SIGN LANGUAGE TRANSLATION -YOLO

A PROJECT REPORT

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Under the guidance of,

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IN

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(ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)

At

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY

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Presidency school of computer Science Engineering and Information Science, Pres

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CERTIFICATE

This is to certify that the Project report **"SIGN LANGUAGE TRANSLATION-YOLO"** being submitted by **"VUTHARAJI YASWANTH, AKKULAPPAGARI NIHARIKA, CHINNAM V N S L HARSHITHA"** bearing roll number(s) **"20211CAI0167, 20211CAI0095, 20211CAI0204"** in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Computer Science and Engineering (AI & ML) is a Bonafide work carried out under my supervision.

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DECLARATION

We hereby declare that the work, which is being presented in the project report entitled **SIGN LANGUAGE TRANSLATION-YOLO** in partial fulfillment for the award of Degree of **Bachelor of Technology** in **Computer Science and Engineering (AI & ML)**, is a record of our own investigations carried under the guidance of **Dr. Sivaramakrishnan S, Associate Professor, Presidency School of Computer Science Engineering, Presidency University, Bengaluru.**

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ABSTRACT

The Sign Language Detection System is an innovative solution designed to bridge the communication gap for sign language users by leveraging cutting-edge advancements in computer vision and natural language processing. This real-time system employs a YOLOv8-based deep learning model, trained on the Roboflow Universe dataset, to accurately detect and interpret hand gestures corresponding to the sign language alphabet.

The system processes video input from a live camera feed, identifies gestures using the optimized YOLOv8 detection pipeline, and translates recognized signs into both text and synthesized voice output, facilitating seamless communication. Additionally, it supports bidirectional communication by converting spoken input into sign-based representations, enhancing accessibility for both hearing and non-hearing individuals.

Key features include real-time gesture recognition, live video annotation, idle-based word construction, and a user-friendly Streamlit interface. The implementation of YOLOv8 significantly enhances detection speed and precision, contributing to the model's high accuracy rate of 0.97, which confirms its reliability for real-world application. This project plays a vital role in promoting inclusive communication for the deaf and hard-of-hearing communities.

Keywords: Sign Language Detection, Gesture Recognition, YOLOv8, Computer Vision, Real-Time Translation, Bidirectional Communication, Gesture-to-Text Conversion, Natural Language Processing

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CHAPTER-1

INTRODUCTION

While artificial intelligence (AI) continues to reshap the communication landscape, it plays a special role in changing the gap between the deaf and the difficulty of hearing and the hearing 1population. For those who relate the sign language as a main method of communication, practical and accurate translation systems are essential to promote the include and improve accessible. However, an important communication barrier still exists because of the lack of common awareness and understanding of the symbolic language among users who have not been introduced.

This project aims to fill this gap by introducing a symbolic language detection system in real time that allows transparent interaction between symbol language users and non -user users. The system converts the gestures into text and vocals, and also performs an opposite translation by interpreting the words in the gestures of the sign language. This two -way capacity ensures dynamic and comprehensive communication in the scenarios of the real world.

At the center of the system is a model of detecting object Yolov8 (you only look at version 8), acting as an architectural skeleton. Yolov8 is one of the most advanced and effective learning models to detect real -time objects, allowing the system to recognize with exact gestures corresponding to the alphabet of the sign language. The model is formed using the Roboflow universe notes, providing complete variants in gestures for strong performance. Applications related to the video entry section directly via webcam, detect hand gestures in real time and convert them into text with computer vision techniques. The recognized text is also converted into audio output with vocal art, ensuring liquid communication. The system also allows the items of the word to be translated into a sign, thus allowing two -way interactions. User interface, built using Streamlit, provides reaction and intuitive experience.

This project is an important step for technology, providing a practical solution that allows individuals to trust in the symbol language. By exploiting AI's power, computer vision and natural language processing, the system promotes better understanding and communication in different societies. It not only resolves the challenges of accessibility, but also contributes to a more connected and empathetic world.

1.1 Background

Sign language is the main way of communicating for millions of people with hearing impaired or difficult to hear. It is a rich language and expression based on visual, facial expressions and body motion. However, a wider population often does not have knowledge and signs of symbolic language, leading to communication holes that can affect access to education, employment, health care and social integration.With the appearance of artificial intelligence (AI) and computer vision, the development of intelligent systems to recognize and explain the sign language in real time. -DEPTH learning models like Yolov8 provides high -speed and high -speed gestures, which make them ideal for applications that require real -time interaction. By integrating these models into natural language processing and speech synthesis, it is possible to create powerful systems that facilitate two -way communication between the signing parties and non -use people.

1.2 Importance of Sign Language Recognition

The symbolic language translation into spoken or written language - and vice versa - is essential to promote societies including. It improves access to essential services, educational resources and communication among individuals for hearing impaired people. Some of the **Main advantages include**:

- Improving access capabilities- Allows deafness and difficulty interacting in environments where symbolic language is often not understood.
- Promoted- Barriers to communicate and promote equality participation in social, academic and professional gender.
- Empowerment for independence- Reduces dependence on human interpreters and allows private interaction and directly with services and systems.
- Emergency communication care- Provides an instant translation in important situations in which immediately communication is essential. A system that can perform a two -dimensional translation actually fills an important distance and serves as a step forward in technology design.

1.3 Scope of the Project

This project focuses on developing the translation system and detecting sign language in real time by using the deep learning model based on Yolov8.

The main scope includes:

- Gestures for text and words conversion- Detects hand gestures corresponding to signs
- and by converting them into text and audio outputs.
- Translate the speech- Accept the entrance to the voice, convert it into text and display the gestures of the corresponding symbol language for two -way communication.
- Processing video in real time- Uses a direct camera stream to capture hand movements flexibly.
- Develop user interface- Building interactive interface and can be accessed by rationalized use.
- Deployed to prepare- Ensures that the system is effective and accurate for real applications such as education, public service office or health care.

CHAPTER-2

LITERATURE SURVEY

Recent advancements in deep learning, computer vision, and natural language processing have greatly influenced the development of sign language recognition systems. These systems aim to fill in communication gaps between those who use sign language especially in real life jako. time settings. The following is a detailed survey of different studies that have contributed towards improving scholars' abilities the accuracy and efficiency of electronic signs language recognition systems.

A Survey on Deep Learning-Based Strategies for Sign Language Recognition (2022) [1] presents a good overview of the state of the art practices applied to sign language recognition. The feature extraction has made tremendous advances as drawn by the study. Classification methods. The approaches to be discussed by the authors include convolutional neural networks (CNNs) and recurrent neural networks (RNNs), which were effectively used to sign language recognition. The paper highlights the way in which, these techniques are being fine-tuned. To provide more accuracy and efficiency, demonstrating evolution of deep learning in sign language (cross-languages) and cultures.

1. Ahmadi et al. (2024) [2] presented efficient YOLO-based deep learning model. Created as a specialized American Sign Language (ASL) recognition system. This study highlights the flexibility of YOLO (You Only Look Once) – an object detection algorithm, which is so popular. Adapting to the challenging real-time sign language recognition job. The model improves gesture recognition accuracy through the combination of speed of the YOLO and the accuracy required for signing language detection. The research unravels the ability of YOLO-based models to be modified. Manage various languages, so that the system becomes more robust to use at global level.

2. Alaftekin et al. (2024) [3] introduced a real-time sign language system that is based on YOLO. Consolidates the identity of hand gestures as well as dynamic interaction. Their system excels in understanding instantaneous live gestures which is vital for making smooth communication. Sign language. The study relates to the encounters with processing of real-time hand movements. And places the emphasis on model efficiency in providing high-quality performance. This research highlights the use of YOLO models in real-time applications where both industries and real-time applications benefit from it. Speed and accuracy are crucial.

3. YOLOv8: The latest version of A Landmark in AI Integration (2024) [4] is introduced. YOLOv8, an important development in the AI-driven gesture recognition. YOLOv8 offers enhanced real-time gesture recognition capabilities and improved performance in handling complex sign language gestures. This research indicates how YOLOv8 can improve the performance of the bilingual abilities of sign language systems, however, allowing the system to be not only capable of recognizing but also of responding in the sign language system. Signs and not only translate them into text and speech successfully. The paper discusses how the syncing YOLOv8 with deep learning and computer vision has taken the boundaries to a new level of Jahren. Real-time communication systems, thus making them convenient and efficient to the users.

4. 4. Bhuiyan et al. (2019) [5] discussed the application of deep convolutional neural networks (CNNs). In Sign Language recognition, where static and dynamic hand gestures are to be considered. Their research provides a thorough review of the possible application of CNNs for extracting features from hand gestures and properly classify them. From this, this work gives an in-depth understanding of how CNN architectures are able to process single gestures and continuous gesture sequences. That is important for real time applications. The study also explores the challenges that are involved in treating complex hand shapes and variation in sign language as well as the ways in treating them. To overcome these obstacles.

5. DeepSign, a deep learning-based work on sign language was presented by [7] – Kothadiya et al. (2022). System for detection and recognition that is concerned with real-time processing. DeepSign incorporates cutting-edge neural networks to identify hand gestures in an instant and with a great level of precision. The system is developed having an intuitive interface, which is crucial in making sure that non-trained workers are ready to use the system. Experts can use the system strongly. The study also emphasizes the significance related to the creation of systems which are accurate and efficient enough for real world deployment, like in real world deployment, such as in educational or healthcare environments.

6. M et al. (2021) [8] built a sign language translator based on the YOLO algorithm, which is aimed at translating the sign language into English. Towards the enhancement of the real-time gesture detection efficiency. Their approach focuses on using YOLO's ability to detect objects, to be able to track the movements of hands, in dynamic situations. The study attaches importance to the need to have speed and accuracy, particularly for agriculturally-based businesses. Environments in which sign language users require feedback in real-time. This research contributes to the emerging corpus of the knowledge in terms of using YOLO for real-time applications, demonstrating its prospective in improving sign language communication systems.

7. Mocialov et al. (n.d.) [9] investigated continuous sign language recognition with the help of learning, specifically for sequential gestures' processing. Their work addresses the challenges connected with gesture recognition in sequences that is necessary for understanding. Continuous sign language conversations. The research stresses the need for sequential gesture. And the need to adjust models in order to make longer gestures and phrase recognizable, Level sequences which are common in the sign language communication.

8. Oudah et al. (2020) 10 performed a review of different methods of recognition of hand gestures based on computer vision. Their research divides various gesture recognition techniques. From old image processing methods to the state-of-the-art deep learning based methods. The study highlights that the use of computer vision methods alongside deep learning models ie, the artificial neural networks have overridden the original formulation of the Cauchy boundary value problem changed gesture recognition by allowing the efficient and accurate processing of hand gestures in real time.

9. Pigou et al. (2015) [11] submitted a CNN-based architecture to identify static hand gestures in sign language. Their research has been among the earliest that have proved the efficiency of deep learning in identification of hand gestures and it formed the foundation for further studies. In static sign language recognition. The application of CNNS in the classification is discussed in the study. Forms hand shapes and gestures with a high amount of accuracy, especially in controlled environments. Environments where gestures remain static.

10. Rivera-Acosta et al. (2021) [13] built an American Sign Language conversion tool. YOLO based LSTMs (Long Short-Term Memory) networks. The integration of LSTM with the help of YOLO, the system was able to increase the accuracy because it was able to identify not only individual pointing gestures as well as sequential environment in which they appear. This hybrid approach helps deal with difficulties of identifying continuous and complex sign language phrases. The gestures require the context of the former signs.

11. According to Wadhawan & Kumar (2020) [15], Wadhawan & Kumar (2020) [15] suggested a deep learning approach that is concerned only with static signs, performing outstanding accuracy improvements. Their study demonstrated how deep learning approaches can be enhanced in terms of identification of isolated signs, and it played a part, as well. In order to improve systems that are used to handle basic hand gestures. This approach is particularly useful for applications where users only need to recognize individual signs rather than full sentence-level communication.

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

RESEARCH GAPS:

Although significant progress has been carried out in the field of symbolic language identification, there are a number of challenges and the research distance must be met. These gaps are essential to improve the reliability, accuracy and expansion of symbolic language translation systems in real time.

Some of the main research gaps in the existing document include:

- Handling Complex Sequences and Contextual Gestures- While many models (for example, Yolov8, Deepsign) are superior to recognizing static hand or signs of isolated, they fight with continuous languages and gestures depending on the context. Sign language is often associated with a combination of gestures, facial expressions and physical movements must be understood as a series of actions. The current methods often do not take into account the meaning of nuances that come from the torture or longer -string gestures, resulting in incorrect translations in dynamic conversations.
- Real-Time Processing in Challenging Environments- Many current systems, such as CNN and YOLO -based systems, optimized for the controlled environment but shows limits in the parameters of the real world. These systems may not work well in low light conditions, with background noise or when the user's hand gesture is obscured or partially deformed. In -depth learning models require additional improvements in strength to manage challenges in this real world, especially in different environments, where symbolic language communication often occurs.
- Bidirectional Translation Accuracy- Although some systems (for example, Rivera-acosta et al.) Combining translation to use YOLO and LSTM larger, the accuracy and effectiveness of the sub-translator still require significant improvement. Specifically, the word translation often encountered problems related to speech recognition and context understanding. Although the systems work well for translation of texts into text, the translation of words with accuracy in the gestures of the same smoothness is still a big challenge.
- User Interface and Accessibility- Although some studies have developed visual user interfaces (for example, profound), there is a gap in creating systems that can actually

be accessible to pilot users, especially for people with disabilities. Many systems still require professional knowledge to operate and improve are necessary to ensure that these systems can be used by a series of users in different contexts.

- Multilingual and Multicultural Adaptability- The majority of studies have focused on symbolic language systems for the US symbolic language (ASL), and although Yolo -based systems can be adjusted to other languages, there is always a distance in creating systems that can effectively translate between different symbol languages (for example, English symbol language (BSL), Indian symbol language (ISL)). This limitation limits the general application of symbolic language systems in different cultures and communities. In addition, current systems may not take into account the regional dialects or local variants in signs.
- Scalability and Deployment- Although the success of learning models in controlled tests, many fighting systems with the ability to expand when they are deployed in real applications. Identify gestures in real time requires significant calculation resources and many systems that do not work effectively on low devices. There is a gap in creating this lighting and expansion system for mobile or low platforms without affecting performance.

EXISTING METHODS:

The recognition of sign language has seen the development of various proposed methods and algorithms, including traditional image processing techniques and modern deep learning approaches. The primary current approaches for constructing sign language recognition systems are:

- Traditional Computer Vision Methods- Sign language recognition research was initially based on established computer vision methods such as edge detection, color segmentation, and optical flow. These methods were mainly concerned with identifying hand shapes and movements by following predetermined guidelines. While effective in controlled settings, they were not robust enough to handle practical challenges like changing lighting levels, background noise or the partial occlusion of hands.
- Convolutional Neural Networks (CNNs)- A large number of techniques for recognizing gestures are performed using CNNs. These networks are trained to identify hand gestures through classification by shape.epl. A CNN-based architecture was suggested by Pigou et al. (2015), which was capable of distinguishing static hand

gestures in a controlled environment. Nevertheless, CNNs are not perfect and cannot detect dynamic gestures or continuous sequences of hand movements; this is necessary for full sign language translation.

- Recurrent Neural Networks (RNNs)- Sequential gesture recognition has been achieved through the use of LSTM networks and RNNs. The capture of the temporal relations between gestures is an important aspect in comprehending sign in motion. Language sequence. Rivera-Acosta et al. (2021) did it in order to enhance precision. conjoined YOLO with LSTM and dealt with the hand sequentially. This was done by using both systems. However, combining RNNs with real-time video benefits the businesses significantly. Computation problems and latency still remain in processing.
- You Only Look Once (YOLO)- YOLOv8 and other components of the broader YALO framework have become highly popular in sign language recognition, thanks to their ability to detect objects quickly and accurately. In addition, YOLO is capable of reading hand gestures and can translate them into text or speech because it has the ability to detect multiple objects in real time. A YOLO-based system for real-time gesture processing and ASL recognition was shown to be highly successful by Ahmadi et al. (2024) and Alaftekin d. 244. While YOLO is highly accurate and fast, it still has some challenges to overcome when it comes to handling long, uninterrupted sequences of gestures.
- Hybrid Models- In certain cases, hybrid models that employ various deep learning techniques have been tested to enhance recognition performance. In their work on continuous gesture recognition, Mocialov et al. (n.d) utilized deep learning methods and sequence processing algorithms to achieve this goal through an algorithmic collaboration. Hybrid approaches aim to overcome the limitations of individual models by utilizing the strengths of various techniques to enhance system performance.
- Speech-to-Gesture Translation- The integration of natural language processing and speech recognition technologies has led to an increase in the number of translations from one form to another. The system proposed by Rivera-Acosta et al. (2021) merges YOLO-based gesture recognition with LSTM networks to enhance speech-to-gesture translation accuracy. This is particularly true for this particular system.

CHAPTER-4

PROPOSED MOTHODOLOGY

The proposed approach involves the creation of a real-time sign language recognition system that can distinguish between users and non-users using sign Language in real time. Sign language can be translated into spoken words and deaf and hard of hearing alike by this system. By utilizing the methodology that incorporates deep learning, computer vision and NLP technologies, an all-encompassing communication approach is achieved.

4.1. Requirement Analysis.

A requirement analysis is the starting point for the proposed methodology. This stage sets the system's main elements, functions, and drawbacks. The system must be capable of real-time sign language recognition with high accuracy. Why? Thus, it must be able to rapidly convert sign language into spoken words for efficient communication. In addition, it must be able to write both directions as well -- which means that voice or text input will be converted into matching sign language. A scalable system that can accommodate multiple users is not limited by any sign language region. Moreover, it must be robust, precise, and capable of dealing with diverse environmental conditions, including light or background noise. In conclusion, the system should be simple to navigate and allow sign language users as well as non-users of different technical abilities....

4.2. Data Collection:

The quality of data and diversity are crucial for training the deep learning model.... Why? Most of the data used in this project comes from Indian Sign Language (ISL) gestures, which include pictures of hand gesture reversing to signify letters and words as well as phrases. The Roboflow Universe is utilized to create a comprehensive set of images that illustrate various gestures in real-life scenarios. This calls for a dataset that has variables like light levels and hand shapes, or a color-changing one that keeps up with the speed of the gestures. In order to customize the model for real-life settings, the customized dataset will have several business-related events. Representations of any given sign which are done by various people. Training the model can be done. Properly labelling the images, which arouses interest to find out about the gestures that are connected to them. With each image. In each image the same letter or word will be depicted in the sign language, for example. “B” and “Hello”, thank you messages among others. These will have annotations on them. The type of tools like the

Label box or the Labelling, and the tags will have typical formats like YOLO annotation format.

4.3. Model Development:

Model development refers to the process of making a choice for the core deep learning model. YOLO's deep learning model that is informed by X.264 million word words for "instant speech" is used. Identify gestures in real time in the project. Applications of YOLO (You Only Look Once). Enables real-time recognition of sign language that can detect and sort out several signs objects in a single operation. Using data augmentation techniques like flips, nonetheless, rotational randomizations and brightness corrections to facilitate a better performance of the model in real situations it will be trained on labelled dataset. For improved accuracy, hyper-parameters including the learning rate, batch size will be used as part of the training in an attempt to change them. The model. To make the model more flexible to the new, unseen data during the training process stage, the given dataset will be split into three sections, namely: training, validation and test sets. The performance of model will be measured by the way of accuracy, precision, recall, and F1-score.

4.4. Application Development:

After the training of the model, the following step is to develop an application that gives a user an opportunity to watch the videos produced by the model. An easy going interface for interacting with the system. The development of the application will utilize Streamlit, a framework that allows for the creation of interactive web applications with minimal code. Real-time video from the webcam will be displayed on the user interface (UI), which will also translate sign language gestures into text and audio. It will also include a module for translating non-sign language text input into gestures in sign language. The service's users are given access to this feature. This technique enables both individuals and non-users to communicate in sign language using bidirectional methods. Regardless of the individual, the application will be user-friendly for anyone, regardless.

4.5. System Architecture:

By integrating the frontend and backend, the system architecture of this sign language recognition application ensures that users have a user-friendly experience in real time.

- Frontend Design (Streamlit Interface)- Streamlit is employed to create the system's frontend, which provides a user-friendly interface that facilitates real-time interaction between users. This web-based interface enables users to initiate and terminate the sign language recognition process with just one button push. It shows the user real time footage of their hand gestures, captured on a webcam. The system alters the interface with identified signs and text as it goes. Processes the video feed. Why? Computer users can monitor the process towards the recognition right at the finger tips. At any given time using this feature.

- Text and voice output is also facilitated from the frontend. A set of word keywords that coincides when one follows a specific gesture it will be shown on the screen. Furthermore, the TTS engine is that is activated in order to convert the perceived text into an audible speech, allowing non-sign users to write messages. Language to communicate with it. It is not difficult for users to monitor their input since the system sees every gesture both visually and audibly, which leads to a smoother communication. It is an interactive system such that the users with minimal technical understanding of the interface can interact and participate in every use of it.
- Video Processing and Gesture Recognition Backend Design. Backend operations, which are comprised of taking webcam inputs, processing every frame and listening for sign language gestures. Are also behind the scene. In order to have efficient video capture and processing, the use of to do that, OpenCV – a strong computer vision library – is used. Every frame from the video feed is analysed on an individual basis to find and interpret hand signals that are critical. For recognition of the sign language process.
- The system uses the YOLO deep learning model in recognizing gestures. Implemented using Ultralytic Yolo framework By using this model, it is possible to identify hand gestures and map them along with the appropriate letters in Indian Sign Language (ISL) from A to Z. By training itself with best.pt weights, the YOLO model is capable of recognizing signs quickly and accurately to great extents.
- The system also manages the time of maintaining gestures and time does not work to improve the accuracy of recognition. For example, if there is no other gesture that is detected during the time not operating in advance, the system assumes that the signing series of signs has ended. The recognized gestures are then converted into text, appearing on the front. The auxiliary part continues to continue the video stream to identify additional gestures, ensuring that the system still reacts and accurately in real time.
- Designed for real -time treatment to manage the data flow continuously and ensure smooth operation, the system applies multi -threaded architecture. The process of identifying,

displaying documents and releasing partners (TTS) operates in parallel through separate streams. By implementing these processes asynchronously, the system can recognize new signs, manage gestures and create a real -time speech without any remarkable time. The TTS engine is performed in its own wire to avoid interfering in the symbolic language recognition process, ensuring that the system still reacts and provides transparent communication. This approach allows effective active interactions in real time, providing user -friendly experiences and accessible to users of sign language and non -signing language speakers.

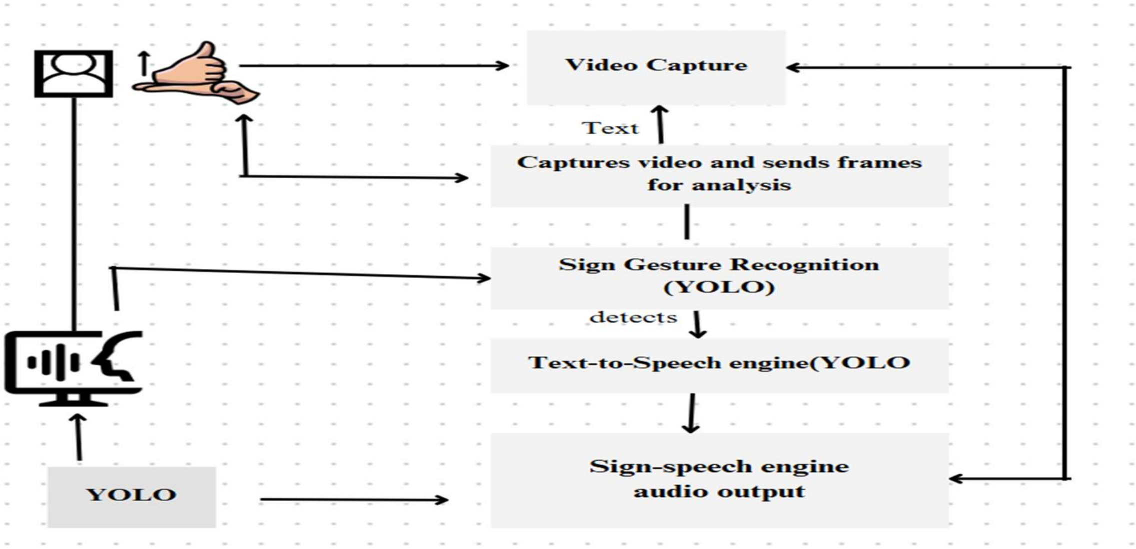

Figure 1 – System Architecture

4.6 Integration:

Integrated is an important step in which all components of the system are combined in a work unit. During this period, the model formed will be integrated into the application based on rationalization. The system will handle real -time contributions from the webcam, will be analyzed by the In -Depth learning model to recognize the gestures of the sign language. The text output of the model will be displayed on the screen and the system will also convert this text out of the speech to facilitate communication with non -signing loudspeakers. In addition, the signature and signature language modules will be integrated to ensure that the system operates in both directions, allowing transparent communication between symbol language users and non-user users. After integration, the entire system will be checked to ensure that it works effectively, with minimum latency and high accuracy.

4.7 Testing:

Testing phase is the system assessment to ensure that it meets all the requirements described in the analysis of the requirements. Unit tests will be done on each individual component, such as gesture recognition model, convert text into signatures and voice -converting speech into signatures. Integrated tests will ensure that all components work together gently, not slow or noticeable errors. Users will be done by hiring real users - users and people who do not use symbolic language - who will interact with the application to provide comments on its functions and persuasion. These comments will be used to improve and refine the system to meet the user's expectations.

4.8 Deployment:

After the system was successful in all tests, it will be ready to deploy. The system will be deployed on the cloud platform or in the form of local applications, depending on the user and target audience. The implementation stage is to prepare the issuing system, ensuring that it is stable, can be expanded and easily accessible for users. A series of final tests will be done to ensure that the system works well under different conditions of the real world. Once deployed, the system will be provided to download or access via the web interface. Documents and instructions will be provided to help users install and use the system effectively.

4.9 Maintenance and Updates:

Once deployed, the system will require regular maintenance and update to ensure efficiency and level of continuous fit. Monitoring tools will be done to follow the system performance and detect all possible problems. When new data kits are available or better algorithms are developed, the system model will be updated to improve its accuracy and function. In addition, users' comments will be collected regularly to identify improvement areas, such as fixing errors, improving the user interface or adding new features to the system.

4.10 Impact Assessment:

Impact on the final stage is to perform the impact assessment to evaluate the effectiveness of the system. This will imply the extent that the system has improved access and communication for symbolic language users and non -user users. The main measures such as the user application rate, the accuracy of gesture recognition and user satisfaction will be evaluated. The impact of the system on social and communications committee will be evaluated, especially in the way it supports communication among individuals with different subject capacity.

CHAPTER-5

OBJECTIVES

The main objective of this project is to develop a real -time identification and translation system, filling the communication distance between the sign language user and the language speaker without signing. This system uses advanced technologies such as computer vision, intensive learning and natural language processing to provide an intuitive and effective platform for real -time communication. The main objective of this project is as follows:

1. Real-Time Sign Language Recognition- The main goal is to design and implement a system that can recognize the gesture of the symbol language in real time. The system will be able to detect accurately and explain the gestures of the hand corresponding to the letters of the Indian symbol language (A - Z) and the commonly used words. This reality recognition is aimed at creating transparent communication for hearing and hearing impaired individuals, allowing them to effectively interact with unsigned languages.
2. Bidirectional Communication- The system will support two -way communication. This means that he not only has to recognize and translate the gestures of the symbol language into text and speech, but also converts the spoken language into a gesture of the symbol language. By combining both the language translation of text / voice and voice and voice, the system will allow both symbolic language users and non -accented language users to communicate freely, promote comprehensive and improve accessible.
3. Integration of Text-to-Speech (TTS) Technology- The system will include the dispute function function (TTS) that converts the gestures of the symbolic language recognized in the spoken words. This will allow users to communicate with language speakers not to be interactive. The goal is to create an integrated system in the TTS output without introducing latency, ensuring liquid and continuous communication.
4. High Accuracy and Robustness- Important goals is to achieve high accuracy in gesture recognition, even in changing conditions such as light, wallpapers and hand size. The system must be strong enough to manage the challenges of the real world, including variants in the form of hand, skin tones and typical speed. By taking advantage of YOLO -based learning models, the system will provide coherent performance and accuracy in different scenarios.
5. User-Friendly Interface- System must be designed with user -friendly interface, using

streamlit for its front web. The interface will allow users to start and easily stop reconnaissance, display signs recognized in real time and provide voice comments. Make sure this system is intuitive and can access to all users, including those with little technical knowledge, which is essential to have its impact according to its plan.

6. Efficient and Real-Time Processing- The system must be able to handle video streams in real time without significant delay. The goal is to minimize all delays in the process of identification and translation, ensuring that the symbolic gestures are translated into text or words as quickly as possible. This calls for competent management of video frames. And data management asynchronous in order to achieve smooth performance.

7. Scalability and Adaptability- The system should be able to grow and be able to cope with a number of different variants in the symbol language, to keep up to different variants in the region and culture are addressed in the symbolic language gestures. This will help to make sure that this system can be adapted to a number of users, and cases of use irrespective of geographical location or countries.

8. Impact on Social Inclusion- The primary objective that this project is to achieve is to ensure that there is consistency. Of the society, by providing a good communication channel for the sign language users. Unsigned language users. With a view to removing communication barriers, the system focuses on targeting them. Grant the right to those who have a hearing impairment by giving them the tools have to communicate autonomously and be confident enough through daily interaction.

9. System Performance Optimization- The performance of the system has to be optimized and efficiency in order to make sure it will be able to function transparently in the real conditions. This is optimizing accuracy of gesture recognition, processing delay minimization and providing a system that can handle huge volumes of data in real time with no error.

CHAPTER-6

SYSTEM DESIGN & IMPLEMENTATION

There are a number of working components in the design and deployment of the system. in order to let symbolic language identification in real time. The first step in building This system is processing of data before data. For the said system, a compilation of data is needed. Which are used from the gestures of Indian symbol language (ISL) are images of the static use of gestures and dynamics which depict letters, words and standard sentences in the ISL. To prepare data for the model, images are noted by tools like Labelbox or Labelling, in which each image is marked by boxes that are surrounded by gestures, identify letters or corresponding words. These captions are then resized at 320x320 pixels to meet the input size requirements of the Yolov8 model. Pixel value is standardized from 0 to 1 to ensure effective training. In addition, data increase techniques such as reversing, rotating, expanding and lighting are applied to the data set to increase its diversity and strength, thus improving the performance of the model through different lighting, corners and background conditions.

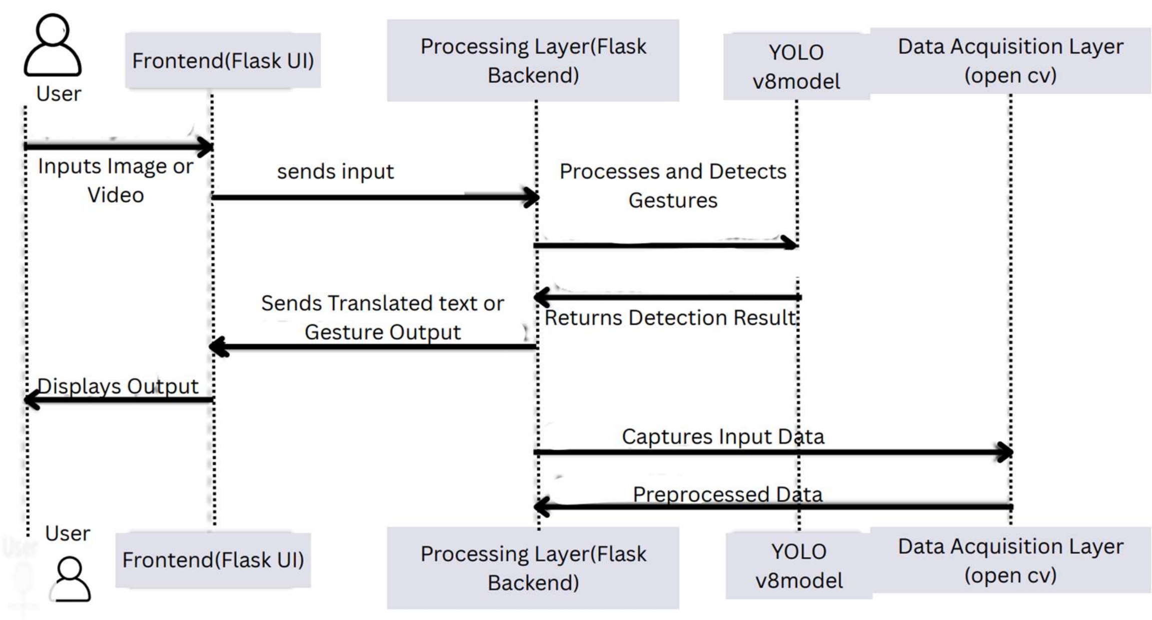

Figure 2 - Gesture Recognition System Sequence Diagram

After the data set is ready, the next step is to form a model. The Yolov8 model was chosen for its effectiveness and accuracy in detecting real -time objects. The formation of the model includes the configuration of the YAML configuration file that specifies the structure of the data set, the class name (for example, letters, words) and the journey path in the direction of training, authentication and testing. The training process takes place in some ages, where the

model learns how to detect and classify gestures from the hands. During this period, the model performance was closely monitored and HyperParammet as the learning ratio, the size of the lot and the desired number of desired to be optimized for better accuracy. The confirmation data is used to ensure that the surface -free model, while the performance measures such as the mean average accuracy (MAP) are followed to evaluate the effectiveness of the model. The testing phase according to the training process, in which the accuracy, accuracy, recovery and F1 points of the model are evaluated on a collection of confusing tests and matrices created to determine improved areas.
The heart of the system lies in recognition of real -time gestures, performed by integrating a live video stream of live formation model Yolov8. Use webcam of user webcam. Each frame is processed by the YOLO model, identifying the gestures of the hand and classifying them in the letters or their corresponding words. The recognized gestures are displayed in real time on the screen with the corresponding text. The system uses multi -threaded channel to ensure that gesture identification and writing activities (TTS) occur simultaneously without delay. This approach allows the system to provide low latency treatment, ensuring that the accredited gestures are quickly displayed, allowing effective communication between sign language users and non -sign language speakers.

User interface is developed using Streamlit, the Python frame allows creating web applications. The interface provides liquid experience and interacting for users. Thanks to Streamlit, users will observe that their gestures are looked up, and transformed into text on the screen. The system also facilitates the signature text language conversion wherein the users can type the easily. Text and system will manifest gestures of symbol language pertaining to the image. Besides, the system has offline concept which enables users to download videos recorded. In order to detect gestures, this can be helpful in low internet connectivity or not. The interface is simple and intuitive, which means that users with different industries can access it. Levels of technical expertise.

Apart from gesture recognition, the function of the text is incorporated into the system.
dissection (TTS) in order to transform the material recognized as a speech. When the system identifies gestures and shows the text which is related to the screen, the PYTTSX3 or GTTS tool is applied to turn the text into discourse. This feature is essential to make the system access to unique languages, allowing them to understand recognized gestures. The TTS

engine operates asynchronously to ensure that the words are created in real time, continuously when the gestures are detected or after the fact is a fully recognized word.

System also includes voice translation function. When the user speaks to the microphone, the system uses natural language processing techniques (NLP) to convert words that are pronounced into text. This document is then mapped to the corresponding Isl gestures, then animated and displayed on the screen for sign language users. This feature allows two - dimensional communication between the sign language user and the language speaker without signing, thus promoting the calculation including and filling the intersection of communication between the two groups.

The technology stack comprises of YOLOv8 real-time gesture detection, Python backend programming, OpenCV for video stream processing, Streamlit for frontend development, and pyttsx3 or gTTS for TTS functionality. Besides, they deal with backend and front end not only communication, Flask is used for data management and numerical computations as well. while Panda & NumPy are for managing datasets. By combining these technologies, the recognition system of the sign language is made more smooth and efficient and also easy to use.

The implementation process is rounded off by completion of system integration. All components will be put together and made to work adequately at this stage. Flask is that deals with backend logic such as gesture recognition and TTS. functionality and interacts with the frontend that was created using Streamlit. By integrating the two systems through HTTP requests, both systems can dynamically translate recognized gestures into speech and display them on the UI. A multithreading approach ensures that both the recognition process and speech generation are executed at the same time, resulting in a responsive and interactive user experience.

The system is subjected to rigorous testing and validation. Ultimately, Testing is conducted to determine the accuracy of gesture recognition, to test latency for real-time performance and to ensure user-friendliness. After analysing the feedback from testing, improvements are made to ensure the system's accuracy, responsiveness, and usability in real-world scenarios.

CHAPTER 7

TIMELINE FOR EXECUTION OF PROJECT

Table 1 : Time Line

TASK	DATA	CONTENT
Review- 0	29 Jan 2025 - 31 Jan 2025	-Title Finalization with Supervisor -Literature Survey -Finalizing Objectives -Deciding Methodology
Review- 1	17 Feb 2025 - 22 Feb 2025	-Title -Abstract -Literature Survey (Minimum 10 papers) -Objectives -Existing Methods (Drawbacks) -Proposed Method -Architecture Diagram -Modules -Hardware and Software Details -Time Line (Gantt Chart) -References -Spiral-Binded Hard copy of Review-1 Report
Review- 2	17 Mar 2025 - 21 Mar 2025	-Algorithm Details -Source Code Details -50% Implementation with Live Demo

		-50% Report Softcopy to be Submitted
Review- 3	21 Apr 2025 - 26 Apr 2025	-Algorithm Details -Source Code Details -100% Implementation -100% Completed Report (Hardcopy and softcopy) -Live Demonstration of the Project
Final Viva Voce	12 May 2025 - 24 May 2025	-100% Implementation Details -100% Completed Report (Hardcopy and Softcopy -Live Demonstration of the Project -Plagiarism Report -Publications Copy of the Paper

CHAPTER-8

OUTCOMES

The main result of this project is the successful development and implementation of an Indian language identification and translation system in real time. Using learning algorithms in -depth, especially the YOLO model (you do not see once), combined with computer vision techniques, the system can recognize with the accuracy and translate Isl gestures into text and words in real time. This achievement allows transparent communication between hearing impaired and deaf people, filling the gap to understand and interact.

In addition, another important result is the ability of the system to convert text in writing in the gestures of the sign language, thus allowing two -way communication. This feature allows people who do not know the symbolic language communication with the hearing impaired by translating their text into a gesture of the corresponding symbol language, by promoting greater comprehensive and social interaction. In addition, the integration of the natural language treatment (PNL) for the translation of vocal language into signatures to further improve the usefulness of the system, allowing the language to be spoken into a sign language gesture and improving the overall communication experience. Projects also led to a significant increase in access to people with hearing disorders. By eliminating the need for professional interpreters, this system provides an affordable and practical tool for daily communication, allowing users to interact freely in different parameters. The system's live demonstration highlights its ability to identify in real time, the ability to convert text into discourse and its language translation functions from the signature voice, showing the potential of the system to meet the communication needs of the real world.

In addition to the technical implementation, the project creates a complete document, including detailed reports on the design of the system, challenges encountered and solutions provided. This document acts as a valuable resource for research and development in the future in the field of supportive technology, especially in the field of symbol language translation. The last, the project set out the basic things about future improvements and expansion, such as improving the accuracy of recognition, managing multiple signals of signs and integrating advanced functions such as real -time video conferences with symbolic language explanation. The results of this project contribute not only to improve communication for people with hearing impairment.

CHAPTER-9

RESULTS AND DISCUSSIONS

Signal language identification frame, using webcam stream, showing the effectiveness of symbolic language recognition in real time. The YOLO model, formed on a set of symbolic language data, accurately identifies individual letters in the US symbol language (ASL). The system processes each video frame, detecting the movements of the hands and mapping them to their corresponding letters. Users can track their gestures in real time through a rationalized interface, where the letters are determined to be displayed. In addition, the system combines a vocal text tool (TTS), converts a series of letters recognized in the text and creates an audio output once a complete word is determined and maintained for a sufficient time. This feature allows real -time communication, allowing individuals to interact perfectly with people who do not know the symbol language. Although the system's solid performance, some challenges were encountered in tests. Different factors such as lighting conditions, the clarity of hand movements and hand positioning compared to the camera have a significant impact on the accuracy of symbolic language identification. In the scenarios that the hand is obscured or has a background noise in the video stream, the system sometimes has difficulty recognizing certain signs. However, with other training and improvement data, these issues may be reduced. The integration of the vocal text in the auxiliary part has significantly improved the accessibility by providing the output of accurate words and natural consonants, improving communication for people who do not include symbol language.

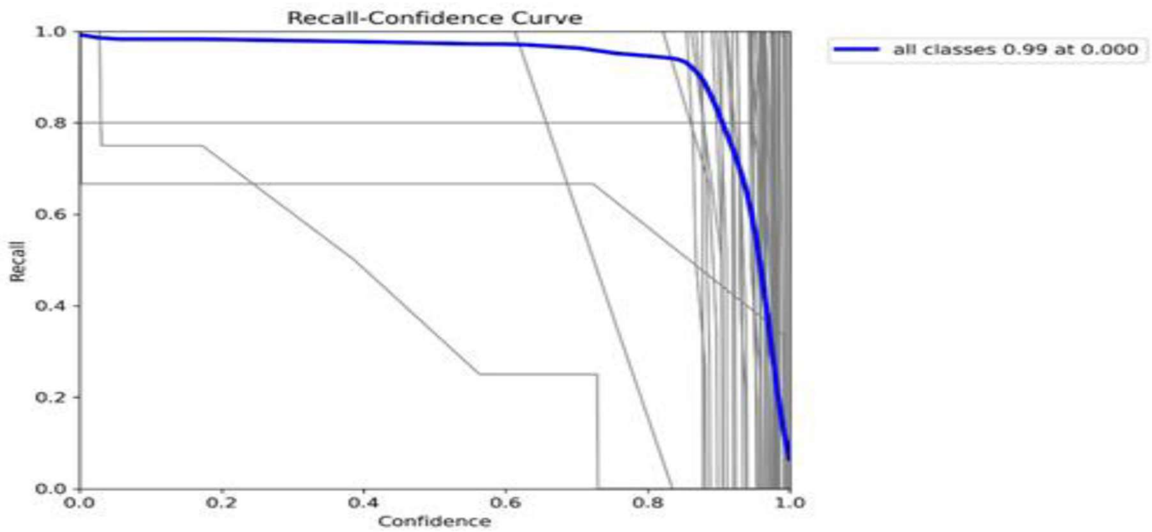

Figure 3: Recall-Confidence Curve

The performance of the model has been analysed using several key metrics, including accuracy, precision, and recall. The Recall vs. The confidence curve in Figure 3 displays the model's performance by measuring the correlation between recall and confidence, which is a measure of its accuracy. As per the graph, recall typically decreases as confidence threshold increases and model selection becomes more selective, resulting in predictions being rejected with lower certainty. The occurrence of false negatives is more common than true positives. The blue line denotes the overall model performance, indicating high recall at lower confidence levels, while the dark lines indicate differences in performance among individual gesture classes. Finding the ideal confidence threshold that balances detecting all objects while maintaining accuracy is essential for real-time applications like YOLO, where accuracy should be guaranteed. This visualization aids in this effort.

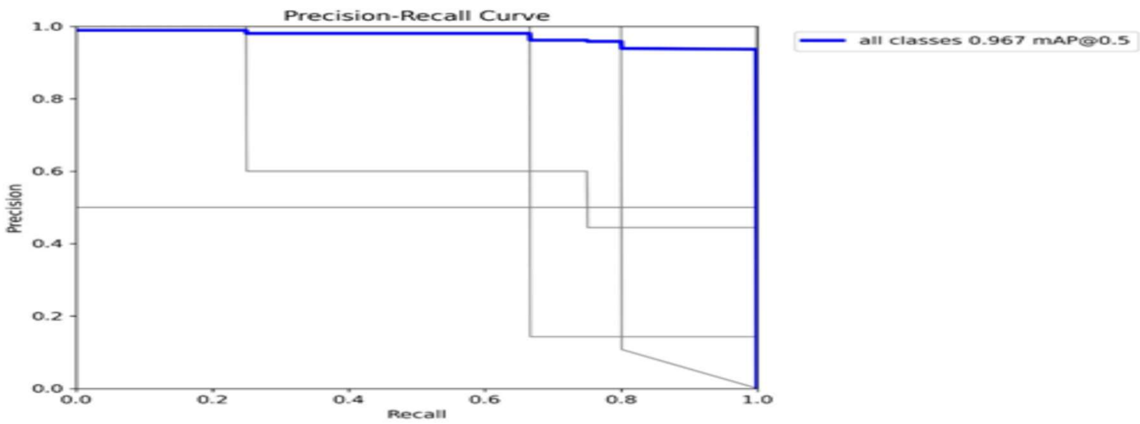

Figure 4: Precision-Recall Curve

In Figure 4, The Precision vs the recall curve is used to evaluate the model's performance, highlighting the trade-off between precision (the accuracy of detections) and recall (which involves finding all true objects). The blue line indicates the overall model performance, with an accuracy (mean Average Precision, mAP) of 0.967. Just one example. The performance of individual gesture classes is indicated by dark lines. Based on the data presented in this graph, the model is capable of detecting most gestures with accuracy, guaranteeing reliable sign language recognition in real time.

Table 2: Model Performance Matrix

METRIC	VALUE
Accuracy	0.97
Precision	0.967
Recall	0.99

Overall, the system is very accurate at 96.7% precision and recalls 99% of information received, but difficulties exist when dealing with specific conditions such as hand positioning, lighting effects, background interference etc. [See details in discussion below]. The system's real-time sign language recognition, text-to-speech capabilities, and high-performance evaluation metrics make it a practical tool for people who are already proficient in sign languages to improve their communication.

CHAPTER-10

CONCLUSION

Even with the promising performance, the model has a few limits. The accuracy of detection can be affected by shifts in gesture styles for users, location of the hands, as well as the background clutter. And lighting conditions. Such complications represent the necessity of continuous data collection. Model training using a large dataset that includes different hand shapes of users. Environmental circumstances. Increasing resilience might also involve making strategies such as adaptive thresholding, extraction of background or attention processes. A few improvements may be carried out in the future to this regard in order to upgrade the system. Dependability and functionality. The model would take a more flexible and useful shape. The real-life scenarios if it was enlarged to include a more diverse set of indications, i.e. words, alphabets, and contextual motions. The technology can also be brought closer to the users. Improving audio synthesis with speech model that sounds natural and including language support.

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APPENDIX-A

PSUEDOCODE

START

1. Initialize system components:
   - Load YOLOv8 pre-trained model on sign language gestures.
   - Initialize Streamlit user interface
   - Initialize the webcam video feed with the use of OpenCV.
   - Initialize Text-to-Speech (TTS) engine

2. Begin video capture from webcam

3. LOOP until user stops:
   a. Capture a frame from webcam
   b. Preprocess the frame:
      - Resize frame
      - Normalize pixel values
      - Background subtraction if necessary
      - Convert frame to RGB
   c. Hand gestures detection in the frame with YOLO model.
   d. IF gesture detected:
      - Extract bounding box coordinates
      - Classify gesture (letter/word)
      - Show detected text on Streamlit UI.
      - Append currently detected character to word buffer.
      - Bounding box and label on video frame.
   e. Check idle time:
      - IF no new gestures detected for threshold time:
         - Consider current word buffer complete
         - Display full word
         - Convert word to speech using TTS engine
         - Clear word buffer for next input
   f. Display live video feed with annotations on Streamlit UI

4. Additional Module: Voice-to-Sign (Bidirectional Communication)
   a. Capture voice input from microphone
   b. Convert speech to text using Speech Recognition API
   c. Map spoken words to corresponding sign language animations/images
   d. Display the animation or image sequence on the UI

5. Allow the user to:
   - Upload image for offline gesture recognition
   - Input text to see sign language translation

6. Terminate:
   - Release webcam resource
   - Close all windows
   - End Streamlit session

END

APPENDIX-B

SCREENSHOTS

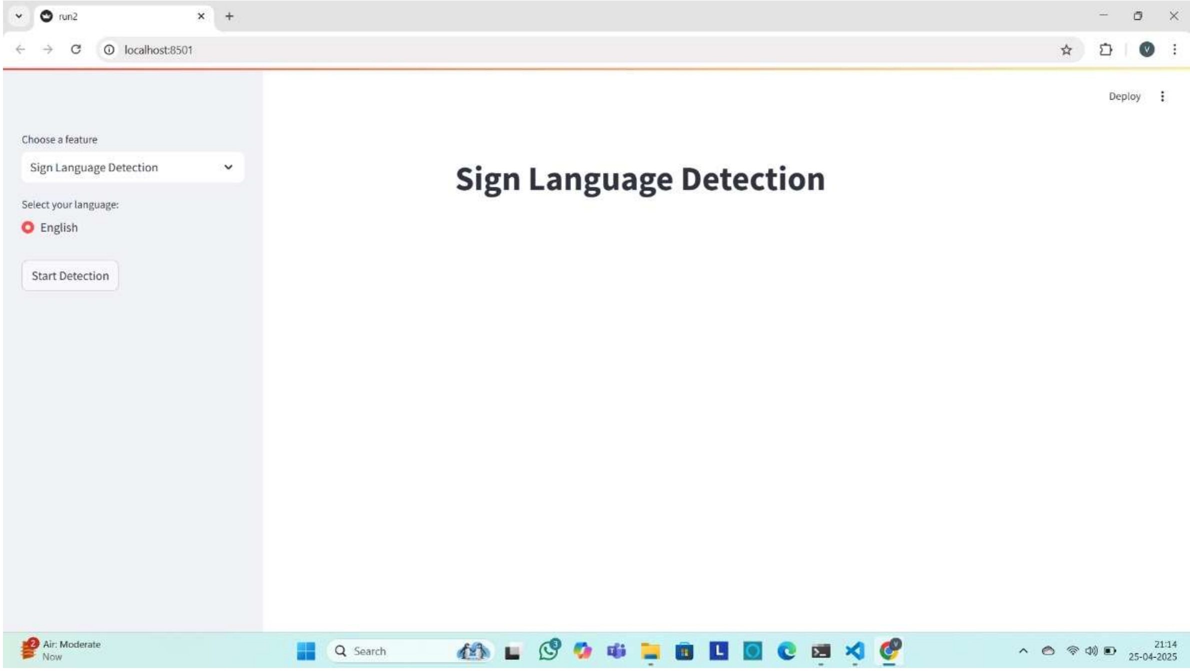


Figure 5: Home Page

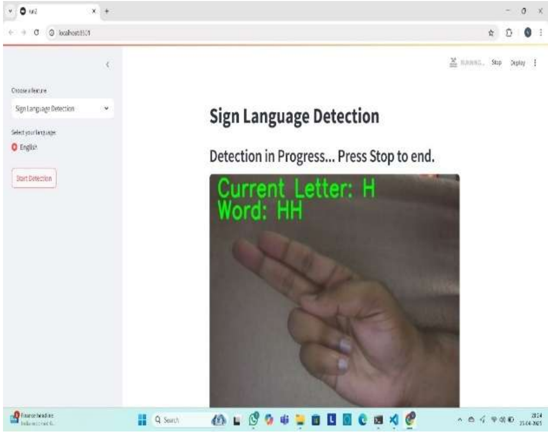


Figure 6 : Detection 1

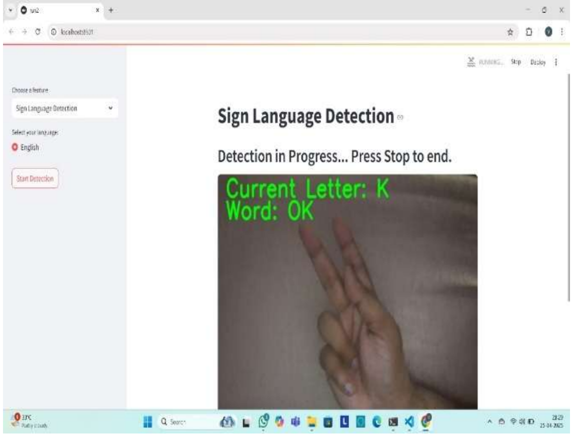


Figure 7: Detection 2

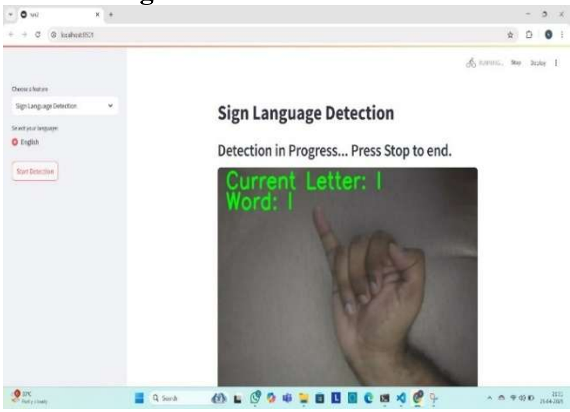


Figure 8: Detection 3

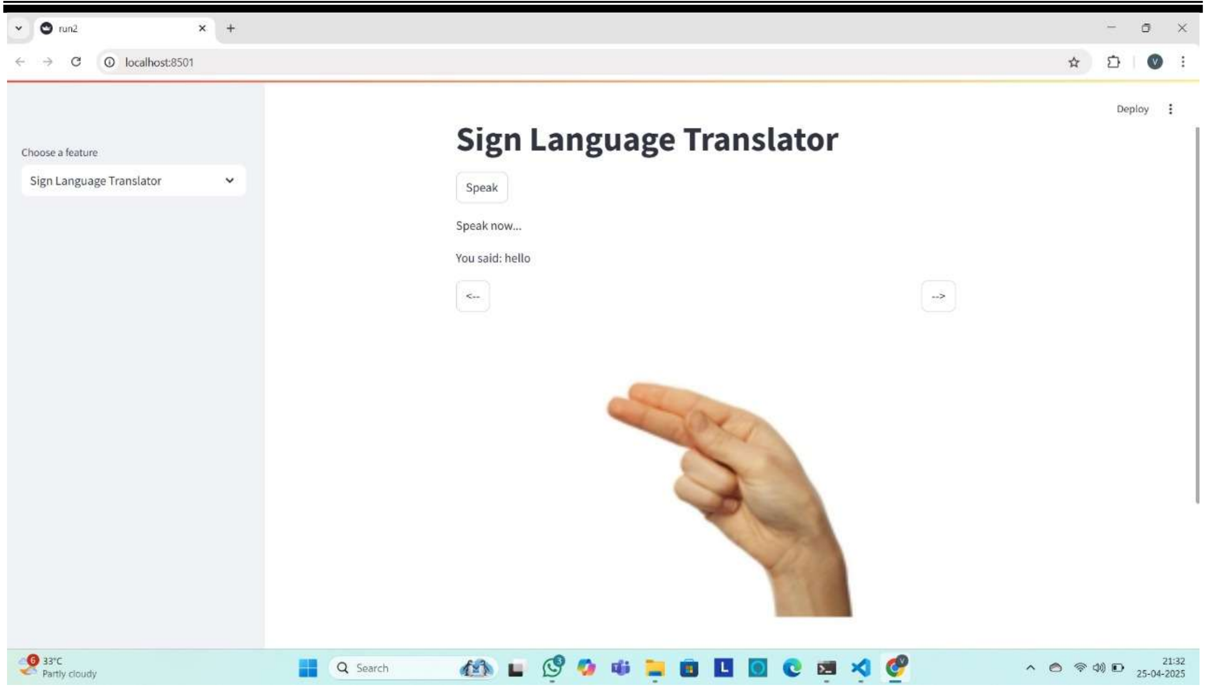


Figure 9: Translation 1

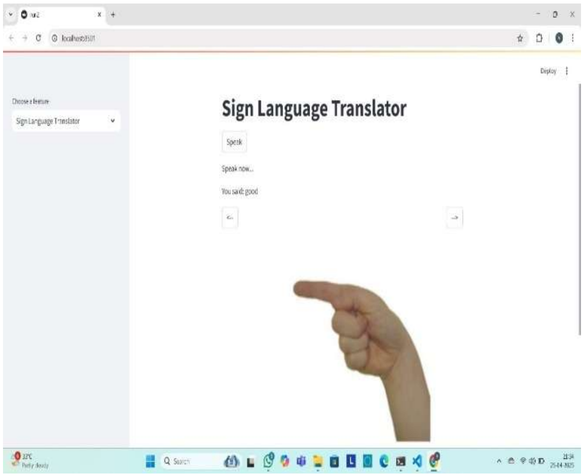


Figure 10: Translation 2

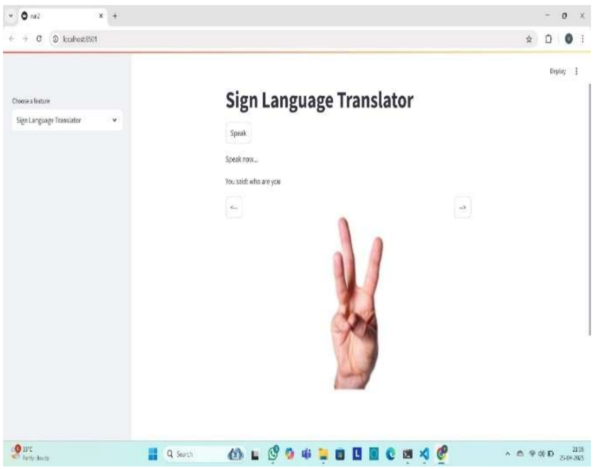


Figure 11: Translation 3

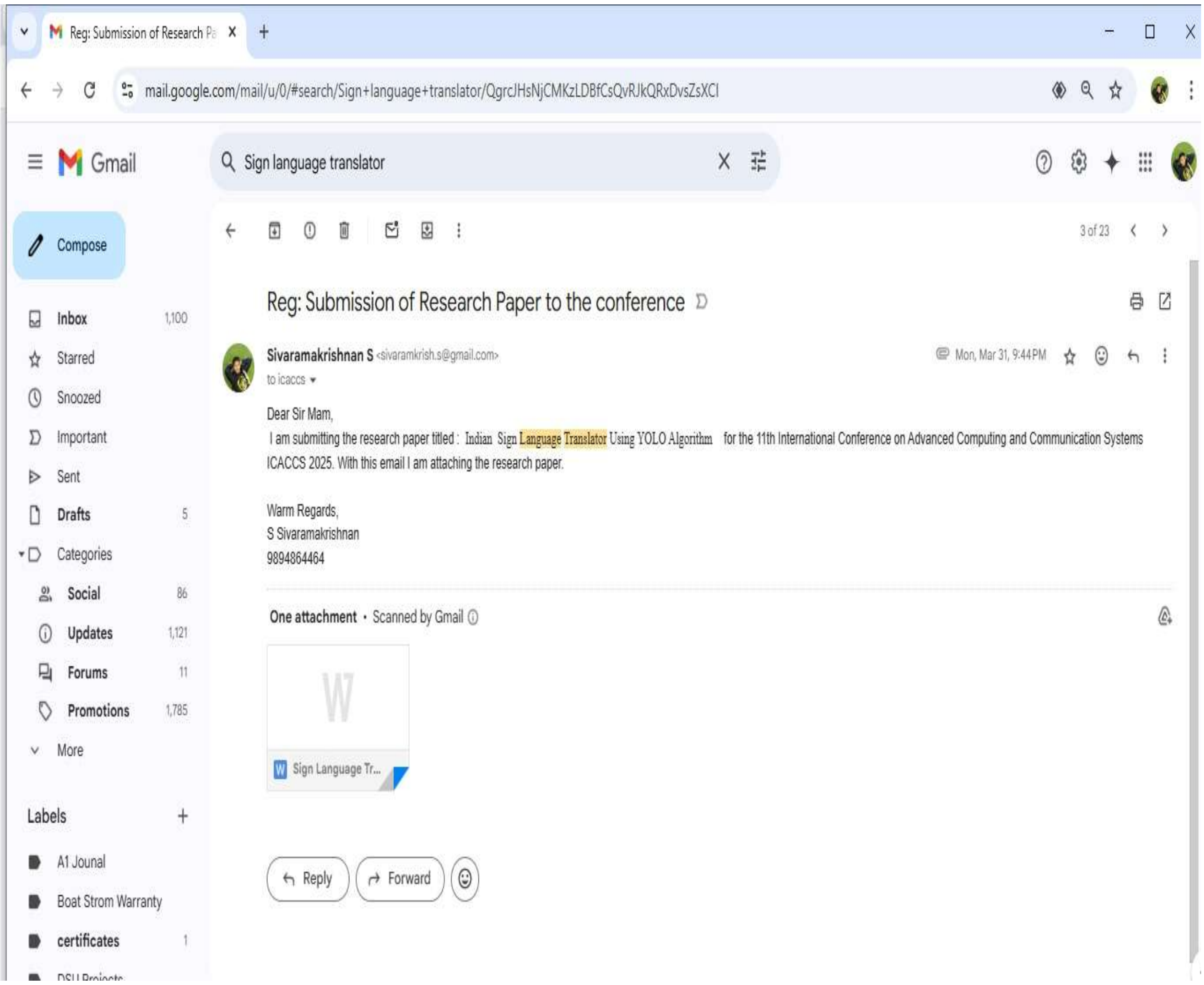
APPENDIX-C

ENCLOSURES

1.Journal publication/Conference Paper Presented Certificates of all students.

2. Similarity Index / Plagiarism Check report clearly showing the Percentage (%). No need for a page-wise explanation.

3. Details of mapping the project with the Sustainable Development Goals (SDGs)



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Sustainable Development Goals

The Sign Language Recognition Framework aligns with several UN Sustainable Development Goals. Primarily, it addresses SDG 10 by reducing inequalities, enabling real-time communication for individuals with hearing and speech impairments, and fostering equal social and professional opportunities. It also supports SDG 4 by providing an accessible learning resource for inclusive and equitable quality education, benefiting both students and educators. Additionally, the project contributes to SDG 9 by leveraging innovative technologies like YOLO, real-time video processing, and AI to create a smart and scalable communication solution. Indirectly, the system enhances psychological and emotional well-being (SDG 3) by improving communication, reducing isolation, and increasing self-esteem among those with hearing and speech disabilities.