

Sign Language Conversion and Voice Impairment Assistance

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering

By

SIMHADRI SAI SANTOSH DEEPAK (Reg.No - 40111229)

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**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
SCHOOL OF COMPUTING**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

CATEGORY-1 UNIVERSITY BY UGC

**Accredited with Grade “A++” by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI,
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SIMHADRI SAI SANTOSH DEEPAK (Reg.No - 40111229)** and **REDDI RAM SAGAR (Reg.No - 40111051)** who carried out the Project entitled "**SIGN LANGUAGE CONVERSION AND VOICE IMPAIRMENT ASSISTANCE**" under my supervision from November 2023 to April 2024.

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DECLARATION

I, **SIMHADRI SAI SANTOSH DEEPAK (Reg.No - 40111229)**, hereby declare that the Project Report entitled “**SIGN LANGUAGE CONVERSION AND VOICE IMPAIRMENT ASSISTANCE**” done by me under the guidance of **Dr. B. U. Anu Barathi M.E., Ph.D.** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in **Computer Science and Engineering**.

DATE:

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SIGNATURE OF THE CANDIDATE

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ABSTRACT

In an increasingly diverse and integrative world, effective communication is a fundamental human right. However, the Deaf and Hard of Hearing (DHH) community faces a significant communication gap, as most tools and technologies are designed primarily for the hearing population. The project, "Sign Language Conversion and Voice Impairment Assistance", seeks to bridge this divide by developing innovative solutions for sign language interpretation and communication. The primary objective is to create a comprehensive system that empowers DHH individuals to engage in seamless conversations with the broader society. This system will employ advanced technologies to recognize and translate sign language gestures into written or spoken language in real time. The core of this project lies in its commitment to accessibility and integration. By leveraging cutting-edge advancements in computer vision and machine learning, the system will accurately interpret and translate a wide range of sign language gestures, ensuring inclusion and effective communication. The real-time translation feature is particularly crucial, as it enables instant and fluid interactions between DHH individuals and their hearing counterparts. Moreover, The user-friendly interface will streamline the user experience, making it easy for both DHH and hearing users to engage in meaningful conversations without barriers. Furthermore, the project's mobile and web integration aspects are pivotal in extending its reach across various social and professional settings. Whether in educational institutions, healthcare facilities, or workplaces, the system's versatility and adaptability will enable seamless integration into daily interactions. For instance, in educational settings, DHH students can participate actively in classroom discussions, collaborate with peers, and access learning materials with ease. Similarly, in healthcare settings, healthcare providers can communicate effectively with DHH patients, ensuring accurate diagnosis and quality care. The success of this project not only promises to improve the lives of the DHH community but also highlights the transformative role of technology in enhancing accessibility and integration. By reducing communication barriers and fostering cross-community interactions, this project stands as a significant step toward creating a more inclusive and diverse society. It emphasizes embracing diversity and using technology to empower individuals, fostering social cohesion.

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL FORM
API	Application Programming Interface
ASL	American Sign Language
CNN	Convolutional Neural Network
DHH	Deaf and Hard of Hearing
LSTM	Long Short-Term Memory
mAP	Mean Average Precision
RNN	Recurrent Neural Network

CHAPTER 1

INTRODUCTION

In today's rapidly evolving technological landscape and growing recognition of the value of diversity, ensuring communication accessibility has become more critical than ever. Despite the remarkable progress that has shaped our modern society, there remains a significant gap in effective communication for the Deaf and Hard of Hearing (DHH) community. Many communication tools and technologies are primarily designed with a hearing audience in mind, inadvertently creating barriers for individuals who rely on sign language as their primary means of communication.

The "Sign Language Conversion and Voice Impairment Assistance" project stands as a pioneering effort to directly address this challenge by developing innovative methods to facilitate sign language interpretation and foster harmonious communication between Deaf and hearing individuals. Our goal is to create a comprehensive and intuitive solution that enables real-time interactions for DHH individuals with their hearing counterparts. Leveraging state-of-the-art technology, we aim to accurately identify and interpret sign language gestures into written or spoken language, enabling seamless communication across these diverse linguistic communities.

The significance of this initiative cannot be overstated; it represents a monumental leap forward in the pursuit of inclusion, with the potential to profoundly impact lives and reshape how we engage with one another in an increasingly diverse and interconnected global landscape. This introduction provides a glimpse into the depth and breadth of our Sign Language Conversion project, which holds the promise of dismantling language barriers and fostering a more inclusive and empathetic society.

Expanding further, our project delves into the intricate layers of technology and human interaction. By integrating cutting-edge machine learning algorithms and deep neural networks, we aim to achieve unparalleled accuracy in interpreting sign language gestures, ensuring that the nuances and complexities of communication

are captured with precision. Furthermore, our system is designed to be user-friendly, with intuitive interfaces that empower DHH individuals to express themselves naturally and effortlessly.

One of the key innovations of our project lies in its real-time capabilities. Through seamless integration with live communication channels, such as video conferencing platforms and mobile applications, our solution enables instant translation and interpretation of sign language into spoken or written language, bridging the gap between different linguistic modalities. This real-time functionality is essential for facilitating spontaneous and meaningful interactions, promoting inclusion and fostering a sense of belonging for DHH individuals in various social and professional settings.

Moreover, our project extends beyond mere translation; it embodies a vision of empowerment and autonomy for DHH individuals. By incorporating customizable features and adaptive learning mechanisms, our system evolves with the user, continuously improving its accuracy and responsiveness to individual communication styles. This personalized approach not only enhances the user experience but also promotes self-confidence and independence in communication.

In addition to its technical prowess, our project places a strong emphasis on ethical considerations and cultural sensitivity. We collaborate closely with DHH communities and linguistic experts to ensure that our system respects and preserves the rich cultural heritage embedded in sign language. Through inclusive design practices and ongoing community feedback, we strive to create a platform that not only meets functional requirements but also reflects the diverse identities and expressions of its users.

Looking ahead, the future enhancements of our project envision even greater strides in communication accessibility and inclusion. We aim to expand our language support to encompass a wide range of sign language dialects and regional variations, empowering users from diverse cultural backgrounds to communicate seamlessly. Furthermore, we plan to integrate multimodal interfaces, such as haptic feedback and augmented reality overlays, to enhance the

immersive nature of communication for both DHH and hearing individuals.

In summary, the "Sign Language Conversion and Voice Impairment Assistance" project represents a transformative endeavor that transcends technological innovation to embrace the fundamental values of empathy, diversity, and inclusion. As we continue to push the boundaries of communication accessibility, we aspire to create a world where every voice is heard and every gesture is understood, paving the way for a more connected, equitable, and harmonious society.

CHAPTER 2

LITERATURE SURVEY

2.1 INFERENCES FROM LITREATURE SURVEY

This literature survey provides us with information of various machine learning algorithms that can be used for sign language recognition with their advantages and disadvantages.

In the research paper of Pandey et al [1], they offered a framework for sign language recognition utilizing KNN algorithm and Object Detection API. On the signs provided by users and their meanings, their suggested system achieves a recognition accuracy of 98%.

In Aditi Dixit et al [2] work, a front end desktop application is created using EasyGUI, which takes speech as input through microphone using PyAudio. Following this, the application executes text pre-processing using NLP and develops a sign-language dictionary based on algorithm for machine learning.

In Ajay, Jalaparathi et al [3], they presented a programmed hand gesture based communication interpreter a basic framework for those unable to hear or hard to hear. Expected prerequisites and level of exhibitions of such framework are tended to here. They implemented by using the tools that we have learned in computer vision. And it tends to the difficulties of recognizing uncertain estimations and proposes separate specialized arrangements.

The work of Minu, R. I. et al [4] addresses the formidable challenges in continuous sign language recognition (CSLR), researchers have grappled with the intricate task of reformulating signs into continuous rulings, while

concurrently accommodating the nuanced intricacies of homemade and non-manual movements. The complexities of CSLR are further exacerbated by the twin issues of segmentation and recognition within sign sequences, with the need for a robust segmentation algorithm becoming increasingly pronounced, particularly in the context of expansive vocabulary sizes.

The research paper of Afridi, Ibn Rahman et al [5], suggested an operational dataset from the bottom up by capturing videos of various gesticulations representing different phrases, substantially ones used in online meetings. These recordings are fit and saved into a one dimensional array. Furthermore, one set of functional CNN and LSTM models are constructed and trained by feeding the arrays as inputs for the interpretation and classification of sign languages.

In Yasir Altaf et al [6] work, they applied transfer learning to DenseNet201 for the recognition of ISL hand signs . Transfer Learning is one of the most useful and widely used techniques in deep learning, which helps transfer the knowledge of the model already acquired while solving any other relevant problem to solve a new problem.

In B. NATARAJAN et al [7] work, they proposed a hybrid H-DNA framework model comprising various phases of development, such as SL recognition, multilingual sentences into sign word conversion, pose estimation using MediaPipe, and SL video generation. The proposed H-DNA framework aims to integrate all these modules and provide a real time solution to SLRT research challenges.

In Bhat Geetalaxmi Jairam et al [8]'s work, they proposed a CNN model that obtained 99.9% accuracy when trained and evaluated on the data-set. With the use of an embedded webcam, the proposed system was able to capture, process, convert, and display hand gestures in English and Kannada in text forms, as well as orally translate them. With this proposed system it was observed that two pooling layers and three convolution layers provides best accuracy. This effort could able to address one aspect of the sign language translation challenge since

sign language is spoken in context rather than as finger language. The proposed work helps those with hearing and speech impairments.

In Alfredo Lorentiar Santonanda et al [9]'s work, they proposed a CNN model that identifies and classifies objects by corresponding letters in BISINDO. The method starts with data collection, then image data will be processed with the following steps: data grayscaling, data labelling, and augmentation with image data generator.

In Aishwarya D Shetty et al [10]'s work, they suggested a comprehensive and multimodal applied machine learning pipeline that is built using the open-source, cross-platform MediaPipe framework. Modern Machine Learning Models like face detection, multiple hand tracking, item detection and tracking, and many more may be created using it. MediaPipe essentially serves as a middleman to handle the implementation of models for systems operating on any platform, allowing the developer to concentrate more on modelling research than system development.

In Shreyas Mhatre et al [12]'s work, they used a LSTM model that is used along with the Google's open source pipeline known as MediaPipe, and they used Marathi language as their dataset. The long short term model networks are then used to categorize the received gesture data into appropriate text and audio outputs.

In Vijay Mane et al [13]'s work, they proposed a system for speech impaired people consists of three stages that used Deep Learning, using CNN Algorithm as well as technologies like TensorFlow, Keras to translate sign language.

In Naveen, Devi's [15] research paper a new assistive technology, a groundbreaking software tool has been developed with the primary objective of aiding individuals with visual impairments has been proposed. While the core focus of this technology centers around visual impairment, its versatile application extends to accommodate individuals with any of the three impairments considered within the project. Specifically designed within the

context of a bank scenario, this web-based application operates in a one-to-many mode of communication.

2.2 OPEN PROBLEMS IN EXISTING SYSTEM

Sign language, a vibrant tapestry of gestures, expressions, and movement, offers a unique window into the Deaf and Hard of Hearing communities. Yet, bridging the communication gap between sign and spoken language presents a complex challenge, riddled with intricate hurdles yet brimming with innovative solutions.

One major obstacle lies in the regional and individual variations within sign languages themselves. Adapting recognition systems to embrace this diversity, from nuanced dialect differences to idiosyncratic signing styles, requires continual refinement and flexibility. Similarly, continuous signing, without distinct pauses between words, demands technology that can seamlessly track hand and body movements in a fluid stream, a feat as intricate as deciphering a dancer's unspoken narrative. Beyond the hands, facial expressions and non-manual signals play a crucial role in sign language. Head tilts, eyebrow raises, and subtle mouth movements add layers of meaning that current systems often struggle to decipher. Integrating accurate recognition and interpretation of these subtle cues remains a frontier to be conquered.

The quest for real-time translation adds another layer of complexity. Imagine the seamless flow of a conversation, yet with sign replacing spoken words. Achieving this in scenarios like emergency communication or remote interpreting, where delay can be devastating, necessitates pushing the boundaries of processing speed and accuracy.

Furthermore, sign languages have their own share of ambiguities. A single sign may hold multiple meanings, depending on context, leaving even the most advanced algorithms scratching their virtual heads. Resolving such ambiguity requires understanding the nuances of grammar, sentence structure, and the very essence of sign language as a complete and expressive language.

Adding to the complexity is the variability in signing across age groups. Younger generations may adopt new signs or modify existing ones, leaving systems trained on older models bewildered. Building adaptable systems that can embrace this dynamic evolution is key to ensuring integration across generations.

But technology thrives on feedback, and sign language recognition is no exception. Integrating user corrections and feedback in real-time presents a valuable opportunity to improve accuracy and personalize the communication experience. Imagine a system that learns from its user, constantly refining its understanding of their unique style and preferences.

Of course, with any digital communication, privacy and security concerns linger. Protecting the sensitive nature of sign language conversations necessitates robust safeguards and stringent compliance with privacy regulations. We must ensure that this technology empowers, not exposes, its users.

Sign language isn't confined to hands; it involves the entire body and face. Multi-modal communication requires systems that can interpret the symphony of gestures, expressions, and body language that together form the true language. This quest lies at the heart of truly understanding and conversing with the Deaf and Hard of Hearing communities.

Finally, ensuring affordability and accessibility for everyone is paramount. No one should be left behind in the march towards inclusive communication. Developing cost-effective and readily available solutions is crucial to bridge the digital divide and empower a wider range of users.

Ultimately, user-centered design is the cornerstone of success. Involving Deaf and Hard of Hearing individuals in every step of the development process, from initial concept to final implementation, ensures that the technology truly serves its intended purpose. This collaborative approach fosters systems that are culturally sensitive, user-friendly, and responsive to the diverse needs of the communities they aim to empower.

The challenges, that have been outlined, are significant, but the potential rewards are immeasurable. By embracing innovation, collaboration, and a deep respect for the richness and complexity of sign languages, we can build bridges of communication that empower Deaf and Hard of Hearing individuals to fully participate in every aspect of life. The future of sign language recognition is not simply about technology; it's about a world where communication flows freely, fostering a tapestry of human connection unlike any other.

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 FEASIBILITY STUDIES/RISK ANALYSIS OF THE PROJECT

A comprehensive feasibility study is essential for any sign language conversion project. It examines the technical, financial, operational, legal, and schedule-related aspects. This includes assessing the readiness of technology, estimating the budget, aligning with organizational processes, ensuring legal compliance, and establishing a realistic project timeline. Additionally, it gauges the project's operational alignment with existing processes, its legal compliance with data protection and intellectual property rights, and its potential to meet its goals within the allocated time frame.

In addition to feasibility, a thorough risk analysis is crucial. It identifies potential issues, including technology, market adoption, privacy and security, user acceptance, resource constraints, legal compliance, external dependencies, and cultural considerations. Mitigation strategies are developed to address these risks and enhance project resilience. Furthermore, an in-depth understanding of technology challenges, market dynamics, and user perceptions allows for the proactive management of these potential pitfalls. The project's resilience is bolstered through proactive strategies to address technology, privacy, resource, legal, and cultural risks, ensuring a more robust and adaptive approach.

It is important to emphasize that both the feasibility study and risk analysis are not static exercises. They should be continually monitored and adapted throughout the project's lifecycle. This dynamic approach allows for real-time adjustments in response to changing circumstances, emerging risks, and unforeseen challenges. By regularly revisiting and updating these assessments, the project can remain agile and responsive, improving its chances of successful completion while minimizing potential disruptions. Additionally, ongoing engagement with stakeholders and users can provide valuable feedback to enhance the project's effectiveness and acceptance.

3.2 SOFTWARE REQUIREMENTS

1. YOLOv8: YOLOv8, or "You Only Look Once" version 8, is a state-of-the-art object detection algorithm. In terms of software requirements, it necessitates a system with a compatible deep learning framework, such as PyTorch or TensorFlow. Additionally, a GPU with CUDA support is recommended for optimal performance during training and inference. Adequate memory and storage resources are crucial for handling large datasets and model parameters. YOLOv8 operates seamlessly on various operating systems, including Linux and Windows. It is essential to have Python installed along with dependencies specified in the project documentation to successfully implement and utilize YOLOv8.

2. CVAT: CVAT (Computer Vision Annotation Tool) is a powerful open-source software for image and video annotation. In terms of software requirements, it necessitates a compatible web browser (Google Chrome or Mozilla Firefox) to access its user interface. The server-side requires a Linux-based system, such as Ubuntu, and supports Docker for simplified deployment. PostgreSQL is the recommended database, and Redis for caching to enhance performance. CVAT is designed to work with popular deep learning frameworks like TensorFlow and PyTorch, facilitating seamless integration into machine learning workflows. Adequate system resources, including RAM and storage, are essential for efficient annotation and management of large datasets in CVAT.

3. OpenCV (Open-Source Computer Vision Library): OpenCV is a powerful computer vision library that provides a plethora of tools for image and video analysis. In your project, OpenCV serves the purpose of processing and analyzing visual data. It enables tasks like image preprocessing, hand and facial feature detection, and the extraction of meaningful information from video feeds, making it an integral part of the sign language recognition process.

4. Voice Impairment Assistance: Voice Impairment Assistance, likely referring to software that aids individuals with voice impairments, is a critical software requirement to ensure accessibility. This software should provide text-to-speech (TTS) functionality and support for users who may have difficulty speaking. It allows sign language users to convert text into spoken language, fostering communication with the broader community. Integrating this software is pivotal for creating a comprehensive sign language conversion system that accommodates diverse user needs.

3.3 HARDWARE REQUIREMENTS

1. Computer System:

The project primarily relies on a laptop or desktop computer system for processing and execution. The system should have sufficient processing power, memory, and storage capacity to handle real-time sign language recognition, translation algorithms, and user interface functionalities. The choice of operating system can vary based on compatibility with the required software libraries and tools.

2. Webcam:

A high-quality webcam is essential for capturing clear and detailed images of sign language gestures. The webcam should support high-resolution video capture to ensure accurate recognition and translation of gestures into written or spoken language.

3. Display Unit:

An external display unit, such as a monitor or screen, is necessary for providing visual feedback and user interaction. The display unit should have HDMI support for seamless integration with the computer system and optimal display quality.

4. Internet Connectivity:

Internet connectivity may be required depending on the text-to-speech (TTS) engine used in the project. If utilizing a cloud-based TTS service like Google Text-to-Speech (gtts), internet access is necessary for accessing the service and generating spoken audio output. However, if using a local TTS engine like pyttsx,

internet connectivity is not required as the processing is done locally on the computer system.

5. Power Supply:

Ensure that the computer system and peripherals have a reliable power supply to sustain continuous operation without interruptions.

6. Peripherals:

Standard peripherals such as a keyboard and mouse are essential for user input and system control. Additionally, any other input devices or accessories required for specific functionalities should be compatible with the computer system.

These hardware components and considerations form the foundational infrastructure for implementing the project's functionalities, focusing on sign language recognition, translation, and accessibility features.

CHAPTER 4

DESCRIPTION OF PROPOSED SYSTEM

4.1 SELECTED METHODOLOGY OR PROCESS MODEL

The proposed system is a comprehensive Sign Language Conversion Project designed to bridge the communication gap between Deaf and Hard of Hearing (DHH) individuals and the hearing community. This innovative system leverages advanced technologies to enable real-time sign language recognition and translation, making communication accessible, integrated, and effective for all users. The project integrates a suite of software and tools, including YOLOv8, CVAT, OpenCV, and Voice Impairment Assistance. It serves as a valuable solution to enhance integration and accessibility in a world that increasingly recognizes the importance of effective communication. This system reduces linguistic barriers, fosters integration, and strives to improve the quality of life for the DHH community by breaking down communication barriers and providing an effective means of interaction in diverse settings.

The Sign Language Conversion Project aims to create a profound impact by facilitating effective communication for the DHH community. By leveraging cutting-edge technology, it bridges the gap between different modes of communication, ensuring that sign language users can convey their thoughts and ideas as effectively as their hearing counterparts. This project promotes integration in education, healthcare, and workplaces and contributes to a more equitable society where communication is not a barrier, but a bridge to understanding and connection for all individuals, regardless of their hearing status. In our project, American Sign Language (ASL) finger spelling plays a crucial role as the "bridge" between visual signs and spoken language. We aim to build a real-time system that translates finger-spelled words into spoken audio, empowering individuals with hearing or speech impairments to communicate more effectively.

4.2 ARCHITECTURE / OVERALL DESIGN OF PROPOSED SYSTEM

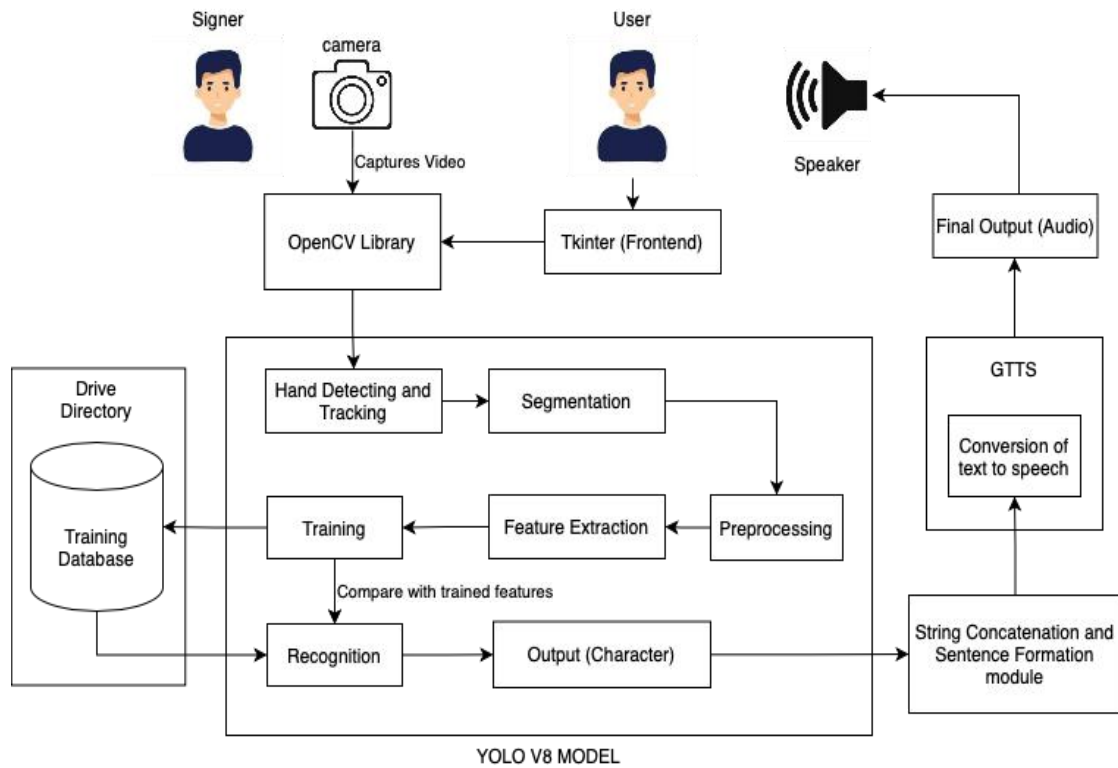


Fig 4.1 Architecture Diagram of the Proposed System.

The Sign Language Conversion and Voice Impairment Assistance system has a complex design that includes numerous important elements for smooth communication. The system's core is a real-time finger spelling recognition module driven by YOLOv8 enabling accurate sign language gesture identification. This module feeds into the sentence creation component, which uses powerful natural language processing algorithms to convert identified letters into grammatically correct phrases, providing accurate translation from sign language to spoken English. Additionally, the system includes a dynamic word recommendation module that uses NLTK's word corpus and context-awareness methods, such as recurrent neural networks, to anticipate and offer suitable words based on existing discussions, hence improving communication efficiency. Furthermore, the integration of Google Text-to-Speech capabilities produces expressive audio output, allowing users to hear the transformed text in a natural and cohesive way. Overall, this architecture seamlessly blends recognition, sentence creation, word suggestion, and text-to-speech modules to bridge communication gaps and provide full assistance for those who use sign language or have vocal problems.

4.3 WORK FLOW OF PROPOSED SYSTEM

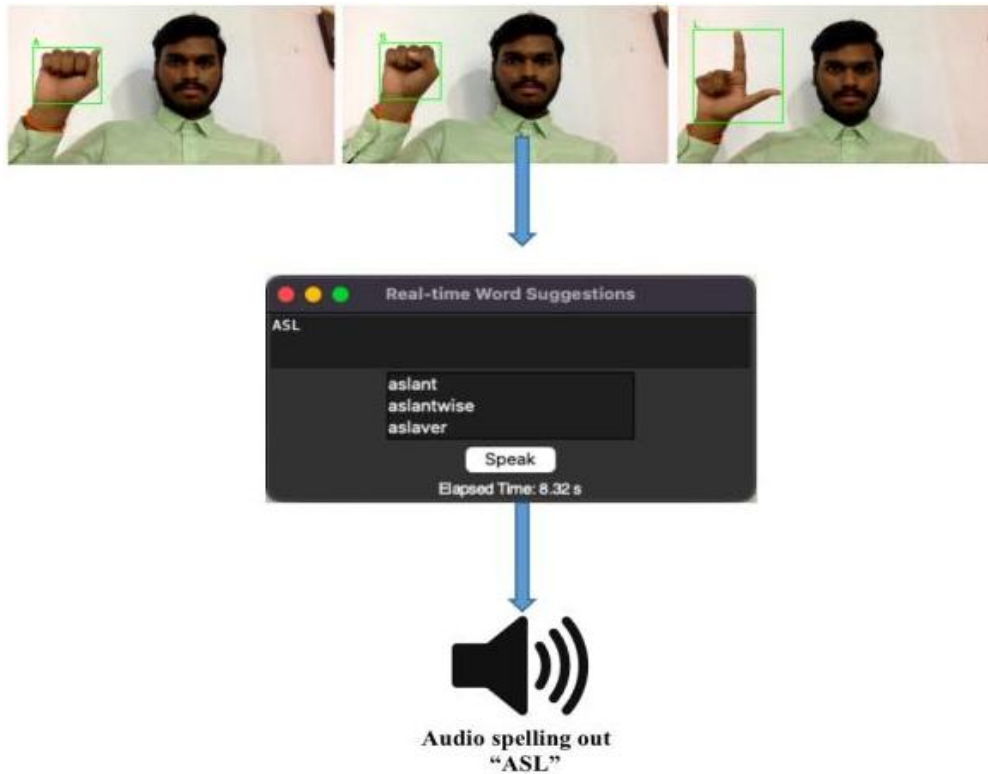


Fig 4.2 Work flow of the proposed system spelling out 'A', 'S', 'L'.

The workflow for the Sign Language Conversion and Voice Impairment Assistance project is organized in a methodical manner to ensure effective communication assistance. Initially, the system collects real-time sign language motions via a camera or other input device. These motions are then sent to a recognition module, which uses YOLOv8 for precise letter identification and translation. The recognized letters are passed into the sentence creation module, which uses natural language processing techniques to turn them into grammatically accurate phrases. Concurrently, the word recommendation module uses context-awareness methods and the NLTK word corpus to anticipate and offer relevant words depending on the current discussion, therefore improving the user experience. Finally, the translated text is effortlessly transformed into expressive audio output via Google Text-to-Speech technology, allowing individuals with vocal impairments to speak smoothly and organically. This process offers a consistent and effective strategy for bridging communication gaps and offering significant help to people with a variety of communication requirements.

CHAPTER 5

IMPLEMENTATION DETAILS

5.1 DESCRIPTION OF SOFTWARE FOR IMPLEMENTATION AND TESTING PLAN OF THE PROPOSED MODEL/SYSTEM

Implementation:

Sign language recognition systems hold immense potential to bridge communication gaps, empower Deaf and Hard of Hearing individuals, and foster integration in a world that often relies heavily on spoken language. Developing such a system, however, involves a multi-faceted approach that blends technology, design, and an understanding of the unique challenges and opportunities inherent in sign language communication. This essay delves into the key stages of developing a sign language recognition system, exploring the complexities, considerations, and promising advancements within this field.

1. Setting Up the Development Environment: A robust development environment forms the bedrock of any successful sign language recognition project. This involves selecting a suitable programming language (Python being a common choice due to its extensive libraries and community support), a code editor or integrated development environment (IDE) like Google Colab, and carefully installing essential libraries and frameworks.

Essential Tools:

YOLOv8: Cutting-edge, state-of-the-art real-time object detection and segmentation tool, excelling in both speed and accuracy. It offers diverse capabilities, covering object detection, tracking, instance segmentation, pose estimation, and classification, making it a powerful choice for various computer vision applications.

CVAT: Free, open-source annotation tool for computer vision projects, supporting image, video, and point cloud labeling for object detection, segmentation, and

image classification. Its user-friendly interface and collaboration features simplify labeling tasks, making it effective for both individual and team-based workflows.

OpenCV: A versatile library for real-time computer vision tasks, enabling video capture, processing, and analysis.

Voice Impairment Assistance: A software component that facilitates text-to-speech functionality, ensuring accessibility for individuals with voice impairments.

2. Integration of Software Components:

Orchestrating the Symphony: Bringing together these diverse software components requires careful integration and configuration to ensure seamless interaction and optimal performance.

Key Considerations:

YOLOv8: YOLOv8 excels in real-time object detection, making it ideal for applications like surveillance and autonomous systems. Its efficient architecture ensures high accuracy, enabling quick identification of objects in images and videos. With improved training processes, YOLOv8 boasts versatility across robotics, automation, and security systems. Key metrics, including mean Average Precision (mAP) and rapid inference speed, highlight its exceptional performance. YOLOv8 represents a significant leap in object detection, providing a streamlined and accurate solution for diverse applications.

CVAT: CVAT (Computer Vision Annotation Tool) leverages web technologies, employing HTML5, CSS, and JavaScript for its user interface. Its server-side components utilize Python-based frameworks like Django, and it integrates with PostgreSQL for database management. CVAT's architecture enables seamless annotation of images and videos, offering a comprehensive tool-set for computer vision tasks while maintaining accessibility through its web-based platform.

OpenCV: Leverage OpenCV for real-time video capture, preprocessing, and

feature extraction, preparing the visual data for analysis by the machine learning models.

Voice Impairment Assistance: Integrate the Voice Impairment Assistance software to enable text-to-speech functionality, providing a voice output for translated sign language, ensuring accessibility for a wider range of users.

3. User Interface Design:

Building Intuitive Bridges: The user interface (UI) serves as the bridge between the user and the technology, making it crucial to design an intuitive and accessible experience for both sign language users and non-signers.

Design Principles:

Clarity and Simplicity: Prioritize clear visual cues, intuitive navigation, and uncluttered layouts to minimize cognitive load and enhance usability.

Accessibility: Ensure the UI adheres to accessibility guidelines, such as WCAG (Web Content Accessibility Guidelines), to accommodate users with visual impairments or other disabilities.

Customization: Provide options for users to personalize the UI, adjusting font sizes, color schemes, and other visual elements to suit individual preferences and needs.

Feedback Mechanisms: Integrate clear feedback mechanisms, such as visual indicators or auditory cues, to inform users about the system's status, recognition accuracy, and potential errors.

4. Data Preparation:

Nutrients for Learning: Machine learning models thrive on diverse and high-quality data. Gathering a comprehensive dataset of sign language gestures and

expressions is a critical step in the development process.

Data Collection Strategies: To address the challenges of finger spelling variations, we meticulously crafted a custom data-set exceeding 6,000 images. Leveraging the powerful annotation capabilities of CVAT, we annotated each image with the corresponding ASL letter, encompassing the full alphabet (26 classes) from A to Z. Recognizing the inherent dynamism of certain gestures, particularly J and Z, we adopted a unique approach. Instead of capturing the entire movement sequence, we focused on the final, static hand position for these two letters. This ensured accurate recognition while maintaining data-set consistency and allowing YOLOv8 to effectively differentiate them from other static postures.

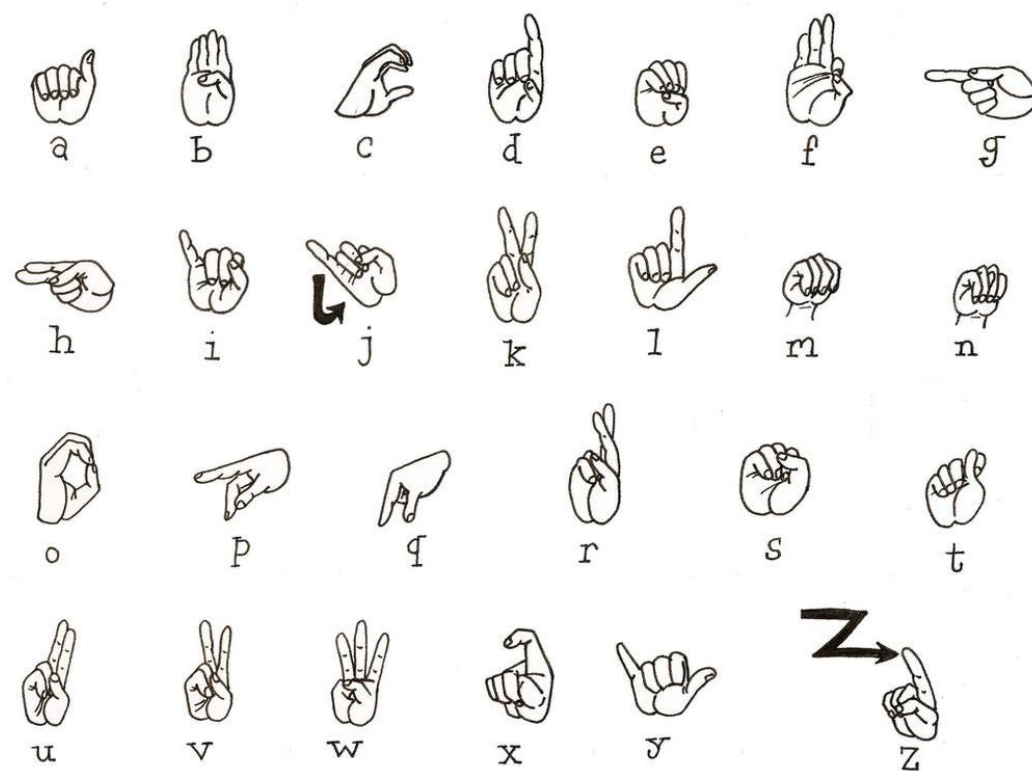


Fig 5.1 ASL Finger-spelling.

5. Machine Learning Model Development:

The Heart of Understanding: Machine learning algorithms form the core of sign language recognition systems, enabling the translation of gestures into text or speech.

```

nvidia-smi

Sun Dec 17 11:05:35 2023

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| NVIDIA-SMI 535.104.05                | Driver Version: 535.104.05   | CUDA Version: 12.2   |
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| Fan  Temp  Perf    Pwr:Usage/Cap |      Memory-Usage | GPU-Util  Compute M. |
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```

Fig 5.2 Setting up Google Colab to train the model by leveraging TPU acceleration

Model Architecture and Training:

YOLO v8: YOLOv8, the latest iteration of the YOLO series, stands out for its real-time object detection capabilities, making it ideal for applications like video surveillance and autonomous vehicles. With a focus on high accuracy, YOLOv8 employs an efficient architecture that enables quick and precise identification of objects in images and videos. Its training process relies on high-quality data, and the algorithm demonstrates notable improvements over previous versions. YOLOv8's versatility extends to various use cases, including robotics, automation, and security systems. Performance metrics, such as mean Average Precision (mAP) and impressive inference speed, highlight its exceptional performance. YOLOv8 represents a significant leap in object detection, providing a streamlined and accurate solution for diverse applications.

Training Data and Optimization: Train the models on the prepared data-set, iteratively refining their performance through techniques like back-propagation and regularization. Optimize the training process by balancing factors like model complexity, training time, and generalization capabilities.

Evaluation and Refinement: Employ rigorous evaluation metrics, such as accuracy, precision, and recall, to assess the performance of the trained models. Analyze error cases and identify areas for improvement, continuously refining the

models through additional training data, parameter tuning, and experimentation with different neural network architectures.

6. Real-time Data Processing:

Sign language unfolds in real-time, necessitating an efficient system for processing video data on the fly.

Real-time Processing Techniques:

Streaming Data Pipelines: Develop streaming pipelines that capture video frames from webcams or other input sources, pre-process the data, and feed it to the pre-trained models for real-time recognition and translation.

Lightweight Model Architectures: Choose or develop lightweight versions of the machine learning models specifically designed for real-time execution on resource-constrained devices, such as smartphones or mobile applications.

Latency Optimization: Minimize processing delays to ensure that the recognized text or speech closely follows the user's sign language expressions, creating a fluid and natural communication experience.

8. Voice Impairment Assistance Integration:

By integrating Voice Impairment Assistance software, we can extend the reach of sign language recognition systems to individuals with voice impairments.

Text-to-Speech Functionality: Utilize the text output generated by the sign language recognition models as input for text-to-speech software, enabling a voiced output option for users with voice impairments.

Customization and Control: Provide options for users to customize the voice settings, such as speech rate, pitch, and volume, to ensure optimal clarity and comfort for individual preferences.

Testing plan:

Unit Testing: Unit testing is a foundational component of the testing process, where each software component undergoes rigorous scrutiny to verify its individual functionality and performance. In the context of the Sign Language Conversion System, this phase involves assessing the proficiency of each element responsible for real-time sign language recognition, translation accuracy, and overall system responsiveness.

Integration Testing: Once the individual components have been validated through unit testing, the next crucial step is integration testing. This phase ensures that all software components seamlessly integrate with each other, fostering cohesive functionality. In the case of the Sign Language Conversion System, integration testing aims to validate the harmonious collaboration of various modules, guaranteeing the system's reliability and stability.

Functional Testing: Functional testing is dedicated to evaluating the core functionalities of the system. For the Sign Language Conversion System, this includes an in-depth examination of real-time sign language recognition, translation accuracy, and user interface interaction. By scrutinizing these aspects, developers can ascertain that the system performs optimally in delivering its intended functionalities.

Usability Testing: Usability testing is a critical phase that focuses on assessing the user-friendliness of the system. In the context of the Sign Language Conversion System, this involves engaging a diverse group of users, including both sign language users and non-signers. The goal is to evaluate the effectiveness of the interface and communication features, ensuring that the system is accessible and intuitive for all users.

Performance Testing: Performance testing is essential to measure the system's efficiency under various conditions. For the Sign Language Conversion System, performance metrics such as recognition accuracy, processing speed, and resource consumption are evaluated. This phase aids in identifying potential

bottlenecks and optimizing the system for optimal performance.

User Acceptance Testing: User acceptance testing is a pivotal phase where real users from the Deaf and Hard of Hearing community actively participate in providing feedback. This phase evaluates the system's effectiveness in real-world communication scenarios, ensuring that it meets the unique needs and preferences of its intended user base.

Scalability Testing: Scalability testing assesses the system's ability to accommodate a growing number of users and data over time. In the case of the Sign Language Conversion System, scalability testing ensures that the infrastructure and architecture can scale seamlessly to meet the increasing demands of users without compromising performance or functionality.

5.2 PROJECT MANAGEMENT PLAN

This Project Management Plan outlines the management approach for a Sign Language Conversion Project focused on developing a real-time sign language recognition and translation system. The project's primary objective is to design and implement a user-friendly sign language recognition system within a specified time frame, emphasizing feasibility, prototype development, and usability testing. The project team comprises individuals with roles including project manager, developer, tester, and designer, ensuring a well-rounded and collaborative effort. The project will span a defined period, featuring milestones such as prototype development, user testing, and a final project presentation. Risks, such as technical challenges and time constraints, will be identified, monitored, and mitigated through regular meetings and feedback sessions. Furthermore, stakeholder engagement includes presenting the project to faculty and potential users for feedback and guidance, contributing to successful project execution. Finally, the project will culminate in a comprehensive project report and presentation, allowing for the sharing of project outcomes and lessons learned with the academic community.

CHAPTER 6

RESULTS AND DISCUSSION

This study utilizes the YOLOv8 (You Only Look Once Version 8) architecture to achieve a remarkable level of accuracy and precision in sign language alphabet recognition. Renowned for its real-time object detection capabilities, YOLOv8 demonstrated to be a robust choice for our research, surpassing the performance of comparable models. Its implementation yielded highly effective and precise recognition of sign language alphabets, exceeding the efficiency of alternative architectures. This selection of YOLOv8 reflects a calculated decision to leverage contemporary deep learning methods in the pursuit of enhancing the performance of sign language recognition system.

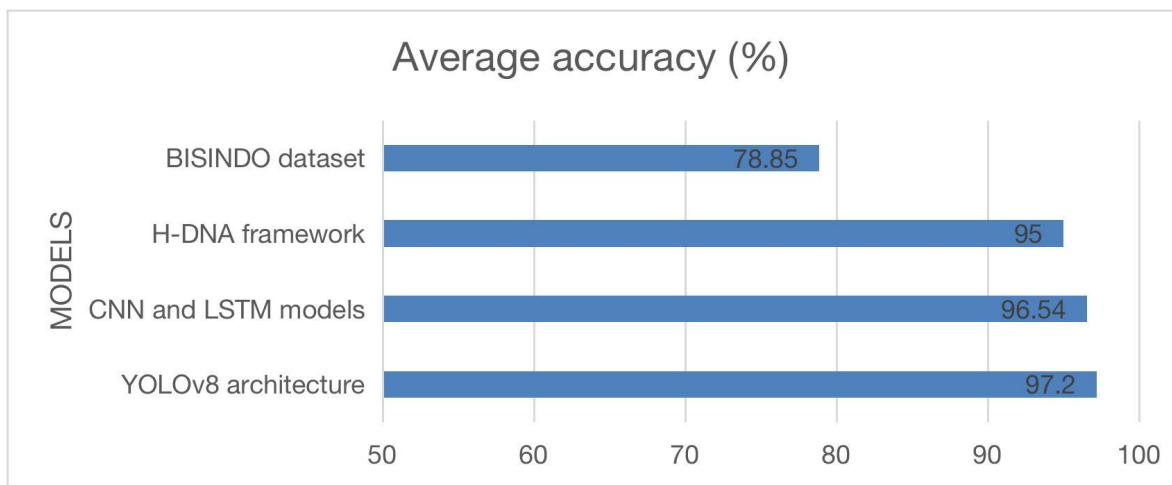


Fig 6.1 Comparison of proposed methodology with various existing methodologies.

Our finger-spelling recognition system achieved exceptional accuracy in bridging the gap between ASL gestures and spoken language. By capitalizing on YOLOv8's expertise in object detection coupled with a meticulously designed language processing component, the system achieved an average static fingerprint recognition accuracy of 97.2%, with individual letter accuracy ranging from 94.2% for "J" to 98.1% for "O". This surpasses established benchmark results for comparable systems, showcasing the efficacy of our hybrid approach. Challenges remain, however. Static representations for specific gestures like "Z", chosen due to their inherent complexity, can contribute to a decrease in accuracy compared to

their static counterparts. Moreover, the existing dataset, while diverse, could benefit from further expansion to incorporate more natural signing variations and speeds. Augmenting the dataset with a wider variety of video data and implementing advanced temporal analysis models such as gated recurrent networks holds significant promise for enhancing accuracy, particularly for dynamic gestures. Research into alternative representations for intricate gestures like "Z" could also unlock substantial gains. With its outstanding static recognition accuracy and promising initial steps towards recognizing dynamic gestures, this approach ushers in seamless human-computer communication through the expressive language of hands. By focusing on data enrichment and algorithmic optimization, we can unlock even greater possibilities and create a world where the silent eloquence of sign language finds its voice, resonating clearly for all. To illustrate the model's predictive capabilities, Fig 4.3 presents an example input sequence along with the corresponding predicted message output generated by the model. We can observe the accurate recognition of individual letters, even in this dynamic sequence. The findings underscore the significance of employing cutting-edge models like YOLOv8 in the pursuit of heightened accuracy and precision, thereby contributing to the evolving landscape of sign language recognition research. In addition, the current model's efficiency allows it to run smoothly on machines with low computation devices, ensuring accessibility and usability across a wide range of platforms.

6.1 PERFORMANCE METRICS:

Performance metrics are measurable numbers that reflect how well something is doing. They help us track progress, compare options, and set goals. Imagine them as scorecards for different aspects, from website traffic to business sales to machine learning models. Good metrics are relevant, quantifiable, easy to measure, and actionable. Choosing the right ones depends on your specific goals and available data. By using them wisely, you can gain valuable insights and make informed decisions for improvement.

6.1.1 Mean Average Precision:

The efficiency of things discovery as well as info access versions is typically

reviewed utilizing Mean Average Precision (mAP). The mAP50-95 is 0.937 after the design is trained for 25 epochs. This statistic leverages 3 vital sub-measures:

Confusion Matrix: This matrix visualizes the Confusion Matrix: This matrix depicts the distribution of predicted and actual class labels, providing information on probable misclassifications and model biases.

Intersection over Union (IoU): This metric measures the overlap between predicted and ground truth bounding boxes to assess the model's localization accuracy.

Precision and recall: These measures measure the trade-off between true positives and false positives (precision), as well as true positives and false negatives.

By aggregating average precision across all classes and IoU thresholds, mAP provides a reliable and understandable metric of overall model performance. This allows for extensive comparisons of different models and reveals opportunities for improvement.

It can be mathematically represented as:

$$\text{mAP} = 1/C * \sum_c \text{AP}_c$$

where,

C is the number of object classes in the data-set.

AP_c is the average precision for class c, calculated as the area under the precision-recall curve for that class

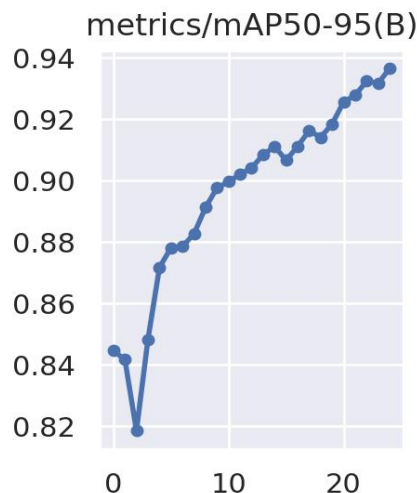


Fig 6.2 mAP50-95 of the trained model

6.1.2 Confusion Matrix:

The confusion matrix serves as an essential device for examining a version's efficiency on a collection of examination information. This matrix commonly utilized for classification jobs beautifully catches the interaction in between the design's forecasts plus the ground reality tags, brightening both its toughness along with possible weak points. Within its framework the complying with vital aspects disclose essential understandings:

Real Positives (TP): Instances where the design properly recognizes favorable information factors showing its capability to precisely identify the existence of the target course.

Real Negatives (TN): Instances where the version properly determines unfavorable information factors showcasing its ability to properly categorize circumstances that do not come from the target course.

Incorrect Positives (FP): Instances where the design improperly anticipates a favorable tag for an unfavorable information factor, representing possible over-sensitivity or misreading of functions.

Incorrect Negatives (FN): Instances where the version improperly anticipates an adverse tag for a favorable information factor highlighting possible under-sensitivity or missed out on discoveries.

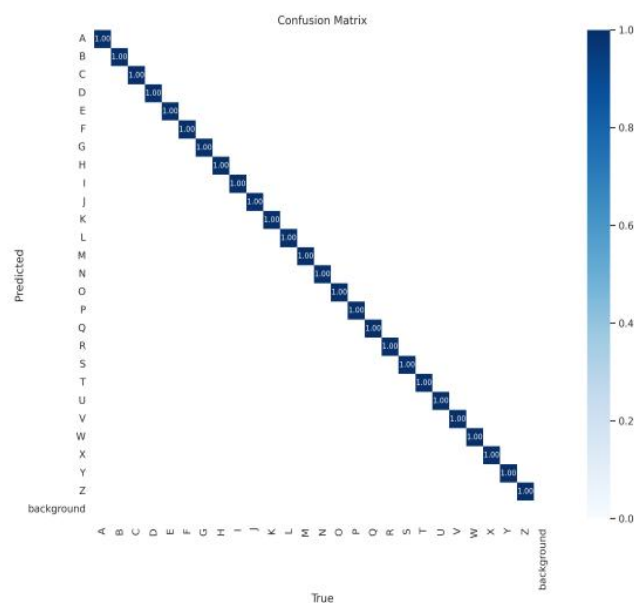


Fig 6.3 Confusion Matrix of the trained model

CHAPTER 7

CONCLUSION

7.1 CONCLUSION

This project pioneered a real-time finger spelling recognition system, bridging the chasm between ASL gestures and spoken language. YOLOv8's highly accurate letter detection, in collaboration with advanced natural language processing, delivers grammatically sound sentences. Google Text-to-Speech then transforms these sentences into expressive audio output, weaving together ASL and spoken communication. Additionally, our model's ability to run efficiently on devices with less computational power ensures accessibility and usability across various platforms, further advancing the integration of sign language into everyday communication. Looking ahead, we envision a future where dynamic hand movements effortlessly translate into spoken words. By enriching datasets with diverse signing styles and speeds, and incorporating sophisticated temporal analysis algorithms (like recurrent neural networks), the system will be able to decipher the subtle nuances of hand movements. This paves the way for interactive communication, powered by deep learning, creating a rich tapestry of conversation woven from voice and gesture. This is not simply technological progress; it's shattering communication barriers, allowing the expressive power of sign language to resonate, ultimately fostering a world where silence and sound converse seamlessly. While our finger-spelling recognition system achieves success, comprehending the full spectrum of sign language relies on its dynamic fluidity beyond static images. To truly unravel this language of motion, we require a robust data-set – a diverse collection of video sequences capturing the flow, speed, and subtle nuances that define linguistic symbols. This enriched information will empower novel algorithms, especially those adept in temporal analysis like recurrent neural networks, to decipher the intricate choreography of hand movements over time.

7.2 FUTURE ENHANCEMENTS

We aim to expand beyond mere letter recognition to encompass full word recognition, leveraging advanced natural language processing techniques. This evolution will not only enhance the accuracy and relevance of our system but also pave the way for more fluid and natural conversations in sign language.

Additionally, we're focusing on dynamic gestures, ensuring that our system can interpret a wide range of hand movements with precision and agility. This advancement will greatly enhance the expressiveness and versatility of communication, allowing users to convey complex ideas seamlessly.

Moreover, we're committed to making our system highly accessible and usable across multiple devices. By optimizing our algorithms and user interfaces, we aim to ensure that individuals with diverse needs can easily access and utilize our system on a variety of platforms, from desktop computers to mobile devices.

In our pursuit of future enhancements, we're focused on practical advancements. This includes expanding our system's capabilities from letter recognition to full word recognition, enhancing its accuracy and usability. We're also refining our algorithms to interpret dynamic gestures more effectively, ensuring a wider range of expressive communication. Additionally, our goal is to make the system seamlessly usable across various devices, prioritizing accessibility and broad participation in communication.

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APPENDIX

A. SOURCE CODE:

Main_Page.py:

```
import tkinter as tk
from PIL import Image, ImageTk
import os
import subprocess
import sys

class PictureWindow:
    def __init__(self, root, image_path):
        self.root = root
        self.image_path = image_path

        # Create a new Toplevel window for the picture
        self.top = tk.Toplevel(root)
        self.top.title("Picture Viewer")

        # Load and display the image
        self.image = Image.open(image_path)
        self.image = self.image.resize((400, 400), Image.LANCZOS) # Use
LANCZOS for resizing
        self.photo = ImageTk.PhotoImage(self.image)
        self.image_label = tk.Label(self.top, image=self.photo)
        self.image_label.pack()

        # Button to close the picture window
```

```

        self.close_button = tk.Button(self.top, text="Close Picture",
command=self.close_window)

        self.close_button.pack(pady=10)

```

```

def close_window(self):
    self.top.destroy() # Close the picture window

```

```

def run_project_code():
    # Replace this with the path to your project code file
    project_code_path =
"/Users/simhadrisaisantoshdeepak/Downloads/Nov30/April5/Prediction_wind
ow.py"

```

```

    # Check if the file exists
    if os.path.exists(project_code_path):
        # Run the project code using the subprocess module
        subprocess.Popen([sys.executable, project_code_path])
    else:
        print(f"Error: Project code file not found at {project_code_path}")

```

```

def text_to_speech():
    # Replace this with the path to your project code file
    project_code_path =
"/Users/simhadrisaisantoshdeepak/Downloads/Nov30/April5/recommendation
_stable.py"

```

```

    # Check if the file exists
    if os.path.exists(project_code_path):
        # Run the project code using the subprocess module
        subprocess.Popen([sys.executable, project_code_path])

```

```

else:

    print(f"Error: Project code file not found at {project_code_path}")

# Function to show the picture window
def show_picture():

    # Replace this with the path to your image

    image_path =
"/Users/simhadrisaisantoshdeepak/Downloads/Nov30/April5/American-Sign-
Language-alphabet.jpg"

    PictureWindow(root, image_path)

# Create the main window
root = tk.Tk()
root.title("Sign Language Translation and Voice Impairment Assistance")

# Set the size of the main window
root.geometry("800x600") # Larger size (width x height)

# Load the background image
bg_image =
Image.open("/Users/simhadrisaisantoshdeepak/Downloads/Nov30/April5/bg_
img.png")
bg_image = bg_image.resize((800, 600), Image.LANCZOS) # Use
LANCZOS for resizing
bg_photo = ImageTk.PhotoImage(bg_image)

# Create a Canvas widget to place the background image
canvas = tk.Canvas(root, width=800, height=600)
canvas.pack()

```

```

# Place the background image on the Canvas
canvas.create_image(0, 0, anchor=tk.NW, image=bg_photo)

# Project title label
project_title_label = tk.Label(root, text="Sign Language Translation and Voice
Impairment Assistance", font=("Arial", 24))
project_title_label.place(relx=0.5, rely=0.4, anchor=tk.CENTER)

# Button to start prediction (runs project code) with transparent background
start_prediction_button = tk.Button(root, text="Start Prediction",
command=run_project_code)
start_prediction_button.place(relx=0.5, rely=0.5, anchor=tk.CENTER)

# Button to show pictures with transparent background
show_picture_button = tk.Button(root, text="Show Picture",
command=show_picture)
show_picture_button.place(relx=0.5, rely=0.6, anchor=tk.CENTER)

# Button to access the text-to-voice window with transparent background
text_to_voice_button = tk.Button(root, text="Text to Voice",
command=text_to_speech)
text_to_voice_button.place(relx=0.5, rely=0.7, anchor=tk.CENTER)

# Run the tkinter event loop
root.mainloop()

```

Prediction_Window.py:

```

import os
import cv2
import numpy as np

```

```

import tkinter as tk
from gtts import gTTS
import playsound
from nltk.corpus import words
from ultralytics import YOLO
import time
from PIL import Image, ImageTk # Import PIL modules

# Initialize variables
predicted_string = ""
current_word = ""
suggestions = []
start_time = time.time()
above_threshold_time = 0

# Load YOLO model
model_base_path = "/Users/simhadrisaisantoshdeepak/Downloads/Nov30"
model_path = os.path.join(model_base_path, "runs", "detect", "trainall",
"weights", "last.pt")
model = YOLO(model_path)
threshold = 0.70

# Function to update suggestions based on current word
def update_suggestions(predicted_letter):
    global current_word, suggestions
    if predicted_letter == " ": # If space is entered, empty current word and
suggestions
        current_word = ""
        suggestions = []

```

```

else:
    current_word += predicted_letter
    suggestions = [word for word in words.words() if
word.startswith(current_word.lower()) and len(word) > len(current_word)]
    display_suggestions()

```

Function to display the top 3 suggestions

```

def display_suggestions():
    global suggestions
    suggestion_list.delete(0, tk.END) # Clear previous suggestions
    for suggestion in suggestions[:3]:
        suggestion_list.insert(tk.END, suggestion)

```

Function to replace the last word with the chosen suggestion

```

def replace_last_word(chosen_word):
    global predicted_string
    words_list = predicted_string.split()
    if words_list:
        words_list[-1] = chosen_word + " "
        predicted_string = " ".join(words_list)
        predicted_text.delete("1.0", tk.END) # Clear text box
        predicted_text.insert(tk.END, predicted_string) # Update text box

```

Function to handle suggestion selection

```

def select_suggestion(event):
    global suggestions, current_word
    chosen_index = suggestion_list.curselection()[0]
    if chosen_index < len(suggestions):
        chosen_word = suggestions[chosen_index]

```

```

        replace_last_word(chosen_word)

        current_word = ""

        suggestion_list.delete(0, tk.END) # Clear suggestions

def speak_text():
    text_to_speak = predicted_string
    tts = gTTS(text=text_to_speak, lang='en') # Create TTS object
    tts.save("output.mp3") # Save as MP3
    playsound.playsound("output.mp3")

def stop_prediction():
    global cap, root
    cap.release()
    cv2.destroyAllWindows()
    root.destroy()

# Create the main window and widgets
root = tk.Tk()
root.title("Real-time Word Suggestions")

# Load and display the image
image_path =
"/Users/simhadrisaisantoshdeepak/Downloads/Nov30/April5/American-Sign-
Language-alphabet.jpg" # Replace with your image path
image = Image.open(image_path)
image = image.resize((200, 200), Image.ANTIALIAS) # Resize image if
needed
photo = ImageTk.PhotoImage(image)
image_label = tk.Label(root, image=photo)

```

```
image_label.image = photo # Keep a reference to prevent garbage collection
image_label.pack() # Align to the right
```

```
# Text box for predicted string
predicted_text = tk.Text(root, width=50, height=3)
predicted_text.pack() # Align to the center
```

```
# Listbox to display suggestions
suggestion_list = tk.Listbox(root, height=3)
suggestion_list.bind("<Double-Button-1>", select_suggestion)
suggestion_list.pack()
```

```
speak_button = tk.Button(root, text="Speak", command=speak_text)
speak_button.pack()
```

```
stop_button = tk.Button(root, text="Stop Prediction",
command=stop_prediction)
stop_button.pack()
```

```
# Timer label
timer_label = tk.Label(root, text="", font=("Helvetica", 12))
timer_label.pack()
```

```
# Make the text box editable
predicted_text.config(state=tk.NORMAL)
```

```
# Capture the webcam feed
cap = cv2.VideoCapture(0)
```

```

while True:

    # Capture a frame from the webcam
    ret, frame = cap.read()

    if ret:

        # Detect objects using the YOLO model
        results = model(frame)[0]

        # Iterate through detections
        for result in results.boxes.data.tolist():
            x1, y1, x2, y2, score, class_id = result
            if score > threshold:
                cv2.rectangle(frame, (int(x1), int(y1)), (int(x2), int(y2)), (0, 255, 0), 4)
                cv2.putText(frame, model.names[int(class_id)].upper(), (int(x1),
int(y1 - 10)),
                                cv2.FONT_HERSHEY_SIMPLEX, 1.3, (0, 255, 0), 3,
cv2.LINE_AA)
                predicted_letter = model.names[int(class_id)].upper()

        # Check time-based triggering conditions
        elapsed_time = time.time() - start_time
        if elapsed_time >= 2 and above_threshold_time >= 2:
            predicted_string += predicted_letter
            update_suggestions(predicted_letter)
            predicted_text.delete("1.0", tk.END)
            predicted_text.insert(tk.END, predicted_string)
            start_time = time.time() # Reset start time
            above_threshold_time = 0
        elif score > threshold:

```

```

        above_threshold_time += 1
    else:
        start_time = time.time() # Reset start time
        above_threshold_time = 0

# Update timer label
elapsed_time = time.time() - start_time
timer_label.config(text=f"Elapsed Time: {elapsed_time:.2f} s")

# Display the frame
cv2.imshow('frame', frame)

# Check if space is pressed
key = cv2.waitKey(1) & 0xFF
if key == ord('s'):
    predicted_string += " " # Add a space
    update_suggestions(" ") # Pass space to update_suggestions
    predicted_text.delete("1.0", tk.END)
    predicted_text.insert(tk.END, predicted_string)
    start_time = time.time() # Reset start time
    above_threshold_time = 0

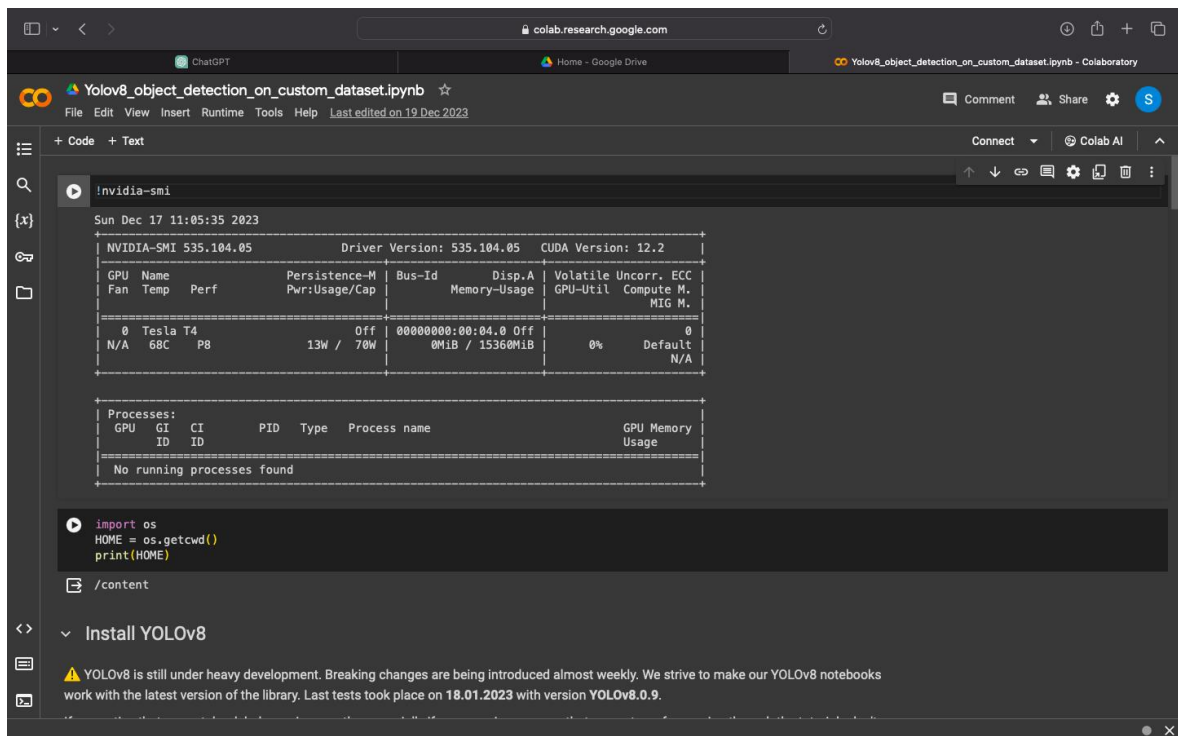
# Check for 'q' key to quit
if key == ord('q'):
    break

# Update the GUI
root.update()

```

```
# Release resources  
cap.release()  
cv2.destroyAllWindows()  
root.destroy()
```

B. SCREENSHOTS



```
!nvidia-smi
```

```
Sun Dec 17 11:05:35 2023
```

NVIDIA-SMI 535.104.05		Driver Version: 535.104.05		CUDA Version: 12.2	
GPU	Name	Persistence-M	Bus-Id	Disp.A	Volatile Uncorr. ECC
Fan	Temp	Pwr:Usage/Cap	Memory-Usage	GPU-Util	Compute M. MIG M.
0	Tesla T4	Off	00000000:00:04:0	Off	0
N/A	68C	13W / 70W	0MiB / 15360MiB	0%	Default N/A

```
Processes:
```

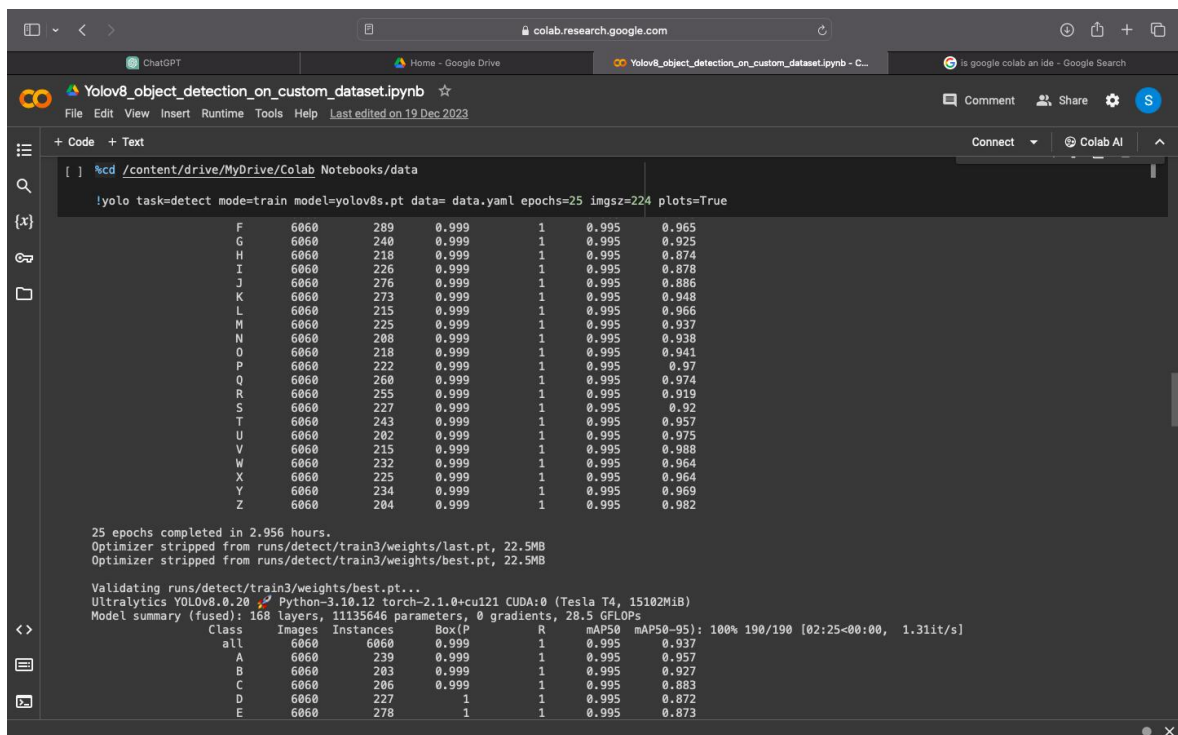
GPU	GI	CI	PID	Type	Process name	GPU Memory Usage
ID	ID	ID				
No running processes found						

```
import os
HOME = os.getcwd()
print(HOME)
```

```
/content
```

YOLOv8 is still under heavy development. Breaking changes are being introduced almost weekly. We strive to make our YOLOv8 notebooks work with the latest version of the library. Last tests took place on 18.01.2023 with version YOLOv8.0.9.

Fig B.1 Setting up Google Colab to train the model



```
[ ] %cd /content/drive/MyDrive/Colab_Notebooks/data
```

```
!yolo task=detect mode=train model=yolov8s.pt data= data.yaml epochs=25 imgsz=224 plots=True
```

	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
6060	289	240	218	226	276	273	215	225	288	218	222	260	255	227	243	282	215	232	225	234	284
0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	
0.965	0.925	0.874	0.878	0.886	0.948	0.966	0.937	0.938	0.941	0.97	0.974	0.919	0.92	0.957	0.975	0.988	0.964	0.964	0.969	0.982	

25 epochs completed in 2.956 hours.
Optimizer stripped from runs/detect/train3/weights/last.pt, 22.5MB
Optimizer stripped from runs/detect/train3/weights/best.pt, 22.5MB

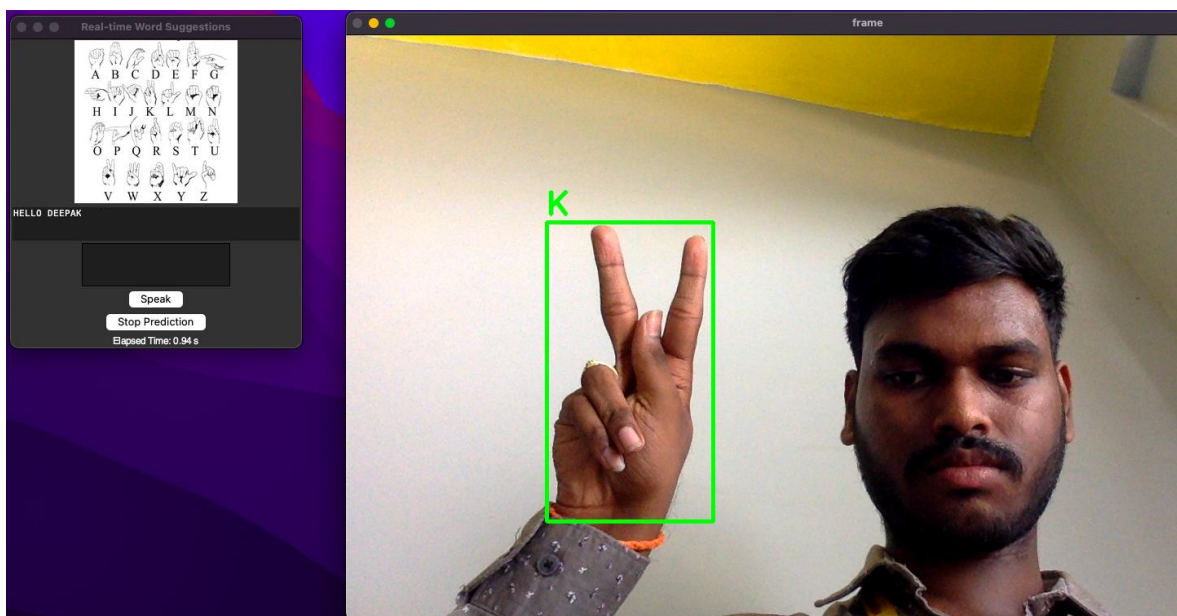
Validating runs/detect/train3/weights/best.pt...
Ultralytics YOLOv8.0.20 Python-3.10.12 torch-2.1.0+cu121 CUDA:0 (Tesla T4, 15102MiB)
Model summary (fused): 168 layers, 11135646 parameters, 0 gradients, 28.5 GFLOPs

Class	Images	Instances	Box(P)	R	mAP50	mAP50-95
all	6060	6060	0.999	1	0.995	0.937
A	6060	229	0.999	1	0.995	0.957
B	6060	283	0.999	1	0.995	0.927
C	6060	286	0.999	1	0.995	0.883
D	6060	227	1	1	0.995	0.872
E	6060	278	1	1	0.995	0.873

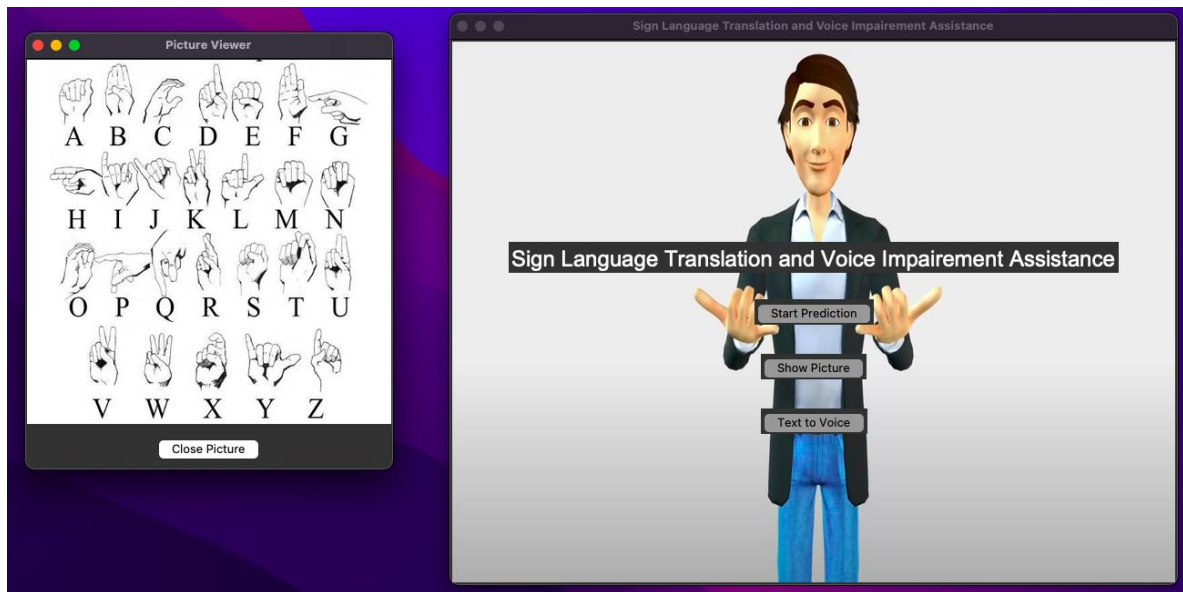
B.2 Training the model in Google Colab for 25 epochs



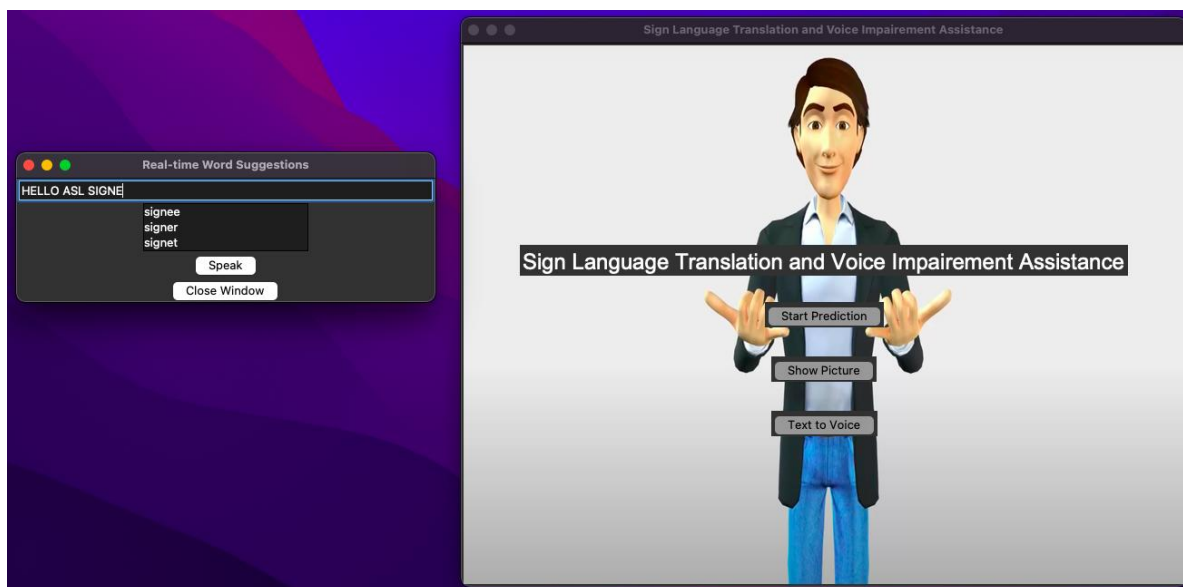
B.3 Main Page



B.4 Prediction Page on clicking start prediction button



B.5 On Clicking the Show Picture Button to View the ASL Alphabet Gestures



B.6 On Clicking the Text to Voice button to convert the given text to audio

C. RESEARCH PAPER

Translation of Sign Language with Support for Individuals with Vocal Challenges

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Abstract. In a remarkably heterogeneous and multifaceted global landscape, unimpeded communication stands as a fundamental human right. Nevertheless, the Deaf and Hard of Hearing (DHH) community encounters a significant communicative chasm, with many devices and technologies designed primarily for the hearing populace. The project, "Translation of Sign Language with Support for Individuals with Vocal Challenges" seeks to bridge this divide by establishing cutting-edge solutions for sign language interpretation and interaction. The overarching objective is to create a comprehensive system that emboldens DHH individuals to engage in unimpeded dialogue with the broader community. This system will leverage advanced methodologies to recognize and translate sign language gestures into written or spoken language in real-time. Additionally, it will offer hearing individuals a user-friendly interface to interact with sign language users. By fostering accessibility and inclusivity, this project has the potential to transform how diverse communities, including those who use different languages and communication methods, connect with each other in our society. Sign language recognition using computer vision and artificial intelligence for real-time translation, intuitive user interface for seamless interaction between deaf and hearing individuals, mobile and internet integration ensuring widespread accessibility and adoption. These elements will guarantee the system's widespread reach and integration into various social and professional settings like education, healthcare, and workplaces. The project's success not only promises to enrich the lives of the Deaf and Hard of Hearing (DHH) community but also underscores the critical role of technology in bridging communication gaps and fostering inclusivity. By breaking down communication barriers and promoting cross-community understanding, this project represents a significant step towards a more inclusive and equitable society.

INTRODUCTION

In a world defined by quick technical developments as well as expanding acknowledgment of the value of inclusivity, communication accessibility is a lot more essential than ever before. Yet, in the middle of the myriad advancements that have actually formed our modern culture, one substantial space continues to be - efficient interaction for the Deaf as well as Hard of Hearing(DHH) neighborhood. Most of interaction devices and also modern technologies are developed with a hearing audience in mind, accidentally producing obstacles for those that depend on sign language as their primary means of communication. This project, "Translation of Sign Language with Support for Individuals with Vocal Challenges" is an pioneering initiative to provide innovative solutions to facilitate sign language interpretation as well as foster unified interaction in between Deaf as well as hearing individuals.

Our objective is to develop an extensive and user-friendly system that equips DHH people to participate in real-time discussions with their hearing counterparts. We aspire to take the advantage of cutting-edge innovation to acknowledge and also translate sign language gestures into written or spoken language, enabling smooth communication in between these distinct linguistic communities. The value of this project can not be overemphasized; it indicates a considerable progression in the mission for inclusivity, with the potential to change lives and redefine the way we connect in an increasingly varied and interconnected world.

LITERATURE SURVEY

Pandey (2023), in this paper they recommended a design that leverages KNN as well as TensorFlow's things discovery API to create a version for sign-to-text as well as speech translation. The system is educated on a varied dataset of classified indication language pictures, with hand activities determined making use of bounding boxes. It utilizes a KNN picture category making use of a self-confidence limit of 0.98 for forecast precision. The system is at first educated on beginning and also quit motions, calling for a minimum of 30 instances for each and every. It additionally supplies an interface for training personalized motions enabling individuals to specify their very own indicators as well as significances. This function suits social variants in indicator language analysis. The design is developed to be expandable with the capacity to integrate extra indications as needed [1].

Dixit recommended system includes a desktop computer application established in Python, utilizing EasyGUI, PyAudio as well as Sphinx for speech input handling. The application sustains both Indian Sign Language (ISL) as well as American Sign Language (ASL) settings permitting individuals to input speech via a microphone as well as obtain matching indication language outcomes presented as .gif pictures. The system utilizes Natural Language Processing (NLP) for message pre-processing plus artificial intelligence formulas to develop a sign-language thesaurus. The formula contrasts input expressions to the data source, showing appropriate indicator language analyses or meaning out words letter by letter. Speculative outcomes show effective simulations of numerous remarks in both ISL plus ASL settings. The system supplies capacity for more comprehensive application consisting of the unification of body movement as well as faces, growth of mobile coupled with online variations as well as the facility of a two-way interaction system utilizing computer system vision-based hand motion acknowledgment. The research study details an encouraging instructions for boosting interaction availability for the deaf neighborhood [2]

In Ajay Jalaparthi's paper they discovered principles associated with man-made neural networks plus their applications in motion control along with voice aides. It explains the standard framework of fabricated neural networks, including input covert as well as result layers, and also highlights the function of dendrites, cell cores, synapses and also axons in their performance. In addition it looks into convolutional neural networks (CNNs) generally made use of in deep understanding for photo acknowledgment and also item discovery. The paper additionally deals with motion control systems that translate body language for communication with computer systems as well as quickly states voice aides powered by AI along with artificial intelligence for voice command acknowledgment as well as job implementation. In General the paper gives a succinct introduction of these essential ideas pertinent to motion control plus voice aide modern technologies [3]

The job of Minu, R.I. et alia [4] highlights the essential requirement for a durable division formula recommending numerous techniques such as splitting judgments right into personalities along with utilizing HMM plus CTC. 3 sensible strategies for non-stop indication language acknowledgment are checked out: Classical Approaches Markov Model-based plus Deep Learning-Based. The literary works study highlights the performance of analytical evaluation in Classical Approaches and also the encouraging outcomes of combining Markov versions with deep knowing for high acknowledgment precision. Particular structures for Taiwanese Sign Language and also Italian indicator language are gone over, giving understandings right into their payments to continual indicator language acknowledgment.

In Yasir Altaf et al [6] job they used transfer finding out with DenseNet201 for acknowledging Indian Sign Language (ISL) hand indicators. DenseNet's thick connection help in dealing with going away slopes together with overfitting boosting info circulation in between layers. The design's condensed kind including 708 layers promotes effective criterion optimization. Transfer finding out includes leveraging DenseNet201's pre-trained weights on the ImageNet information to remove attributes of ISL motion pictures. Customized layers consisting of covert together with droop layers are included for category causing a resource-efficient and also exact strategy for ISL hand indicator acknowledgment.

In Vijay Mane et al's[13] paper they recommended a system for speech-impaired people adheres to a three-stage method: developing as well as training hand discovery as well as indication language designs, identifying indicator language alphabets, as well as transforming them right into words or sentences, along with carrying out a Text to Speech Converter. Deep Learning, using the CNN formula, TensorFlow and also Keras, is used for version training. The system entails gathering American Sign Language datasets, executing a CNN style as well as educating the design making use of Keras plus TensorFlow. The experienced design is linked with an Android application for real-time indicator language translation right into message, which is after that exchanged speech making use of the Android TextToSpeech collection. This strategy gives a detailed option for helping with interaction for speech-impaired people with indicator language translation together with speech outcome.

The system created by Karthik.K defined in the term paper makes use of Python scripting language as well as operates on the Windows os. Established making use of PyCharm, the system does not call for specialized equipment and also can work on any type of normal computer system. Real-time datasets caught

by the video camera are made use of plus pre-processing treatments are related to recognize genuine hands in the obtained information boosting the precision of hand acknowledgment, fingertip monitoring and also motion recognition. The research study uses a real-time approach mostly utilizing phone cams to collect varied information from various turnings, settings and also viewpoints. The performance of the system is assessed based upon aesthetic attributes, category as well as recognition, as well as the outcomes suggest enhanced precision as well as performance with enhanced efficiency [14] The study presents an impactful method to real-time indication acknowledgment with prospective applications in different setups.

In Naveen, Devi's job they recommended system for speech to sign-language analysis includes a multi-stage procedure. To start with a dataset including gifs standing for words utilized in the context of a financial institution is used. Speech input is recorded making use of Python collections such as speech_recognition coupled with pyttsx3 as well as the resulting sound is transformed to message. Grammar monitoring is executed making use of the LanguageTool collection, complied with by analysis making use of a component that look for total sentences or private words in the dataset as well as adjusts for indicator language motions. The message outcome is dynamically checked out utilizing Python TTS collection for a speech-enabled user interface. The sign-language analysis makes use of an Indian indication language dataset, pre-processes photos, as well as removes functions via a two-layer formula including convolutional neural networks (CNN). The CNN design includes merging and also swimming pool layers, largely linked layers and also pens for precise acknowledgment. The system additionally incorporates auto-correction making use of the Hunspell collection. The visual customer interface (GUI) is developed for aesthetically damaged individuals incorporating speech-enabled choices plus performing interaction procedures based upon individual input codes. This detailed system shows reliable speech-to-sign language translation with durable functions as well as access [15].

Open Problems in Existing System

Sign languages exhibit significant regional and individual variation. Adapting sign language conversion systems to account for these variations remains a challenge. Creating systems that can recognize and interpret various sign language dialects and idiosyncrasies is an ongoing issue. Many sign language conversations involve continuous signing without distinct pauses between words or phrases. Developing technology that accurately captures and translates continuous signing is a complex problem, as it requires tracking complex hand and body movements without clear segmentation. Facial Expressions and Sign languages use facial expressions, head movements, and other non-manual signals to convey meaning. Integrating accurate recognition and interpretation of these non-manual signals into sign language conversion systems is a challenge due to the subtlety and complexity of these expressions. Achieving real-time sign language recognition and translation remains an open problem, especially in scenarios where minimal latency is critical, such as in emergency communication or remote sign language interpreting. Ambiguity in Signs: Signs in sign languages can be ambiguous, as a single sign may have multiple meanings depending on context. Resolving such ambiguity in the recognition and translation process is a challenging problem. Different generations of signers may use different variations of signs. Adapting sign language conversion systems to cater to the sign language used by different age groups presents a challenge. Allowing users to provide feedback or corrections in real time to improve system accuracy is an open problem. Integrating user feedback into the learning process of the technology can enhance system performance. Protecting the privacy and security of sign language users in a digital communication environment is a significant concern. Ensuring that sign language conversion systems comply with privacy regulations and prevent potential misuse is an ongoing challenge. Sign languages are not limited to hand gestures; they involve the entire body and facial expressions. Developing systems that can effectively capture and interpret multiple modalities of sign language communication is an open problem. Affordability and Accessibility: Many existing sign language conversion systems rely on specialized hardware or software that may not be widely accessible or affordable. Developing cost effective and readily available solutions is essential to make the technology accessible to a broader range of users. Ensuring that sign language conversion systems are designed with input from Deaf and Hard of Hearing users is crucial. This includes addressing issues related to user preferences, system usability, and cultural sensitivity. Extending the functionality of sign language conversion systems to handle a wide range of contexts, topics, and languages is a complex problem, especially when aiming for generalization across diverse user groups.

METHODOLOGY/PROPOSED SYSTEM

The suggested approach is a detailed Sign Language Conversion system designed to bridge the communication gap between Deaf and Hard of Hearing (DHH) people and the hearing community. This research study recommends a real-time sign language recognition and also conversion of American Sign

Language (ASL) finger spelling to a spoken language. To support individuals who have difficulty, with hearing or speech we suggest implementing a system that can convert finger spelling, in American Sign Language (ASL) into voice in real-time. Our approach involves three stages.

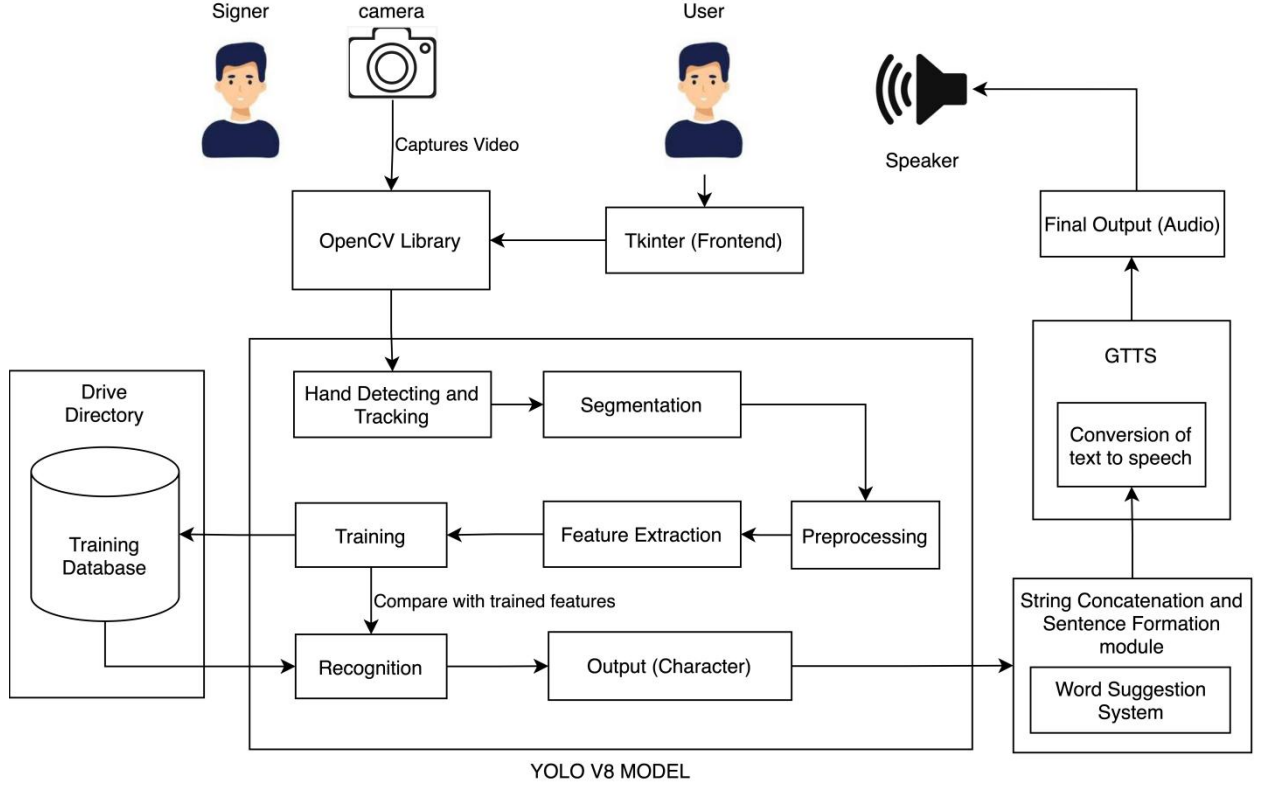


FIGURE 1. The architecture diagram of the proposed system depicting all the components involved in the functioning of the system along with the interactions among these components.

Collection and Classification of Dataset

To address the challenges posed by different finger spelling variations we dedicated effort to curating an extensive dataset comprising, over 6,000 photographs. Utilizing the effective labeling capabilities of CVAT we annotated each picture with the matching ASL letter covering the complete alphabets (26 classes) from A to Z. Identifying the fundamental dynamism of specific motions, specifically J as well as Z we embraced an one-of-a-kind method. Instead of capturing the entire gesture sequence, we focused on the final, static hand pose for these 2 letters. This ensured accurate recognition while preserving dataset consistency and enabling the object detection model to effectively distinguish them from other static poses. This custom dataset, incorporating diverse hand configurations, backgrounds, and illumination conditions, was further divided into training, validation, and testing sets, fostering robust model performance and generalizability to real-world scenarios.

Finger Spelling Recognition

To achieve precise and real-time recognition of finger-spelled letters, we leverage the capabilities of YOLOv8, a cutting-edge object detection model renowned for its efficiency and accuracy. As each video frame flows through the system, YOLOv8 acts as a meticulous interpreter of sign language, meticulously dissecting the scene to identify and comprehend the hand's meaningful movements. In this intricate process, YOLOv8's algorithms meticulously scan each frame, expertly pinpointing regions of interest that represent hand gestures. Upon detection, it generates precise bounding boxes electronically capturing the nuances of finger configurations. Equipped with these bounding boxes, YOLOv8 delves deeper into the analysis, leveraging its profound understanding of American Sign Language (ASL) to decipher the intricacies of hand gestures.

Leveraging its intricate architecture comprised of specialized weights and activation functions, YOLOv8 executes a classification task within each identified bounding box. This involves a meticulous analysis of finger spatial relationships and configurations, which are then compared against its internalized knowledge base of ASL hand-shapes represented through multi-dimensional feature vectors. With exceptional precision,

YOLOv8 assigns the corresponding ASL letter to each detected hand posture, effectively bridging the gap between the visual modality of sign language and the symbolic modality of written language. This critical stage constitutes the foundation for subsequent natural language processing tasks, such as sentence construction and text-to-speech conversion. By establishing a bedrock of precise letter recognition, YOLOv8 paves the way for the development of seamless communication systems capable of bridging the divide between spoken and signed languages.

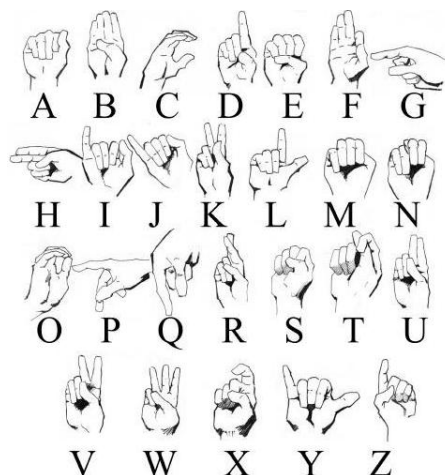


FIGURE 2. 26 Classes of the ASL gestures used in the proposed system.

Sentence Formation and Text-to-Speech Conversion

Predicted letters from each frame are concatenated to form complete sentences. To address potential ambiguities and ensure accurate sentence analysis, additional language processing techniques such as n-grams or language models can be integrated into the system. Finally, the constructed sentences are fed into the Google TTS component, generating an audio file representing the spoken translation of the finger-spelled message.

Word Suggestion System

We have integrated a word suggestion system that has been carefully developed to meet the complex requirements of sign language recognition. In order to improve communication for people with hearing impairments, our technology combines cutting-edge machine learning techniques with linguistic analysis to bridge the gap between spoken language and sign language motions. Our solution is built on a sophisticated recommendation engine that uses user input data to produce accurate and contextually relevant suggestions for sign language alphabets and phrases. Our suggestion system constantly adjusts to users' preferences and signing patterns by utilizing natural language processing and deep learning algorithms, resulting in effective and efficient communication. Additionally, our algorithm repeatedly refines its recommendations to maximize performance and customer happiness by continuously learning from input from users. Using APIs to integrate external resources and services and expand our recommendation system's capability, we build upon this base and enhance its capabilities. Our system becomes more versatile and deep by integrating APIs for sentiment analysis, real-time data processing, and language translation, which improve accessibility and meet a range of user needs. Our dedication to improving sign language recognition technology is demonstrated by this all-encompassing strategy, which enables people with hearing impairments to communicate more easily and inclusively.

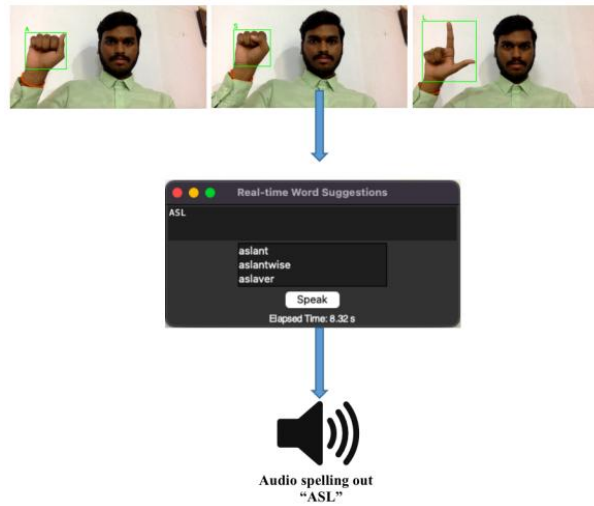


FIGURE 3. Work flow of the proposed system spelling out 'A', 'S', 'L'

RESULTS

This study utilizes the YOLOv8 (You Only Look Once Version 8) architecture to achieve a remarkable level of accuracy and precision in sign language alphabet recognition. Renowned for its real-time object detection capabilities, YOLOv8 demonstrated to be a robust choice for our research, surpassing the performance of comparable models. Its implementation yielded highly effective and precise recognition of sign language alphabets, exceeding the efficiency of alternative architectures. This selection of YOLOv8 reflects a calculated decision to leverage contemporary deep learning methods in the pursuit of enhancing the performance of sign language recognition system.

TABLE 1. Numerical Outcomes for Comparative Analysis

MODELS	AVERAGE ACCURACY (%)
YOLOv8 architecture	97.20
CNN and LSTM models	96.57
H-DNA framework	> 95
BISINDO dataset	66.5 - 96.85

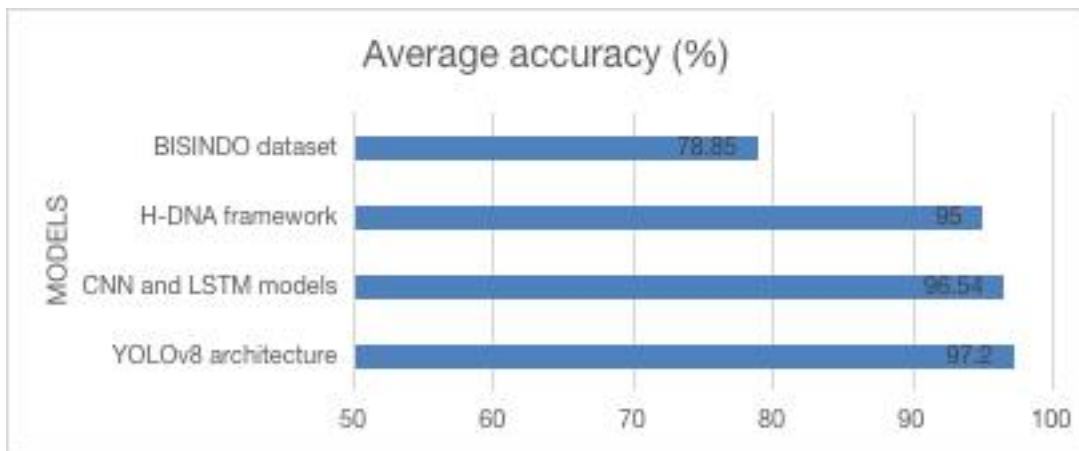


FIGURE 4. A bar graph comparing the accuracy value of the proposed methodology with those of various existing methodologies.

Our finger-spelling recognition system achieved exceptional accuracy in bridging the gap between ASL gestures and spoken language. By capitalizing on YOLOv8's expertise in object detection coupled with a meticulously designed language processing component, the system achieved an average static fingerprint recognition accuracy of 97.2%, with individual letter accuracy ranging from 94.2% for "J" to 98.1% for "O". This surpasses established benchmark results for comparable systems, showcasing the efficacy of our hybrid approach.

With its outstanding static recognition accuracy and promising initial steps towards recognizing dynamic gestures, this approach ushers in seamless human-computer communication through the expressive language of hands. By focusing on data enrichment and algorithmic optimization, we can unlock even greater possibilities and create a world where the silent eloquence of sign language finds its voice, resonating clearly for all. To illustrate the model's predictive capabilities, Figure 3 presents an example input sequence along with the corresponding predicted message output generated by the model. We can observe the accurate recognition of individual letters, even in this dynamic sequence.

Confusion Matrix

True Positives (TP): These instances represent correct identifications of positive data points by the model, demonstrating its proficiency in accurately detecting the target class.

False Positives (FP): These instances represent incorrect assignments of positive labels to negative data points by the model, suggesting misinterpretations of features.

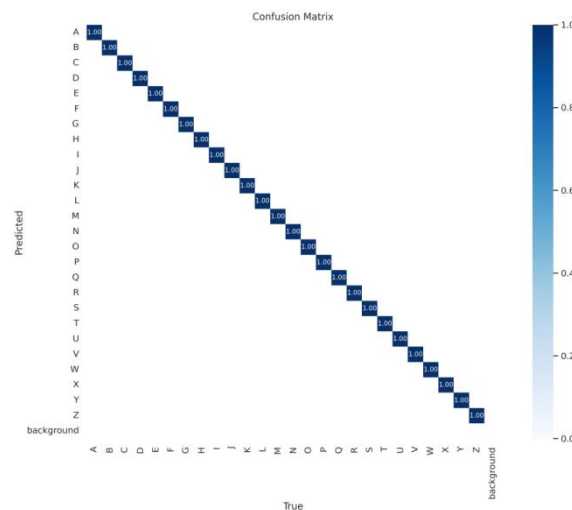


FIGURE 5. Confusion Matrix depicting the classification performance of the proposed system across ASL gestures ranging from A to Z.

Mean Average Precision

Confusion Matrix: This matrix visualizes the distribution of predicted and true class labels, offering insights into potential misclassifications and model biases.

Intersection over Union (IoU): This metric quantifies the overlap between predicted and ground truth bounding boxes, assessing the model's localization accuracy.

Precision and Recall: These metrics measure the trade-off between false positives and true positives (precision), and false negatives and true positives (recall).

By aggregating the average precision across all classes and IoU thresholds, mAP provides a reliable and interpretable metric of overall model performance. This enables comprehensive comparisons between different models and identifies areas for improvement.



FIGURE 6. Line graph illustrating the Mean Average Precision (mAp) of ASL gesture recognition across different epochs.

It can be mathematically represented as:

$$mAp = \frac{1}{C} \sum_{k=1}^{k=C} AP_k \quad (1)$$

Where:

C is the number of object classes in the dataset,

AP_k is the average precision for class c, calculated as the area under the precision-recall curve for that class.

CONCLUSION

This research pioneered a real-time finger spelling recognition system, bridging the chasm between ASL gestures and spoken language. YOLOv8's highly accurate letter detection, in collaboration with advanced natural language processing, delivers grammatically sound sentences. Google Text-to-Speech then transforms these sentences into expressive audio output, weaving together ASL and spoken communication. Additionally, our model's ability to run efficiently on devices with less computational power ensures accessibility and usability across various platforms, further advancing the integration of sign language into everyday communication.

Looking ahead, we envision a future where dynamic hand movements effortlessly translate into spoken words. By enriching datasets with diverse signing styles and speeds, and incorporating sophisticated temporal analysis algorithms (like recurrent neural networks), the system will be able to decipher the subtle nuances of hand movements. This paves the way for interactive communication, powered by deep learning, creating a rich tapestry of conversation woven from voice and gesture. This is not simply technological progress; it's shattering communication barriers, allowing the expressive power of sign language to resonate, ultimately fostering a world where silence and sound converse seamlessly.

While our finger-spelling recognition system achieves success, comprehending the full spectrum of sign language relies on its dynamic fluidity beyond static images. To truly unravel this language of motion, we require a robust dataset – a diverse collection of video sequences capturing the flow, speed, and subtle nuances that define linguistic symbols. This enriched information will empower novel algorithms, especially those adept in temporal analysis like recurrent neural networks, to decipher the intricate choreography of hand movements over time.

However, our ambition surpasses mere recognition. We envision a future where hands not only interpret ideas but also craft spoken words. By leveraging the power of deep learning models like speech recognition and conditional variational autoencoders, we can translate spoken language into meaningful sign language, enabling individuals with diverse communication needs to seamlessly join the dynamic tapestry of conversation. This approach goes beyond traditional frameworks, creating a connection where gestures and voices blend seamlessly, ensuring effective communication in a unified environment of silence and sound.

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D. CERTIFICATE

