functional requirements for the Sign Language to Text conversion project:

1. **Scalability**
    - Handling Increased Users: The system must scale to accommodate an increasing number of users if deployed on a server or cloud platform, without a decline in performance.

2. **Availability**
    - System Uptime: The system should have an availability of 99.9%, ensuring minimal downtime. If used in critical applications, such as for communication for deaf users, uptime is crucial.
    - Failure Recovery: In case of system failures, it must recover gracefully, allowing users to resume their activities without data loss or re-input of previous gestures.

3. **Usability**
    - Ease of Use: The user interface must be simple and intuitive, allowing users with no technical background to interact with the system efficiently.
    - Learnability: The system should be easy to learn, with minimal training or instructions required to understand how to start gesture recognition and view converted text.
    - Accessibility: The interface should follow accessibility guidelines (e.g., WCAG) to ensure that it's usable by people with various disabilities. This may include support for screen readers, high-contrast modes, and large font sizes.

4. **Reliability**
   - Accuracy of Recognition: The system should maintain a gesture recognition accuracy rate of at least 95%, ensuring that most recognized gestures are correctly converted to text.
   - Robustness: The system must remain stable under various conditions, such as changes in lighting for gesture capture or variations in gesture execution by different users.
   - Minimal Dependencies: The system should have minimal external dependencies, making it easier to install and run on different environments without requiring extensive configuration.

5. **Maintainability**
   - Modular Code Structure: The system must be developed in a modular manner to facilitate easy updates, bug fixes, and the addition of new features without impacting existing functionality.
   - Documentation: Comprehensive documentation should be provided for developers and users to assist with system maintenance, updates, and troubleshooting.
   - Testability: The system should be designed to support automated testing, allowing for regular and reliable tests to be conducted during the development and deployment phases.

6. **Extensibility**
   - Addition of New Features: The system architecture should allow for the addition of new features, such as support for more languages, without significant refactoring.
   - Plug-and-Play Models: New machine learning models or gesture libraries should be easily integrable into the system, allowing updates in recognition algorithms without major system changes.

7. **Interoperability**
   - API Availability: Provide an API (Application Programming Interface) that allows other applications to interact with the system, enabling the retrieval of gesture recognition data or text output.

5.4 HARDWARE AND SOFTWARE REQUIREMENT

The hardware requirements for the Sign Language to Text conversion project depend on the system's complexity, the type of devices used for gesture capture, and the processing power needed for real-time gesture recognition. Below are the typical hardware components needed for both the development and deployment environments:

5.4.1 Hardware Requirements

1. **Camera or Motion Sensor**
   - High-Resolution Camera: A camera with a minimum resolution of 720p (preferably 1080p or higher) to accurately capture hand gestures in real-time. The camera should have good frame rates (at least 30 FPS) to handle dynamic gestures.
   - Example: Integrated laptop/desktop camera, external USB webcams,

2. **Processing Unit (CPU)**
   - Processor: Intel Core i5 (or AMD equivalent) or higher.
   - Clock Speed: 2.5 GHz or higher.
   - The CPU should be capable of handling real-time video processing and machine learning tasks related to gesture recognition without lag.

3. **Graphics Processing Unit (GPU)**
   - If the project uses advanced machine learning models or neural networks for gesture recognition, a dedicated GPU will significantly improve performance.
   - GPU: Nvidia GTX 1050 or equivalent.

4. **Memory (RAM)**
   - 8 GB of RAM.

5. **Storage**
   - Storage: 256 GB SSD (Solid State Drive).
   - SSDs are recommended for faster data access, especially when handling large datasets for machine learning, image processing, or saving gesture recordings for analysis.

6. Power Supply

- For Desktop Systems: A stable power supply unit (PSU) rated for at least 500W to support the CPU, GPU, and other peripherals.

7. Network and Connectivity

- Internet Access: Required for downloading model updates, libraries, and deploying cloud-based features, if applicable.
- Wi-Fi/Bluetooth: If the system integrates with other devices (e.g., external sensors), ensure the machine has stable Wi-Fi or Bluetooth connectivity.

5.4.2 Software Requirements

1. Operating System

- Windows 10/11 or higher, macOS 10.14 (Mojave) or higher, or Linux (Ubuntu
- 18.04 LTS or higher).

2. Development Tools

- Visual Studio Code (for cross-platform development and web apps).

3. Programming Languages

- Python: Widely used for machine learning, gesture recognition, and image processing.
- Libraries such as OpenCV, TensorFlow, and PyTorch work well in Python.

4. Libraries and Frameworks

- Gesture Recognition and Image Processing:
- OpenCV (Open Source Computer Vision Library): Essential for capturing and processing images or video streams from the camera.
- MediaPipe: A powerful library from Google for real-time hand and body gesture tracking.

5. **Machine Learning Frameworks:**
   - TensorFlow or Keras: For training and deploying gesture recognition models.
   - Scikit-learn: For data preprocessing, classification, and model evaluation (if using traditional machine learning techniques).

6. **Machine Learning Development Tools**
   - Google Colab: A cloud-based notebook environment that provides free GPU and TPU access for training machine learning models.

CHAPTER 6

SYSTEM ANALYSIS

- **Need Of SignSpeak**
- **Process Model**
- **Feasibility Study**
- **Features**

6.1 NEED OF SIGNSPEAK

The need for SignSpeak, a sign language to text conversion project, arises from the following key factors:

1. **Bridging Communication Gaps:** For the millions of deaf or hard-of-hearing individuals who rely on sign language, communicating with those who do not understand sign language can be a significant challenge. SignSpeak helps bridge this gap by converting sign language into written text, enabling easier communication in everyday situations.

2. **Inclusivity and Accessibility:** In many public spaces such as hospitals, banks, or workplaces, there is often a lack of interpreters. SignSpeak promotes inclusivity by providing a technological solution that ensures accessibility for the deaf community, reducing their reliance on human interpreters.

3. **Enhancing Independence:** With SignSpeak, individuals who use sign language can communicate independently in real-time without needing a third party. This increases their autonomy, especially in settings where immediate communication is essential.

4. **Educational Use:** SignSpeak can be a valuable tool in educational environments, helping students who are deaf or hard of hearing to participate more fully in classrooms, lectures, or group discussions. It also allows non-signing educators and students to interact with signing students.

5. **Efficiency in Services:** Public and private service providers can benefit from SignSpeak by improving service delivery for the deaf community. For example, in customer service, legal proceedings, or medical consultations, the tool can facilitate more accurate and immediate communication.

6. **Promoting Understanding of Sign Language:** By increasing the visibility and use of sign language in various environments, SignSpeak can raise awareness and foster greater understanding and appreciation of sign language among the general population.

In summary, SignSpeak is needed to create a more inclusive, accessible, and efficient communication system between sign language users and non-signers, enhancing their day-to-day interactions and improving access to services and opportunities**.**

6.2 PROCESS MODEL

A process model is an essential component of software development that outlines the steps involved in developing a project. For the SignSpeak sign language to text conversion system, the Incremental process model will be used. This approach is ideal for this project because it involves building the system in small, manageable increments, allowing for frequent testing, refinement, and user feedback. This results in a high-quality product that evolves to meet user needs effectively.

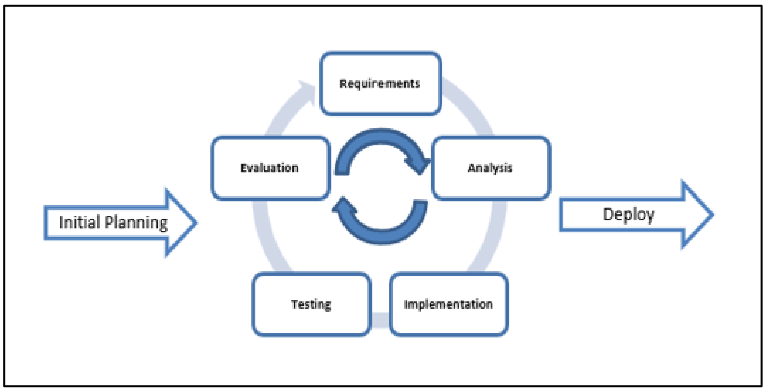


Fig. No. 6.2.1 Incremental Project Management

The Incremental methodology is a way of developing a project step by step. Instead of building the entire system at once, the project is broken down into smaller parts called increments. In the first phase, the team figures out the main requirements and decides which features to work on first. With each new increment, the team builds a portion of the project, tests it, and collects feedback, which helps improve the application over time.

For the SignSpeak project, each increment will focus on adding specific features, like basic sign language recognition, generating text output, and expanding the sign vocabulary. The team will meet regularly during each phase to check progress, solve any problems, and organize tasks. After completing an increment, the team will show the new feature to users and stakeholders to get their feedback. This feedback will be used to make improvements in the next development phase, ensuring that the app becomes better and meets user needs. Each increment will follow four steps: Planning, where the team sets goals, breaks down tasks, and assigns them; Development, where they build the required features, like improving recognition accuracy or adding more signs; Testing and Feedback, where the increment is tested to make sure it works properly and feedback is gathered from users; and Integration, where the new feature is smoothly added to the existing system. After each increment, the team will have a review meeting to look at what went well, what didn't, and what can be improved for the next phase.

This process allows the team to continuously improve the project and adapt to changing needs or feedback. The Incremental model works well for the SignSpeak project because it lets the team add new features without disrupting the overall system. It also helps make sure the final product meets the needs of both sign language users and the community.

In conclusion, the Incremental model is a great fit for the SignSpeak project. It allows the project to improve step by step, adapt to user feedback, and respond to changing requirements, which helps deliver a high-quality product that effectively bridges communication gaps.

6.3 FEASIBILITY STUDY

A feasibility study is an important aspect of any project to determine whether it is viable, achievable, and beneficial. This study will assess the technical, operational, economical, and schedule feasibility of developing a sign language to text conversion system called signspeak.

6.3.1 Technical feasibility

Technical feasibility refers to the assessment of whether the proposed project can be developed using the available technology, skills, and resources. In the case of the SignSpeak sign language to text conversion project, the technical feasibility study will evaluate the technical requirements for building the platform.

Firstly, the technical feasibility study will assess the compatibility of the project with the existing technology infrastructure. This involves ensuring that SignSpeak can be developed using available programming languages, machine learning frameworks, and image processing tools. It will evaluate whether the current hardware (such as cameras for capturing sign language) and software (such as algorithms for gesture recognition and text generation) can support the development of the project. Additionally, the study will consider the scalability of the system to handle a wide range of sign languages and adapt to new signs over time.

Secondly, the feasibility study will evaluate the availability of skilled personnel and expertise required to develop the project. This includes assessing the qualifications and experience of software developers, machine learning experts, natural language processing (NLP) specialists, and UI/UX designers. If there are gaps in expertise—such as the need for specialists in gesture recognition or computer vision—the study will determine whether additional training or outsourcing will be required to fill those gaps.

Thirdly, the technical feasibility study will assess the security and privacy requirements of the project. The study will evaluate whether necessary security measures, including encryption and secure data storage, can be implemented to protect user privacy and comply with data protection regulations.

Lastly, the feasibility study will consider the cost of the technical resources required to develop the project. This includes the cost of acquiring or leasing hardware (e.g., high-resolution cameras), software licenses for machine learning and NLP tools, and the expenses related to hiring or outsourcing skilled technical personnel. It will also assess whether the budget is sufficient to cover ongoing maintenance, updates, and potential scaling of the platform.

In summary, the technical feasibility study for the SignSpeak sign language to text conversion project will assess the compatibility of the project with the existing technology infrastructure, the availability of skilled personnel, security and privacy requirements, and the cost of the technical resources required for successful development. This evaluation will ensure that the project can be completed efficiently, securely, and within budget.

6.3.2 Operational Feasibility

Operational feasibility refers to the ability of an organization to integrate a proposed system into its daily operations. The operational feasibility of the SignSpeak sign language to text conversion project is determined by evaluating its impact on existing workflows, user adoption, and the organization's capacity to support the new system.

One key aspect of operational feasibility is the willingness of end-users to adopt and use the system. For SignSpeak to be successful, it must be designed with an intuitive, user-friendly interface that accommodates the needs of both deaf individuals and those who interact with them. The platform should accurately convert sign language into text in real time and should be easily accessible across devices. Ensuring the system meets the expectations of its target users—including individuals who are deaf or hard of hearing, educators, and customer service personnel—will be critical for adoption.

Another aspect of operational feasibility is the availability of resources to support the system. This includes having the necessary hardware, such as cameras capable of capturing sign language gestures, and software, including machine learning models for sign recognition. The organization must ensure there are sufficient resources to develop, implement, and maintain SignSpeak. This may require additional training for existing staff or hiring new personnel with expertise in fields like gesture recognition, natural language processing, and machine learning.

The availability of technical support is also essential for operational feasibility. The organization must ensure that technical support is available to assist users if they encounter difficulties with the system. The support team should be capable of addressing issues related to sign language recognition accuracy, user interface problems, or system malfunctions. It is important that the support be timely and available as needed to maintain user satisfaction and system reliability.

The impact of SignSpeak on existing processes is another critical factor. The organization must assess how the new system will change current workflows, including communication practices, customer service interactions, and education delivery methods. This could involve rethinking roles and responsibilities for staff who regularly interact with sign language users. The organization must also ensure that these changes are clearly communicated and embraced by all stakeholders involved.

Finally, the costs and benefits of implementing SignSpeak must be evaluated. This includes the expenses associated with developing, implementing, and maintaining the system, as well as potential benefits, such as improved communication for deaf individuals, enhanced accessibility, and increased customer or user satisfaction. The organization needs to assess whether the benefits of using the system justify the investment, especially in terms of improving accessibility and reducing communication barriers.

In summary, operational feasibility is a vital part of the feasibility study for the SignSpeak project. It is important to assess the system's impact on existing processes, the availability of resources and technical support, and the costs and benefits of implementation. By thoroughly evaluating these factors, the organization can determine the operational feasibility of SignSpeak and ensure its successful integration and adoption.

6.3.3 Economic Feasibility

Economic feasibility is a crucial aspect of any project and often determines whether or not to move forward. In the case of SignSpeak, a sign language to text conversion application, economic feasibility refers to the ability of the project to generate sufficient revenue to cover its development, operational costs, and deliver a reasonable return on investment (ROI).

To assess the economic feasibility of SignSpeak, several key factors need to be considered. These include the cost of development, which involves software development, machine learning integration, and user interface design. Additionally, ongoing maintenance costs—such as updates, bug fixes, and server expenses—must be accounted for. Another important consideration is the cost of marketing the app to its target audience, including the deaf community, educational institutions, customer service platforms, and healthcare organizations.

To determine potential profitability, a detailed financial analysis should be conducted, considering all costs and revenue streams. This analysis must also take into account the growth potential of the assistive technology market, which is expected to expand as accessibility becomes a more prominent global issue. Additionally, potential competition from other sign language recognition platforms and any legal or regulatory issues related to data privacy and accessibility must be factored into the financial projections.

Overall, the economic feasibility of SignSpeak will depend on its ability to generate sufficient revenue to cover its costs and deliver a reasonable return on investment. Careful financial planning, market analysis, and strategic partnerships will be critical for success. Continuous monitoring and adaptation to market conditions will also be necessary to ensure long-term sustainability and profitability.

6.3.4 Schedule Feasibility

Schedule feasibility refers to the likelihood that the project can be completed within the specified time frame. For the SignSpeak sign language to text conversion project, it is essential to determine whether the project timeline is realistic and achievable, and whether any potential challenges could cause delays. A well-structured project schedule should be created, outlining all tasks, their expected completion dates, and any dependencies between tasks.

Schedule feasibility is especially critical for the SignSpeak project, as accessibility tools like this are in high demand, and delays could impact the project's ability to stay competitive in the rapidly evolving technology landscape. To ensure that the project timeline is feasible, the team must first identify all the tasks required to complete the project, including development, testing, data collection, and user feedback integration. They must then estimate the duration of each task and create a project schedule that defines the timeline for each phase of the project.

One of the challenges in developing an assistive technology app like SignSpeak is the need to incorporate evolving technologies, such as machine learning and gesture recognition. Keeping up with the latest advancements while adhering to the project schedule can be difficult. The team must ensure that they have access to the necessary tools, technologies, and datasets needed to complete the project on time. Additionally, a clear understanding of the resources available and any constraints, such as dependencies on external vendors or data collection processes, is vital to prevent delays.

Another factor that can impact the project timeline is the availability of team members. The team must ensure that they have enough developers, machine learning experts, and other personnel with the required expertise to complete the project within the allocated time frame. If key team members are unavailable or if there is a shortage of specialized skills, it could lead to project delays. As a result, resource allocation must be carefully planned and monitored.

In summary, schedule feasibility is crucial for the success of the SignSpeak project. By creating a detailed project schedule, anticipating potential roadblocks, and using project management software to monitor progress, the team can ensure that the project is completed within the specified timeframe. This will enable SignSpeak to be launched in a timely manner, improving its chances of success in the competitive market for accessibility tools.

6.4 FEATURES

SignSpeak should has several features to provide a seamless user experience. Some of the key features that the app should include are as follows:

1. **User-Friendly GUI:**
    - The app features an intuitive and easy-to-navigate graphical user interface (GUI) designed to enhance user experience.
    - Responsive design ensures that the interface adapts well to different screen sizes and orientations, providing a seamless experience on various devices.

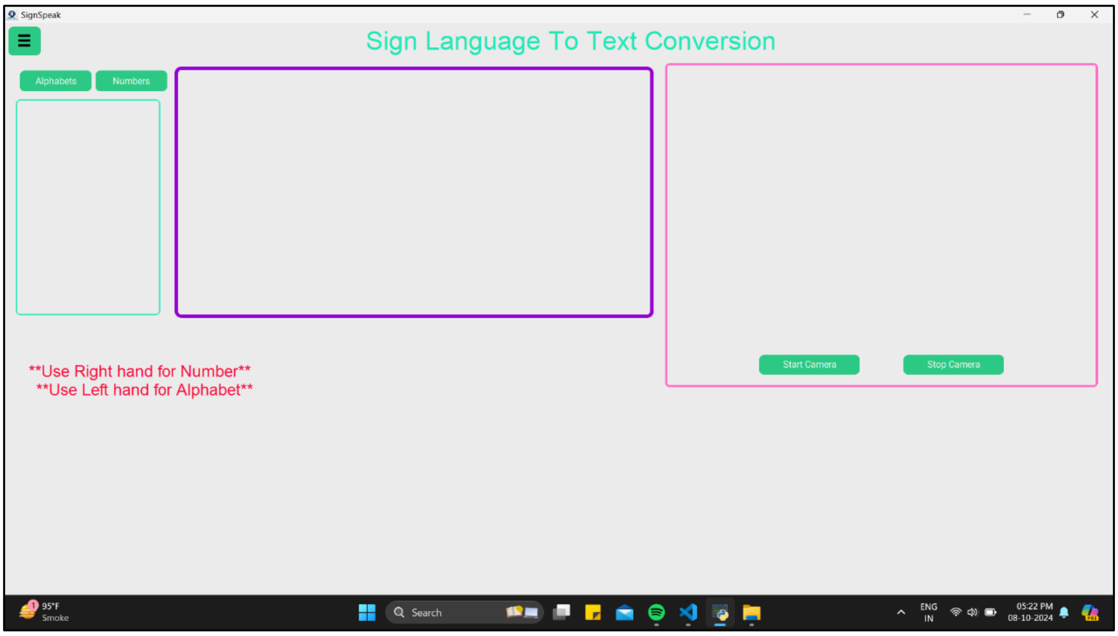


Fig. No. 6.4.1 Landing page

2. **Dark/Light Theme:**
    - The app provides a theme toggle feature, allowing users to switch between dark and light modes based on their preference.
    - The Dark Mode offers a low-light interface for better readability in dim environments, reducing eye strain.
    - The Light Mode provides a bright interface, making it ideal for well-lit environments.

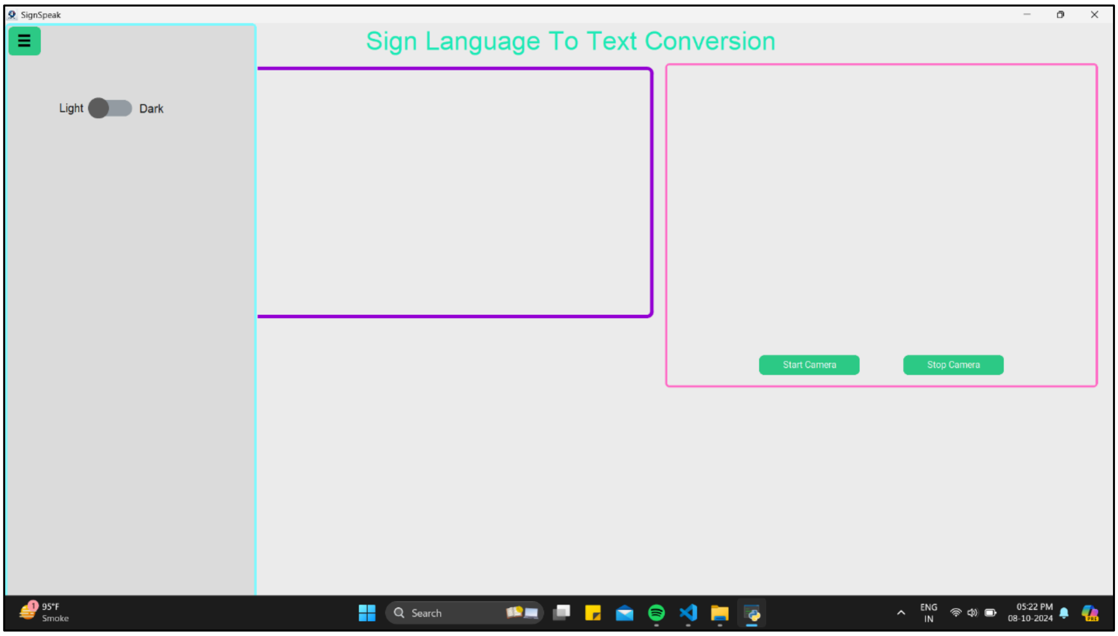


Fig. No. 6.4.2 Light Theme page

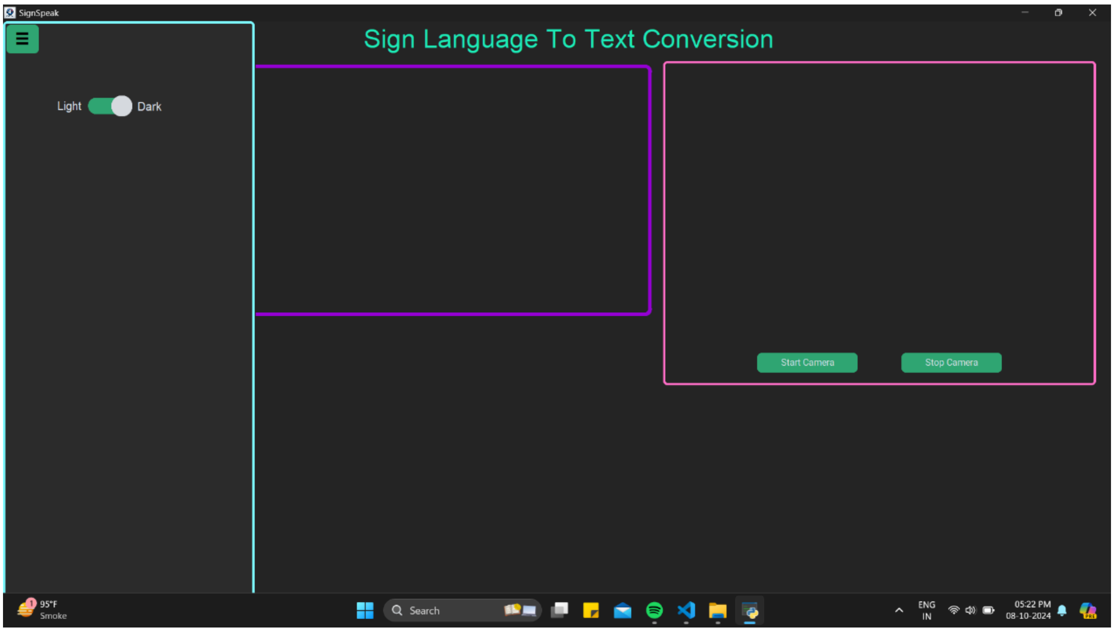


Fig. No. 6.4.3 Dark Theme page

3. Sign Images for Learning:

- The app includes a comprehensive collection of JPG images that illustrate various sign language gestures.
- Each image displays a clear representation of a specific sign, enabling users to see the correct hand shape and positioning.

- Users can refer to these images as visual aids to practice and mimic the signs, enhancing their learning process.
- This feature promotes effective learning by providing a visual reference, making it easier for users to grasp and reproduce sign language gestures accurately.

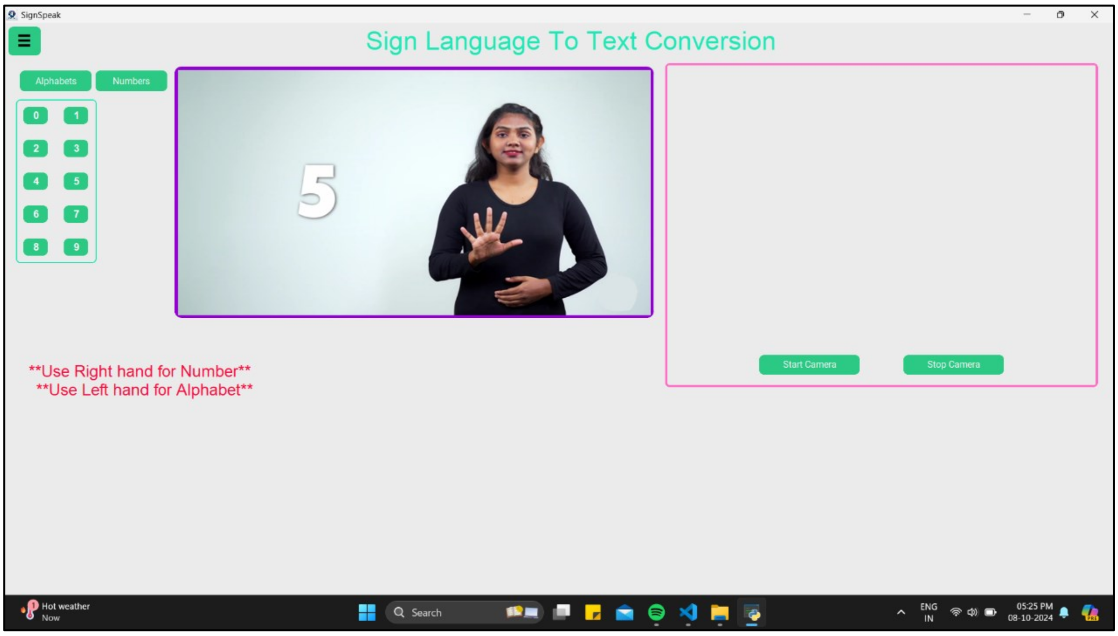


Fig. No. 6.4.4 Number Image page

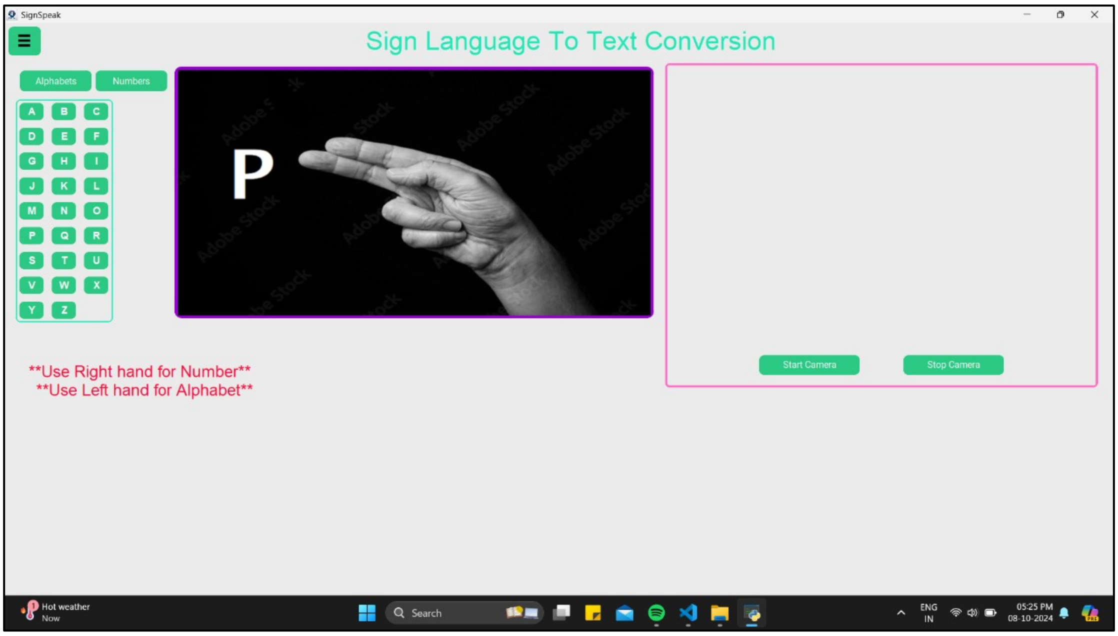


Fig. No. 6.4.5 Alphabet Image page

4. **Camera Control (Start/Stop):**
   - The app allows users to easily control the camera for real-time hand gesture recognition.
   - **Start**: Users can initiate the camera feed to begin detecting and recognizing sign language gestures.
   - **Stop**: Users can pause or stop the camera when they are done with the recognition process, conserving system resources and providing better control over the session.

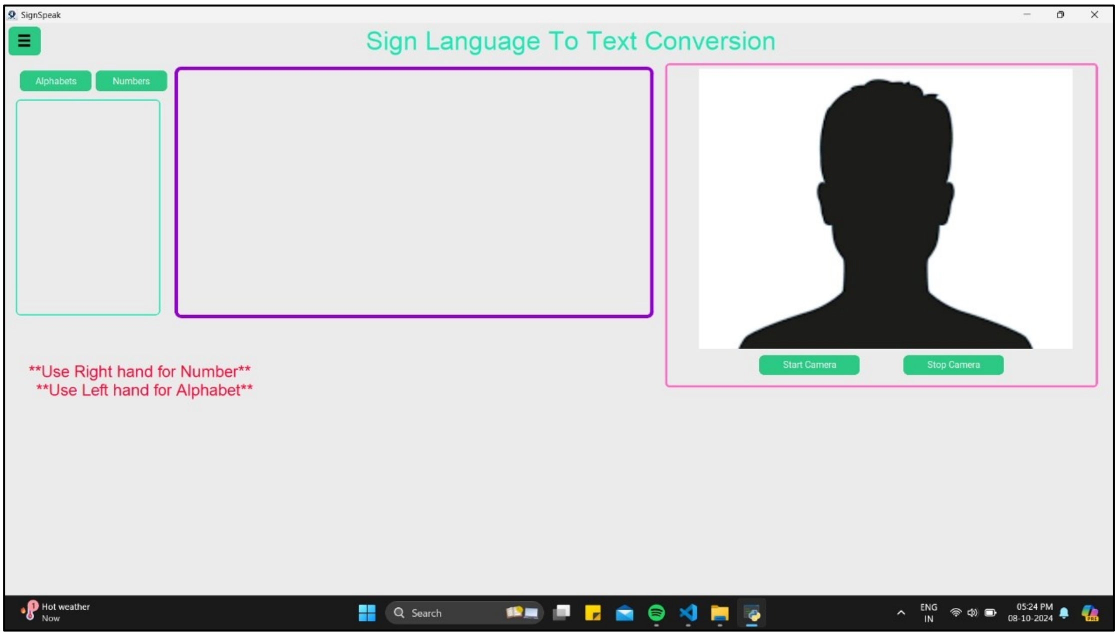


Fig. No. 6.4.6 Camera Control Start Page

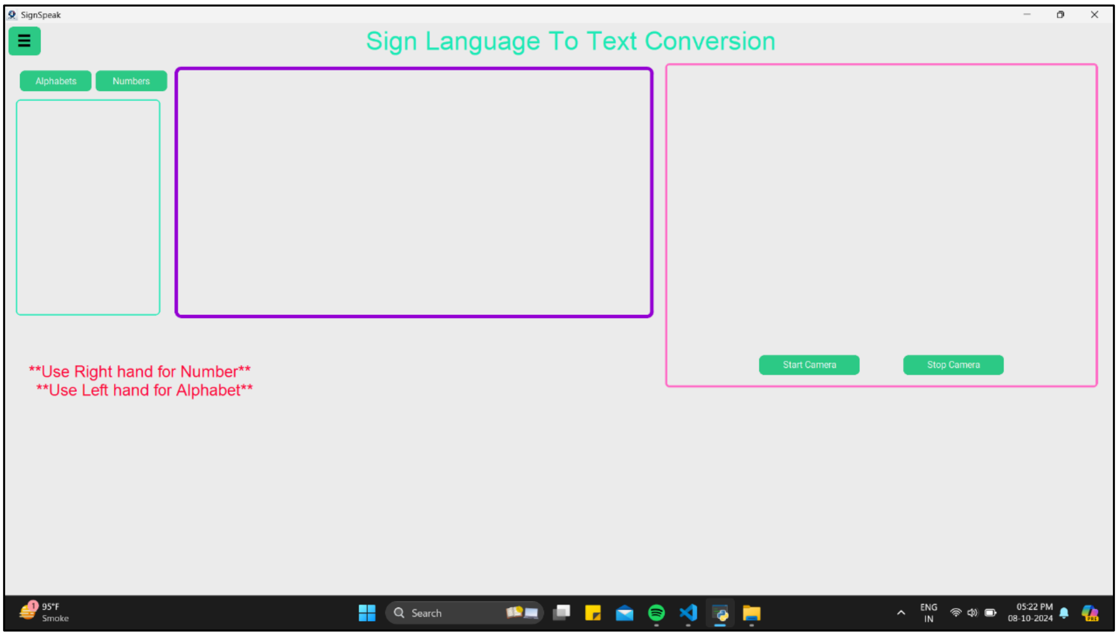


Fig. No. 6.4.7 Camera Control Stop Page

CHAPTER 7

SYSTEM DESIGN

- **Class Diagram**
- **Use Case Diagram**
- **Sequence Diagram**
- **Activity Diagram**
- **Data Flow Diagram**

7.1 CLASS DIAGRAM

The **Class Diagram** represents the static structure of the system, illustrating the relationships between different objects within the application. It highlights the attributes, operations, and associations among different classes involved in the project. For the SignSpeak project, the Class Diagram models essential components like the Camera, Image Processing, GUI, and ML Model, detailing how they interact to recognize sign language gestures and convert them to text. Each class has a distinct role in capturing, processing, and displaying sign language signs.

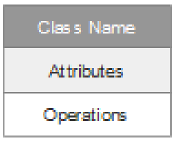
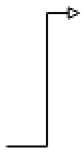
	Class
	Generalization

Table 7.1.1 Class diagram symbols

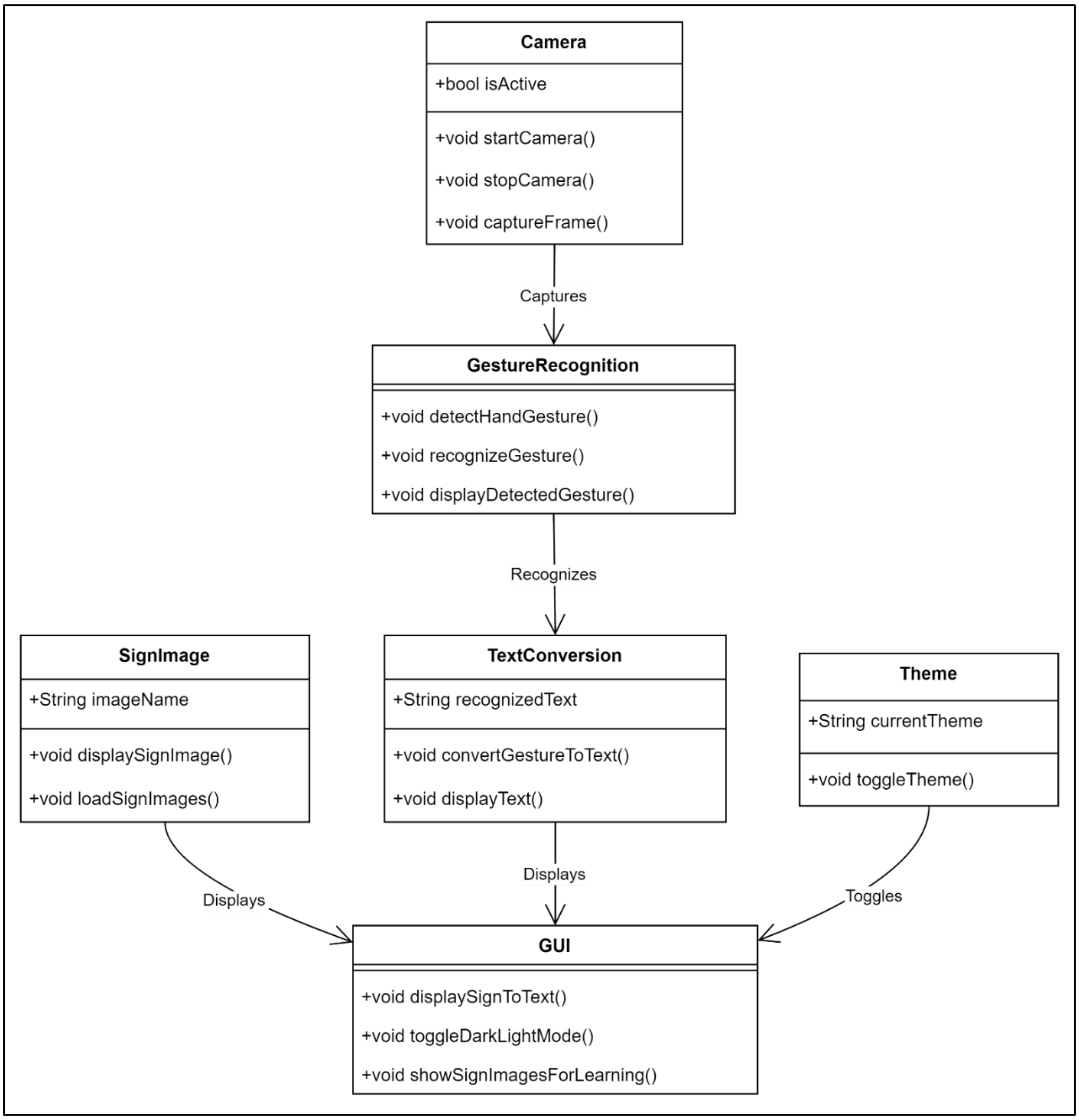


Fig. No. 7.1.1 Class diagram

7.2 Use Case Diagram

The Use Case Diagram shows the interaction between users and the system. It identifies all the possible actions a user can perform and how the system responds to each action. In SignSpeak, users interact with the system by starting the camera, processing the sign images, viewing the result (converted text), and learning the sign images. The Use Case Diagram demonstrates the system's functionality from a user's perspective, highlighting features such as sign language recognition, feedback, and learning modes.

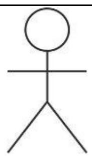
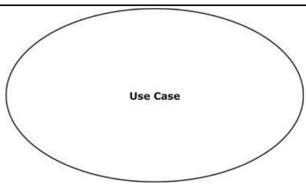
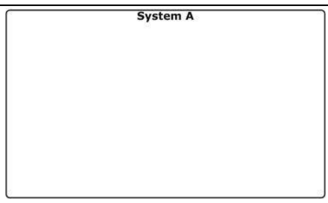
	Actor
	Use-case
	System

Fig. No. 7.2.1 Use-case diagram

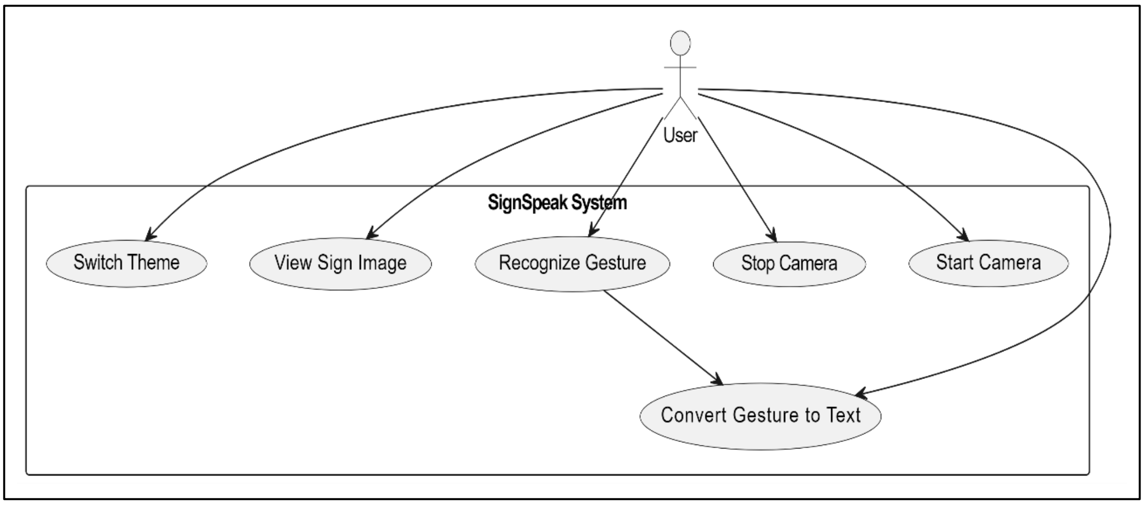


Fig. No. 7.2.1 Use-case diagram

7.3 SEQUENCE DIAGRAM

The **Sequence Diagram** provides a dynamic view of the system, depicting the sequence of interactions between objects over time. For the SignSpeak project, this diagram focuses on how different components of the system (camera, image processing, ML model, and GUI) work together. It shows the step-by-step process involved in capturing an image, processing it, running recognition algorithms, and returning the recognized sign as text to the user interface.

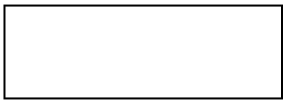
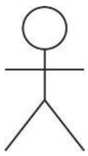
	Object
	Message
	Actor

Table 7.3.1 Sequence diagram symbols

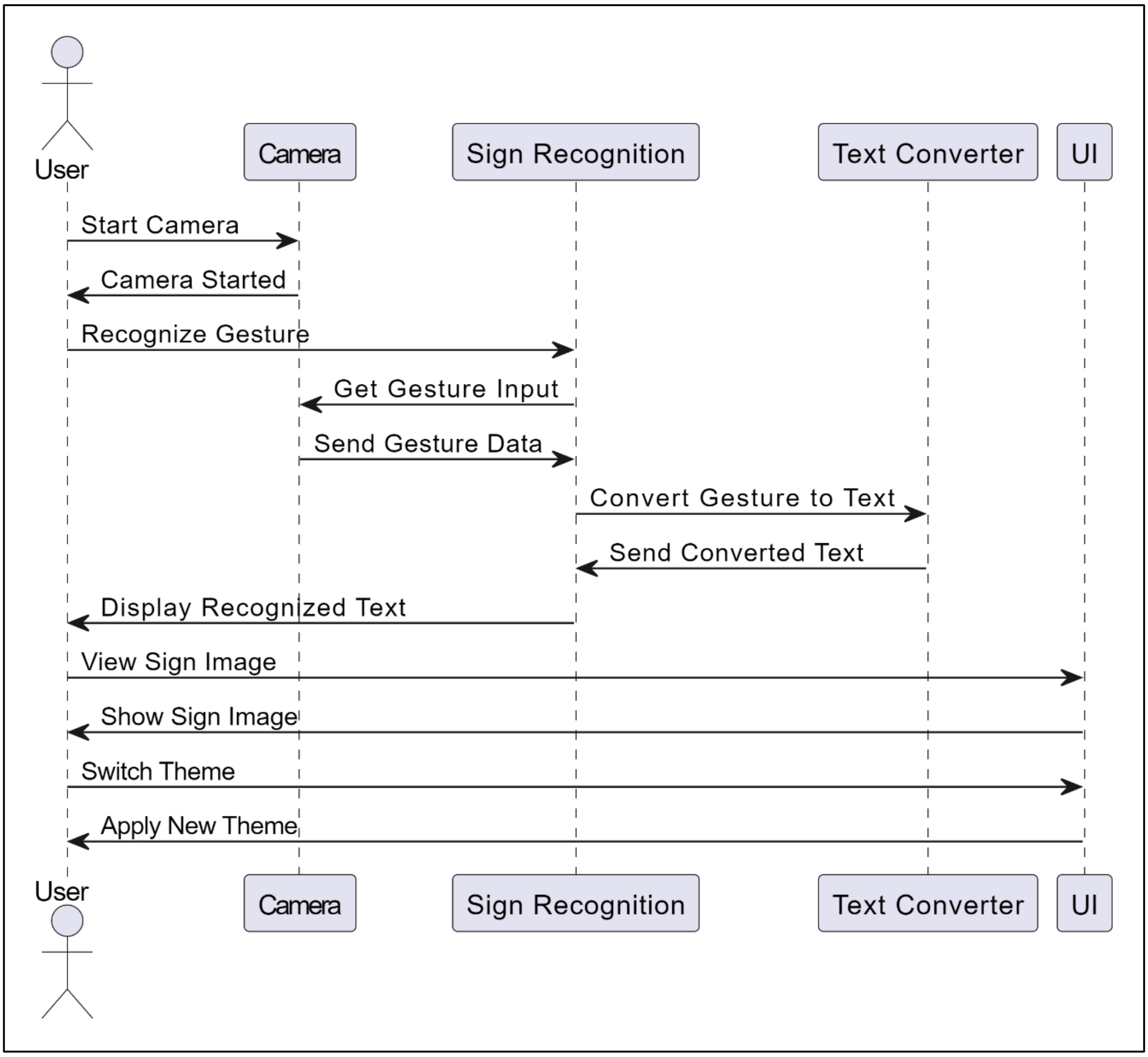


Fig. No. 7.3.1 Sequence diagram

7.4 ACTIVITY DIAGRAM

The Activity Diagram outlines the flow of activities or tasks within the system. It is used to model the workflow of the SignSpeak project, showing the different actions a user can perform, from starting the camera to displaying the recognized text. It visualizes conditional flows, user choices (e.g., choosing between dark and light themes), and the system's reactions to these inputs. This diagram is beneficial for understanding the overall flow and process from the user's perspective.

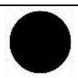
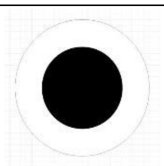
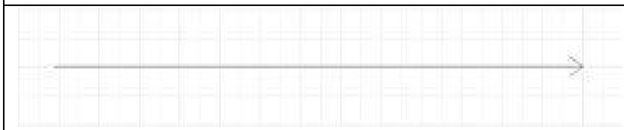
	Initial node
	End symbol/node
	Action/Control Flow
	Action/Activity

Table 7.4.1 Class diagram symbols

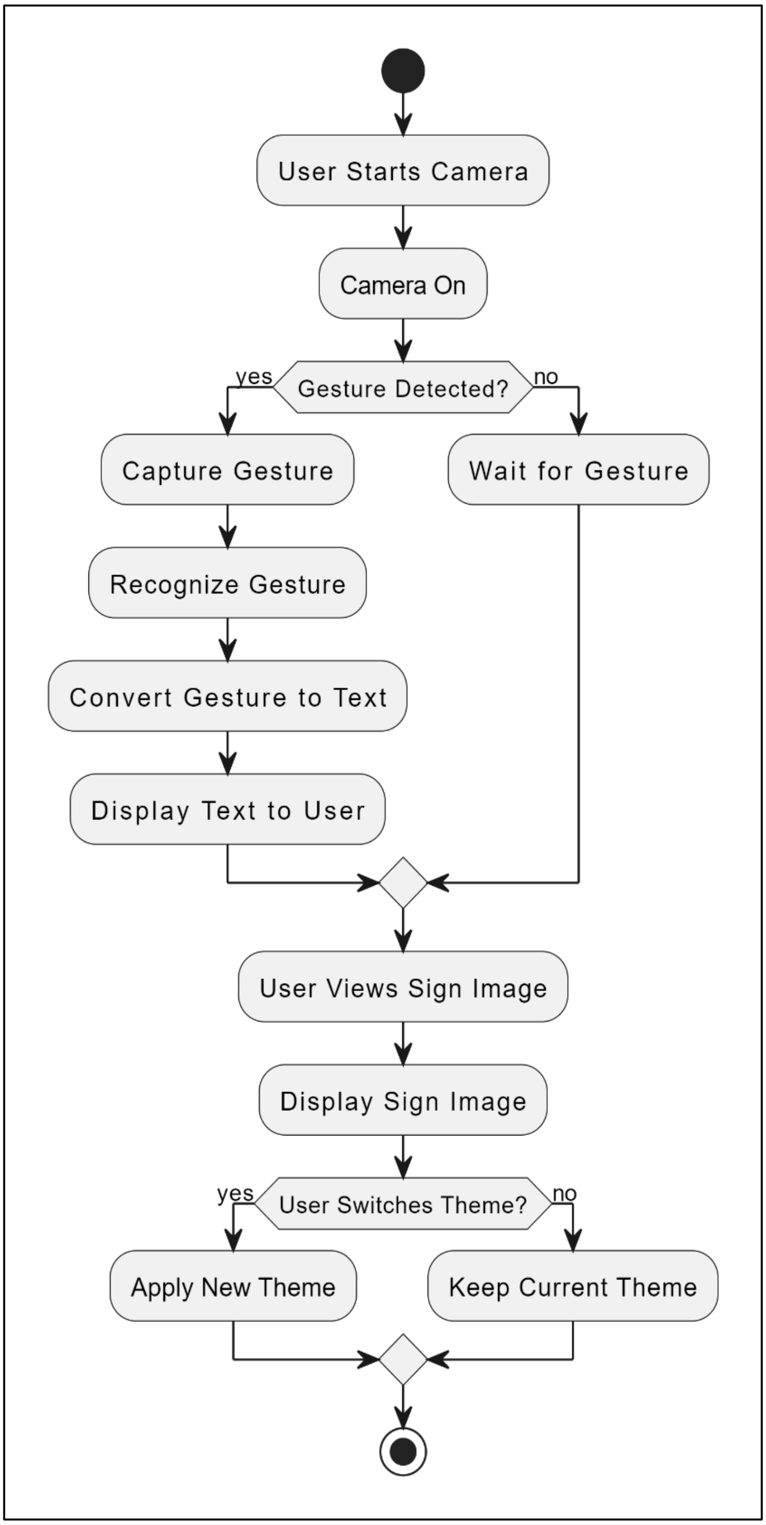


Fig. No. 7.4.1 Activity diagram

7.5 DATA FLOW DIAGRAM

The **Data Flow Diagram** (DFD) provides an overview of how data moves through the system. It represents how input (such as images from the camera) is processed, analyzed, and transformed into output (recognized text). In the context of SignSpeak, the DFD will illustrate how raw data (sign images) is passed through various stages—preprocessing, recognition using machine learning, and displaying text results. This helps in understanding the flow of information and the system's structure in terms of data handling.

	Entity
	Data flow

Table 7.5.1 Data flow diagram symbols

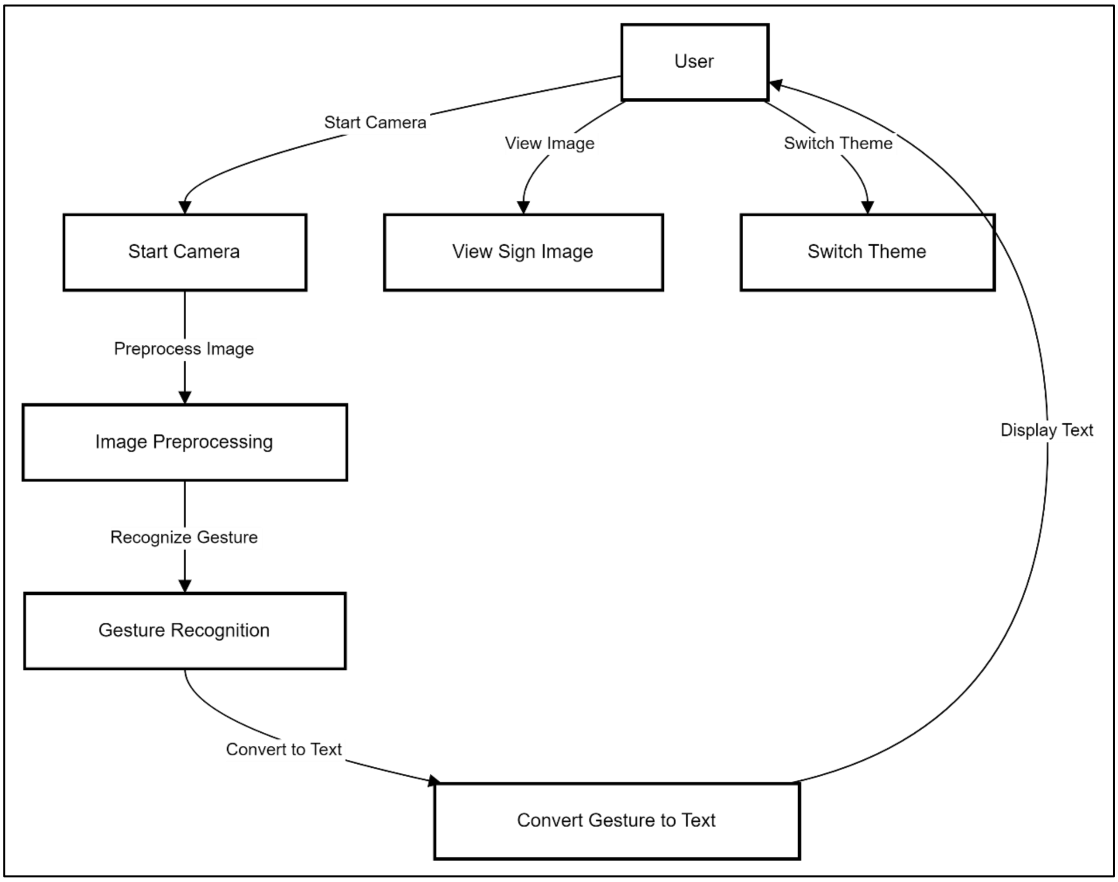


Fig. No. 7.5.1 Data Flow Diagram

CHAPTER 8

MODULE DESCRIPTION

- **Data collection module**
- **Data preprocessing module**
- **Model training module**
- **Prediction module**
- **GUI module**
- **Metrics module.**
- **Real-Time Prediction module**

8.1 DATA COLLECTION MODULE

The Data Collection Module for the SignSpeak project is a foundational component designed to gather and manage large datasets of sign language gestures. This module is responsible for capturing video or motion data from users signing in different languages and environments. To ensure accuracy in converting sign language to text, the system requires a diverse dataset that includes various hand shapes, movements. The data collection process leverages cameras, sensors, or motion-capture devices to record sign language gestures in real-time, creating a rich database that serves as the training foundation for the machine learning models.

This module also includes functionality to preprocess and label the collected data, ensuring that each gesture is tagged with its corresponding text or meaning. The dataset is categorized based on language, context, user demographics, and other factors that help enhance the accuracy and flexibility of the system. It is crucial that the data collection process involves diverse signers, accounting for variations in speed, regi and styles. This ensures the SignSpeak system is robust and capable of accurately converting sign language from a wide range of users.

8.2 DATA PREPROCESSING MODULE

The Data Preprocessing Module for the SignSpeak project plays a critical role in preparing raw data for effective training and evaluation of the sign language to text conversion system. This module encompasses various steps, including data collection, cleaning, normalization, and augmentation, to ensure that the dataset is robust and suitable for machine learning algorithms. The primary goal of data preprocessing is to enhance the quality of the input data, which directly impacts the accuracy and reliability of the sign recognition model.

Initially, the module collects a diverse set of sign language images, representing various signers and signing styles. Once collected, the data undergoes a cleaning process, where irrelevant or low-quality samples are removed. This includes filtering out poor lighting, background noise, or unclear gestures. After cleaning, the data is normalized to ensure consistency in frame rates, resolutions, and formats. This standardization is crucial for training machine learning models, as it allows them to learn from a uniform dataset without being affected by variations in the input.

To further enhance the dataset, the preprocessing module incorporates data augmentation techniques, such as rotation, flipping, or adding noise to the existing samples. This approach not only increases the dataset size but also improves the model's ability to generalize to new and unseen data, making it more resilient in real-world applications. By carefully preprocessing the data, the SignSpeak project can significantly enhance the accuracy and performance of its sign language recognition system, ultimately ensuring a smoother and more effective user experience.

8.3 MODEL TRAINING MODULE

The Model Training Module for the SignSpeak project is a pivotal component designed to enable the application to accurately convert sign language gestures into text. This module involves the collection and preprocessing of a comprehensive dataset that includes diverse sign language gestures. The dataset typically consists of videos or images of individuals performing various signs, annotated with the corresponding text translations.

Once the dataset is prepared, the training module employs advanced machine learning algorithms, particularly deep learning techniques, to develop a neural network capable of recognizing and interpreting sign language. Convolutional Neural Networks (CNNs) are often utilized for image data, extracting important features from the gesture inputs. The model is trained using a supervised learning approach, where it learns to map input gestures to their corresponding text outputs through iterative optimization of its parameters. After training is complete, the model undergoes validation on a separate dataset to ensure that it maintains high accuracy and robustness in real-world scenarios.

The Model Training Module also incorporates a continuous learning mechanism that allows it to adapt and improve over time. As users interact with SignSpeak, new data can be collected, enabling the model to refine its understanding of sign language and reduce errors. This feature is crucial for accommodating the evolving nature of sign language and user preferences, ensuring that SignSpeak remains relevant and effective in meeting the communication needs of its users.

8.4 PREDICTION MODULE

The Prediction Module in the SignSpeak project is a critical component designed to enhance the accuracy and efficiency of sign language to text conversion. This module leverages advanced machine learning algorithms and artificial intelligence techniques to predict and interpret user gestures based on real-time input. By analyzing a series of hand movements and positions, the module can make educated guesses about the intended sign even in cases of minor variations or inaccuracies in execution. This predictive capability is essential for accommodating the diverse ways in which individuals express themselves in sign language, which can vary widely based on personal style and regional dialects.

To achieve high levels of accuracy, the Prediction Module utilizes a combination of techniques, including deep learning and pattern recognition. It is trained on a vast dataset of sign language gestures, allowing it to learn the nuances of various signs and their contextual meanings. The module continuously improves its predictive accuracy through user interactions, employing techniques such as reinforcement learning. As users interact with the application, the module refines its predictions based on feedback, effectively adapting to the unique signing styles of individual users over time. This personalization feature not only enhances user satisfaction but also increases the application's overall effectiveness in translating sign language into text.

8.5 GUI MODULE

The Graphical User Interface (GUI) module of the SignSpeak project plays a critical role in ensuring that users can easily interact with the application. This module is designed to provide a user-friendly and intuitive interface that accommodates various user demographics, particularly individuals from the deaf and hard-of-hearing community. The GUI incorporates clear navigation elements, visually appealing layouts, and accessible features to enhance usability. It employs a clean design that minimizes clutter, ensuring that users can focus on the core functionality of sign language recognition and text conversion. Within the GUI module, key components include the input area for capturing sign language gestures via a webcam , as well as an output area that displays the translated text in real time.

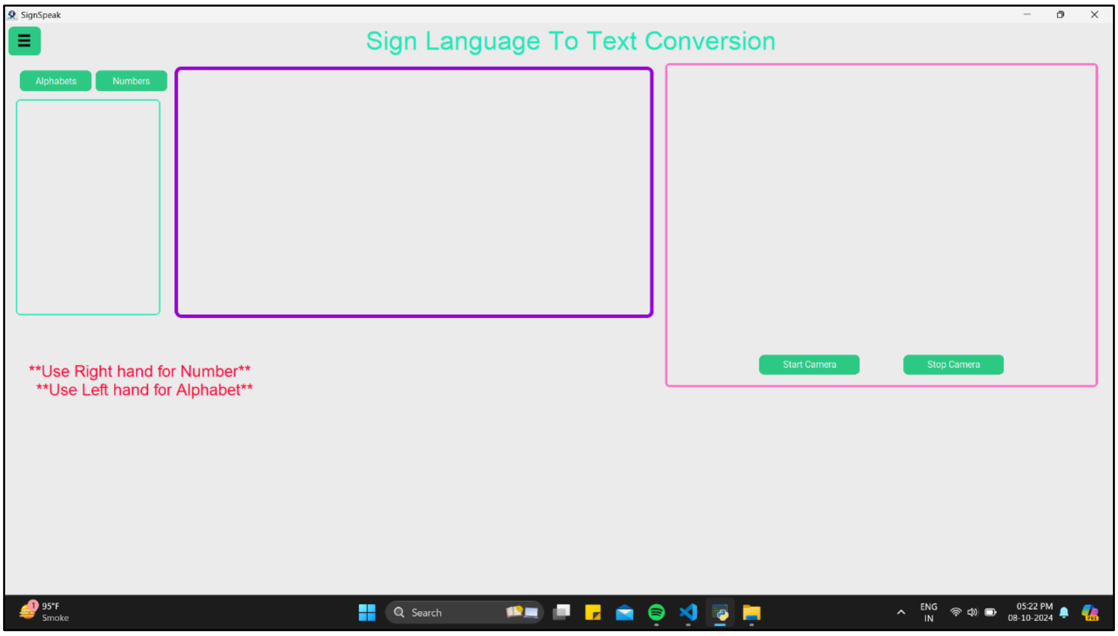


Fig. No. 8.5.1 Landing page

8.6 METRICS MODULE

The Metrics Module in the SignSpeak project plays a vital role in tracking and analyzing the performance and usage of the application. This module collects data on various metrics related to the sign language to text conversion process, user engagement, and application efficiency. By leveraging these metrics, the development team can identify areas for improvement, optimize system performance, and enhance the overall user experience. Key metrics monitored may include the accuracy of sign recognition, the speed of translation, user engagement statistics, and the frequency of feature usage.

In addition to performance metrics, the module also captures user feedback and satisfaction levels through surveys and ratings. This qualitative data helps the team understand how well the application meets the needs of its users, particularly within the deaf community. By analyzing this information, developers can prioritize feature enhancements, fix bugs, and ensure that the application remains user-centric. Furthermore, the Metrics Module can assist in identifying trends over time, such as improvements in accuracy as the underlying algorithms are refined or changes in user behavior as new features are introduced.

Ultimately, the Metrics Module serves as a foundation for continuous improvement within the SignSpeak project. By providing actionable insights into the application's performance and user satisfaction, the development team can make informed decisions that align with user needs and expectations. This iterative approach not only enhances the application's functionality but also helps build trust and credibility within the user community, ensuring that SignSpeak remains a valuable tool for sign language translation.

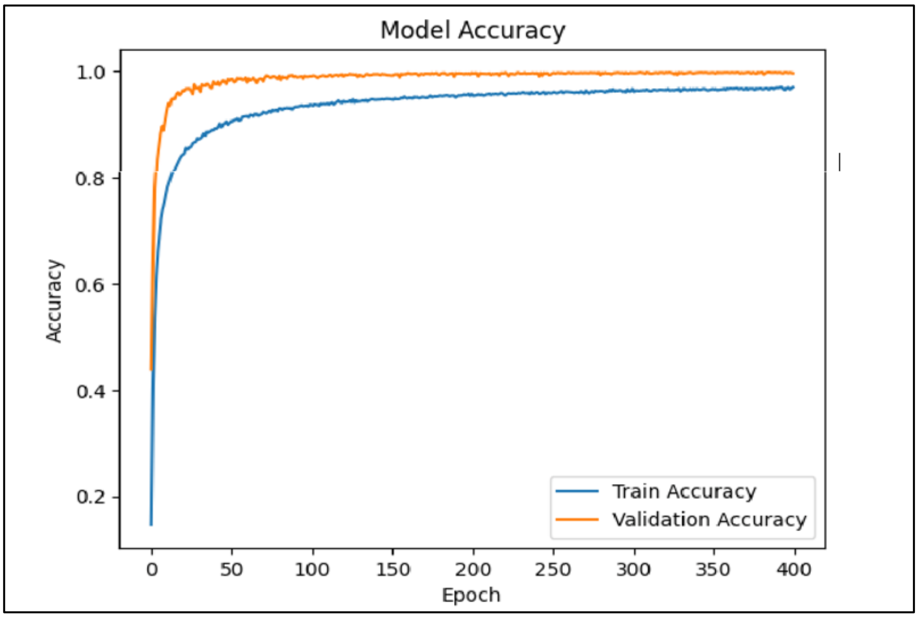


Fig. No. 8.6.1 Accuracy Graph

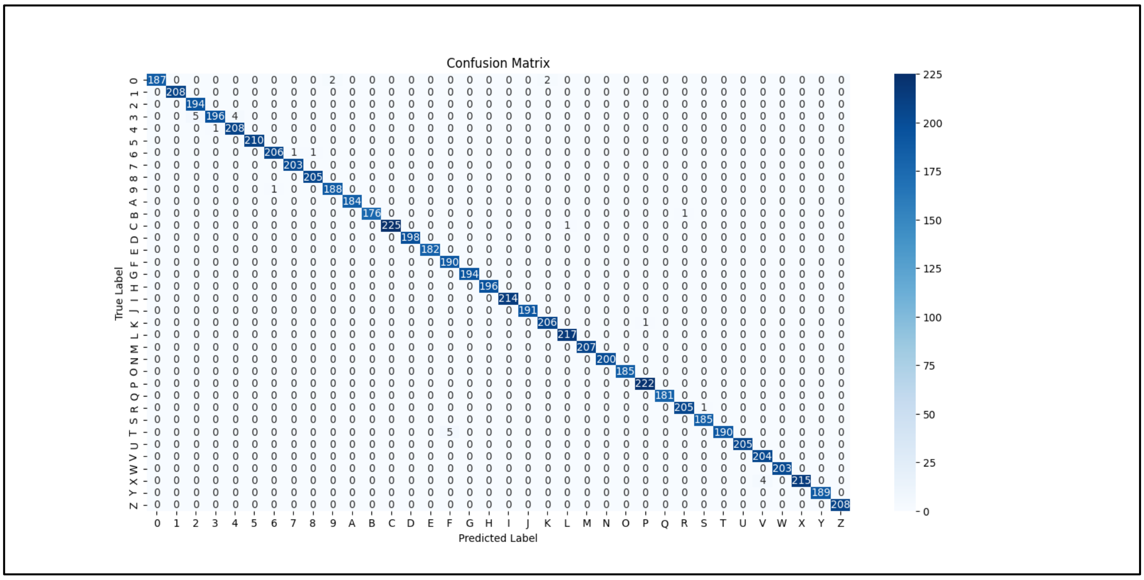


Fig. No. 8.6.2 confusion matrix

8.7 REAL-TIME PREDICTION MODULE

The Real-Time Prediction module is a pivotal component of the SignSpeak project, designed to provide immediate and accurate translation of sign language into text. Utilizing advanced machine learning algorithms and computer vision techniques, this module processes video input captured from a camera in real time.

The system analyzes the user's gestures and movements, interpreting the signs and converting them into text with minimal latency. By leveraging techniques such as convolutional neural networks (CNNs) for image recognition, the module can effectively identify distinct signs from various angles and lighting conditions, ensuring high accuracy and responsiveness. By providing real-time translations, the module enhances accessibility for deaf and hard-of-hearing individuals, facilitating smoother interactions in everyday scenarios, such as conversations, educational settings, and public engagements.

CHAPTER 9

TESTING

Testing is a critical phase in software development, ensuring that the application functions as intended and meets the specified requirements. For the SignSpeak sign language to text conversion project, testing is essential to confirm that the system accurately translates sign language into text, operates smoothly, and delivers a user-friendly experience.

The testing process for SignSpeak involves several key steps:

1. **Dataset Evaluation:**
   - The model was tested on a dataset of 36 distinct actions, each containing 1000 images.
   - The dataset was split into training and testing sets to assess the model's performance on unseen data.

2. **Performance Metrics:**
   - Accuracy: The model achieved a high accuracy of 99.58%, indicating that it correctly predicted gestures in nearly all cases.
   - Precision, Recall, F1-Score: All gesture classes maintained consistently high values across these metrics, reflecting the model's ability to distinguish gestures effectively and minimize false positives and false negatives.

3. **Real-Time Prediction:**
   - The model was tested on real-time video input to ensure it could handle live gesture recognition efficiently.
   - The system provided accurate text translations with minimal latency, validating its practical usability.

4. **Robustness:**
   - The model demonstrated strong performance across both one-hand and two-hand gestures.
   - Testing confirmed the model's reliability for real-world applications involving sign language recognition.

5. **Deployment Readiness:**
    - The testing phase affirmed the model’s robustness, efficiency, and high accuracy, confirming its suitability for deployment in practical sign language interpretation systems.

In summary, testing is a crucial step in the development of SignSpeak, ensuring that the system works as intended, meets user needs, and provides a secure, accurate, and user-friendly experience. The testing process includes unit testing, integration testing, system testing, UAT, load testing, and security testing. Once testing is complete, the system is refined and prepared for deployment to deliver the best possible performance.

CHAPTER 10

LIMITATION AND FUTURE ENHANCEMENTS

- **Limitations**
- **Future Enhancements**

10.1 LIMITATIONS

While the SignSpeak project aims to provide an effective sign language to text conversion solution, several limitations can affect its overall performance and user experience:

1. **Variability in Sign Language:** Sign languages are not universally standardized; different regions may have distinct dialects and variations. This diversity can create challenges for the system, as it may struggle to accurately interpret signs that differ from those present in its training data. Additionally, individual signing styles and fluency levels can vary widely, leading to potential inaccuracies in translation.
2. **Environmental Factors:** The effectiveness of real-time sign language recognition can be impacted by environmental conditions such as lighting, background noise, and cluttered settings. Poor lighting may hinder the camera's ability to capture clear images of the signs, while distractions in the background can lead to misinterpretations. Moreover, factors like camera quality and resolution play a crucial role in the accuracy of gesture recognition.
3. **Limited Vocabulary:** The vocabulary that the system can recognize may be limited, especially for specialized or less commonly used signs. While the module can be trained on a broad dataset, it may still struggle with context-specific vocabulary or new signs that emerge over time. This limitation could restrict users, especially in professional or academic settings where specialized terminology is often required.
4. **User Interface Challenges:** For users who may not be familiar with technology, navigating the application or adjusting settings can be challenging. The user interface must be designed to be intuitive and accessible for all users, including those with varying levels of technological proficiency. If not, it may hinder the overall effectiveness and adoption of the application.

10.2 FUTURE ENHANCEMENTS

1. **Expanded Sign Language Support**
   Example: A future enhancement could include support for additional languages like Australian Sign Language (Auslan) , American Sign Language (ASL) and British Sign Language (BSL) or sign languages from different regions. This expansion could involve collaborations with native sign language users to build a diverse dataset, allowing the app to recognize and translate a broader range of signs.

2. **Contextual Understanding and Semantic Recognition**
   Example: In its current form, SignSpeak might struggle with signs that have multiple meanings, such as "bank" (financial institution vs. riverbank). An enhancement could involve integrating natural language processing (NLP) to analyze the context in which a sign is used. For instance, if a user signs "bank" while pointing to a river, the system could correctly interpret it as a riverbank, providing a more accurate translation.

3. **User Feedback Loop for Continuous Learning**
   Example: Implementing a feedback feature where users can rate the accuracy of translations could lead to significant improvements. If a user finds that the system incorrectly translates a sign, they could submit feedback that allows the developers to adjust the model. For instance, if a user indicates that the sign for "thank you" is not accurately represented, this input could help refine the system's understanding of the sign.

4. **Advanced Personalization Options**
   Example: SignSpeak could introduce user profiles that learn individual signing styles over time. For instance, if a user consistently signs "hello" with a particular gesture, the system could adapt and prioritize that specific sign in future translations, improving accuracy and personalization.

By implementing these enhancements, the SignSpeak project can evolve into a more comprehensive and versatile tool, significantly improving the communication experience for both deaf and hard-of-hearing individuals and their hearing counterparts.

CHAPTER 11

CONCLUSION

The "SignSpeak" project aims to bridge the communication gap between French Sign Language (FSL) users and the broader population by converting sign language gestures into text in real-time. The project utilizes advanced machine learning techniques and image processing to achieve this goal. Specifically, MediaPipe is used for detecting hand movements and landmarks, which are critical for accurately interpreting the gestures. The core of the system is an LSTM model that has been trained on a dataset consisting of 36 distinct actions, each represented by 1000 images. This model was carefully trained and tested, achieving an impressive test accuracy of 99.58%, along with consistently high precision, recall, and F1-scores across all gesture classes. The project highlights the potential of deep learning models in handling complex tasks like sign language recognition, making it possible to translate gestures into text efficiently and accurately.One of the significant achievements of the project is its ability to handle both one-hand and two-hand gestures, which are common in sign languages like FSL. The system is built with a robust architecture that allows for real-time gesture recognition, providing immediate feedback in the form of textual output. This feature makes "SignSpeak" a practical solution for real-world applications, enhancing accessibility for the deaf and hard-of-hearing communities. The project's success demonstrates how AI and machine learning can be leveraged to create inclusive technologies that promote better communication and understanding. Overall, "SignSpeak" is a step forward in using artificial intelligence to break down language barriers and foster inclusivity.

CHAPTER 12

APPENDICES

- **Business Model**
- **Product Deployment Detail**

12.1 BUSINESS MODEL

The business model for SignSpeak, a sign language to text conversion system, focuses on generating revenue through a combination of premium subscriptions, partnerships with educational institutions, and targeted advertising. The system serves as a unique platform that enhances communication for the deaf and hard-of-hearing communities while providing valuable tools for users and organizations.

The primary source of revenue for SignSpeak will be premium subscriptions. Users can opt for a monthly or yearly subscription to access advanced features, such as unlimited real-time translation, personalized learning modules, and offline access to sign language resources. This subscription model provides a consistent income stream while offering users enhanced value and a richer experience.

In addition to subscriptions, SignSpeak will establish partnerships with educational institutions, organizations, and businesses to provide tailored solutions that enhance accessibility and communication. These partnerships can involve licensing the app for classroom use, offering workshops, and providing training sessions for educators and employees. Such collaborations will not only generate revenue but also help foster inclusivity in various environments.

Furthermore, the system can integrate targeted advertising, focusing on products and services relevant to the deaf and hard-of-hearing community. By analyzing user preferences and behavior, SignSpeak can deliver ads that resonate with its audience, providing businesses with a unique opportunity to reach a niche market. Advertisers can engage with users on a cost-per-click or cost-per-impression basis, making this an attractive avenue for additional revenue.

Overall, the SignSpeak business model is designed to create a sustainable and impactful service that enhances communication and promotes inclusivity. Through premium subscriptions, strategic partnerships, and targeted advertising, the app aims to generate consistent revenue while delivering significant value to its users and partners.

12.2 PRODUCT DEPLOYMENT DETAIL

The deployment of the SignSpeak project, which focuses on converting sign language to text, will be executed in a systematic manner to ensure seamless accessibility for users. Initially, the deployment will begin with an internal rollout, allowing the development team to conduct thorough testing of all functionalities and features. This internal phase is crucial for identifying any bugs or issues that may hinder user experience. Once the app has been vetted through rigorous testing and all functionalities are verified, it will move to public deployment, making it available to users who can benefit from enhanced communication access.

For the public deployment, we will leverage cloud hosting services, which provide scalability and flexibility to accommodate varying user demands. This infrastructure allows us to easily adjust server resources based on user traffic, ensuring the app remains responsive and efficient even during peak usage. In addition, implementing a Content Delivery Network (CDN) will enhance the app's performance by minimizing latency, allowing users from different geographical regions to access the app with reduced load times. This combination of cloud hosting and CDN will significantly improve the user experience, ensuring that SignSpeak is readily available to individuals who need it most.

To streamline the deployment process, we will adopt a Continuous Integration and Continuous Deployment (CI/CD) pipeline. This automation will facilitate regular updates and feature enhancements while minimizing the risk of deployment errors. The CI/CD pipeline also allows for quick rollbacks if any issues arise post-deployment. Additionally, a robust monitoring system will be integrated to track performance metrics, detect anomalies, and provide real-time alerts. This proactive approach to monitoring will ensure that any issues are swiftly addressed, maintaining the app's reliability and user satisfaction over time.

BIBLIOGRAPHY

Books:

- Gookin, D. (2016). *Sign Language for Dummies*. Wiley.
- K. D. A. (2019). *Machine Learning for Beginners: A Comprehensive Guide to Understand and Implement Machine Learning Algorithms*. CreateSpace Independent Publishing Platform.
- *Dictionnaire de la Langue des Signes Française* (2011). Éditions du CNRS.

Websites:

- MediaPipe Documentation
  https://google.github.io/mediapipe/

- Scikit-learn Documentation.
  https://scikit-learn.org/stable/documentation.html

- National Center for Sign Language and Gesture Resources. (2023). *Sign Language Recognition: Technology Overview*.
  https://www.ncsgr.org/sign-language-recognition

- W3C. (2023). "Web Accessibility Initiative (WAI): Guidelines." https://www.w3.org/WAI/WCAG21/quickref/

Articles:

- L. P. (2022). "The Rise of Sign Language Recognition Technology." *TechCrunch*.
  https://techcrunch.com/2022/04/14/sign-language-recognition/

- K. M. (2021). "How AI is Changing Communication for the Deaf and Hard of Hearing." *Wired*.
  https://www.wired.com/story/how-ai-changing-communication-deaf/