Sense The New Light of Communication

Mr. J R Harshavardhan[1], Sowjanya K S[2], Poojitha S[3], Tejaswini R M[4], Sindhushree K[5]
[1]*Associate Professor, Department of Computer Science and Engineering, K S School of Engineering and Management, Bengaluru, Karnataka, India*
[2,3,4,5]*Department of Computer Science and Engineering, K S School of Engineering and Management Bengaluru, Karnataka, India*

***Abstract*—Communication barriers faced by speech- and hearing-impaired individuals significantly limit their participation in social, educational, and professional interactions, especially in digital environments. To address this challenge, this paper presents SENSE: The New Light of Communication, an intelligent assistive communication system designed to enable real-time, two-way interaction between speech-impaired, hearing-impaired, and normal users. The proposed system integrates computer vision and machine learning techniques to recognize sign language gestures and translate them into text or speech in real time. Additionally, Speech-to-Text (STT) and Text-to-Speech (TTS) modules are incorporated to facilitate seamless communication across different modalities. The system is implemented as a web-based platform that eliminates dependency on specialized hardware and human interpreters, offering a cost-effective and scalable solution. Experimental results demonstrate reliable performance with low latency and accurate synchronization, validating the effectiveness of the proposed system in promoting inclusive and accessible digital communication.**

***Index Terms*—Assistive Communication System, Sign Language Recognition, Computer Vision, Machine Learning, Speech-to- Text and Text-to-Speech, Meeting Summary.**

I. INTRODUCTION

Communication plays a vital role in social, educational, and professional interactions. However, individuals with speech and hearing impairments often face significant barriers in expressing themselves and understanding others, particularly in digital communication environments. With the rapid growth of online meetings, virtual classrooms, and remote collaboration platforms, the lack of accessible communication tools has become increasingly evident.

Recent advancements in computer vision, machine learning, and speech processing have enabled the development of intelligent assistive technologies that can help bridge this communication gap. Technologies such as sign language recognition, Speech-to-Text (STT), and Text-to- Speech (TTS) provide new opportunities for inclusive interaction by translating different communication modalities in real time. Despite these advancements, many existing solutions either depend on specialized hardware, lack real-time integration, or fail to provide a unified communication platform.

To address these challenges, SENSE: The New Light of Communication is proposed as an intelligent assistive system that facilitates seamless, real-time, two-way communication between speech-impaired, hearing-impaired, and normal users. By integrating sign language detection, STT, and TTS within a single web-based platform, the system promotes accessibility, inclusivity, and independence in digital communication. The proposed solution aims to reduce reliance on human interpreters and enable equal participation in virtual meetings and online interactions.

II. RELATED WORK

Several research efforts have been directed toward improving communication for speech- and hearing-impaired individuals using assistive technologies. Bharti et al. proposed an AI-driven assistive platform that integrates computer vision and speech technologies to support communication between deaf-mute and blind communities. Their work demonstrates the effectiveness of deep learning models in real-time gesture recognition and speech translation, highlighting the potential of AI-based solutions for inclusive communication.

Elgeme et al. introduced a smart speaking glove designed to translate hand gestures into text and speech using embedded sensors. While the system offers accurate gesture detection, it relies on specialized hardware, which limits portability and large-scale adoption. Raghuvanshi et al. presented a comprehensive review of Indian Sign Language recognition systems, emphasizing the use of machine learning and computer vision techniques. Their study identifies challenges such as dataset limitations, gesture complexity, and environmental constraints, underscoring the need for more robust and unified solutions.

In contrast to existing approaches, the proposed SENSE system focuses on a unified, software-based platform that eliminates dependency on specialized hardware while enabling real-time, two-way communication through sign language recognition, Speech-to-Text, and Text-to-Speech integration.

III. PROBLEM STATEMENT

"Despite the widespread use of video conferencing platforms, most existing solutions lack advanced AI features, real-time accessibility tools, and seamless collaboration capabilities. As a result, users—particularly speech- and hearing-impaired individuals—continue to face several critical challenges, including:"

- Speech- and hearing-impaired individuals face significant communication barriers in digital and real- time interaction environments.
- Existing communication platforms are primarily designed for hearing and speaking users, offering limited accessibility for differently-abled individuals.
- Reliance on human interpreters increases cost, reduces privacy, and limits availability for spontaneous communication.
- Lack of real-time integration between sign language, speech, and text results in communication delays and reduced interaction efficiency.
- Absence of a unified platform supporting two-way communication leads to social, educational, and professional exclusion of impaired users.

IV. OBJECTIVE

The primary objectives of SENSE: The New Light of Communication are:

1. To develop an assistive communication system that supports speech- and hearing-impaired individuals in real-time interactions.
2. To implement sign language detection using computer vision and machine learning techniques for accurate hand gesture recognition.
3. To enable Speech-to-Text (STT) conversion so that spoken language can be displayed as readable text for hearing-impaired users.
4. To enable Text-to-Speech (TTS) conversion allowing speech-impaired users to communicate through synthesized voice output.
5. To support two-way communication between impaired and normal users through gesture, text, and voice integration.
6. To provide seamless virtual meeting experience with features such as live interaction and post-meeting summary generation.
7. To design a user-friendly and intuitive interface that ensures accessibility, ease of use, and inclusivity for all users.

V. METHODOLOGY

SENSE: The New Light of Communication follows a structured and modular approach to design, develop, and implement as assistive communication system that enables real-time interaction between speech-impaired, hearing- impaired, and normal users. The system architecture integrates computer vision, machine learning, and speech processing within a web-based communication environment.

A. System Architecture Overview

The proposed system is implemented as a web-based application consisting of three major layers:

- User Interface Layer,
- Application and Communication Layer, and
- Intelligence and Processing layer.

These layers work together to ensure real-time data acquisition, processing, translation, and synchronized delivery of communication outputs.

B. User Interface and Interaction

The application begins with a landing page from which users can initiate a meeting. During the meeting setup phase, users provide basic identification details and join a virtual meeting room. The interface allows users to interact through video, audio, text input, and sign language gestures. Accessibility-focused design principles are applied to ensure ease of use for differently-abled users.

C. Sign Language Detection Module

Sign language detection is achieved using computer vision techniques. Video frames captured through a standard webcam are processed to detect hand landmarks. These landmarks are analyzed using a trained machine learning model to classify hand gestures into corresponding textual representations. The recognized text is then displayed or converted into speech for other participants.

D. Speech Processing Module

The system incorporates two speech processing components:

1. Speech-to-Text (STT):

Spoken audio from normal users is captured and converted into real-time textual captions for hearing-impaired users.

2. Text-to-Speech (TTS):

Text input provided by speech-impaired users is transformed into synthesized speech output, enabling audible communication for other participants.

E. Real-Time Communication and Synchronization

Real-time communication is maintained through persistent connections that allow instant transmission of gesture data, audio, and text among participants. This ensures minimal latency and synchronized interaction during meetings. The system continuously processes multiple input streams in parallel to support smooth two-way communication.

F. Meeting Termination and Summary Generation

Upon completion of the meeting, all communication logs—including recognized gestures, speech transcripts, and text messages—are collected and processed. A structured meeting summary is generated and presented to the user, providing a concise overview of the discussion.

VI. SYSTEM WORKFLOW

The system workflow of SENSE: The New Light of Communication describes the sequential and parallel processes involved in enabling real-time, two-way communication between speech-impaired, hearing-impaired, and normal users. The workflow is designed to ensure minimal latency, seamless interaction and accurate translation of communication modalities.

A. Application Initialization

The workflow begins when the user launches the application through a web interface. The landing page is displayed, providing an option to initiate a meeting. Upon selecting the Start Meeting option, the user is redirected to the meeting setup interface, where basic identification details are entered. A unique meeting session is then created.

B. Meeting Setup and Session Establishment

Once the meeting is initiated, the system establishes secure audio, video, and data communication channels. Permissions for camera and microphone access are requested, and real- time connections are initialized to support continuous data exchange among participants. Reverse Communication Module.

C. Real-Time Communication Processing

During the active meeting session, the system executes multiple processing loops concurrently:

1. Sign Language Processing:

Video frames captured from the webcam are analyzed to detect hand gestures. These gestures are recognized and translated into corresponding textual output, which can also be converted into speech for other participants.

2. Speech-to-Text Processing:

Spoken input from normal users is captured through the microphone and converted into live text captions for hearing-impaired users.

3. Text-to-Speech Processing:

Text input provided by speech-impaired users is converted into synthesized speech, enabling audible communication for other participants.

All translated outputs are broadcast in real time to ensure synchronized communication.

D. User Interaction and Collaboration

The system allows users to interact continuously using voice, text, and gestures. Additional collaborative tools

support effective communication during the meeting. The workflow ensures that each user receives translated outputs in their preferred communication format.

E. Meeting Termination and Summary Generation

Fi When the meeting is concluded, the user terminates the session. The system then aggregates all communication data, including speech transcripts, gesture interpretations, and text interactions. This data is processed to generate a structured meeting summary, which is presented to the user for review.

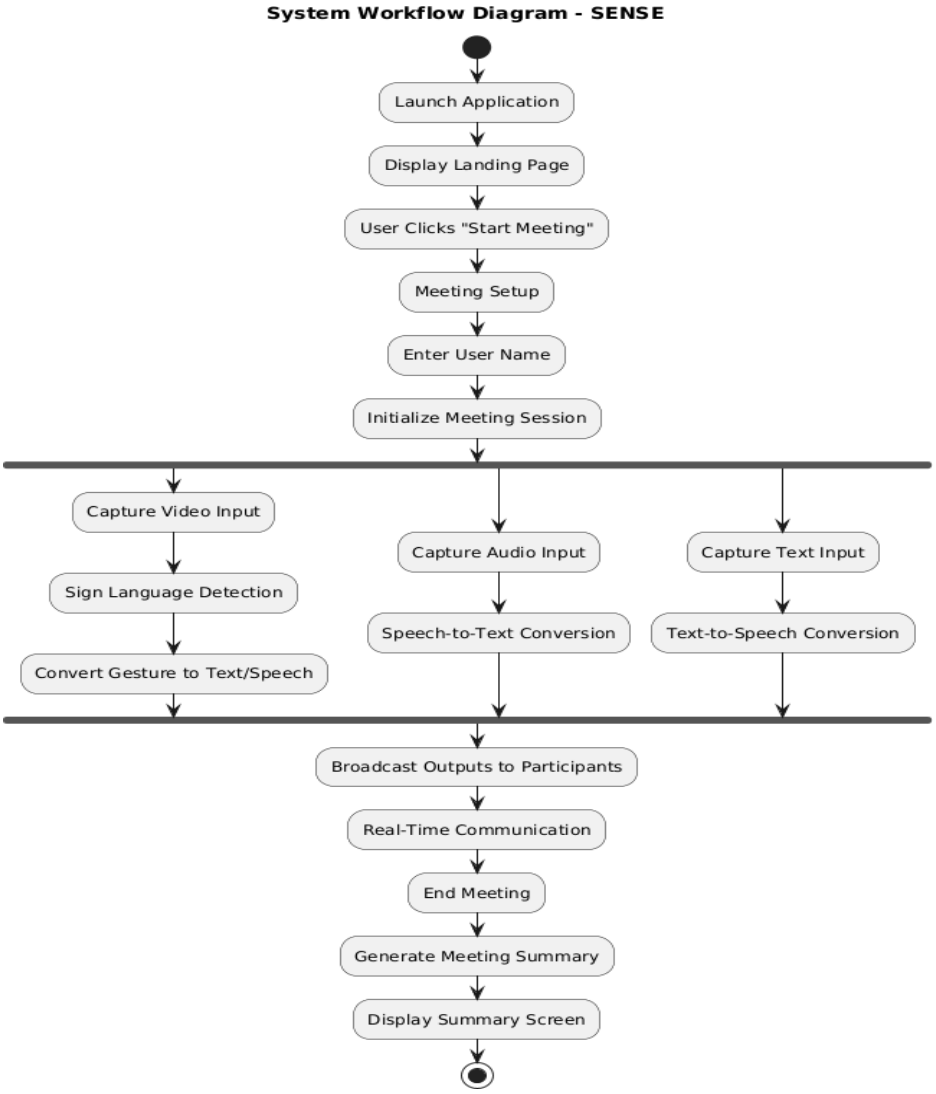

Fig 1 System Work Flow Diagram

VII. IMPLEMENTATION AND RESULT

The implementation of SENSE: The New Light of Communication is carried out as a web-based application integrating real-time communication, computer vision, and speech processing technologies. The system is developed using a modular architecture to ensure scalability and maintainability.

The frontend is implemented using standard web technologies to provide an interactive and accessible user interface for meeting initiation, participation, and summary viewing. The backend manages session control, real-time data exchange, and coordination between different processing modules.

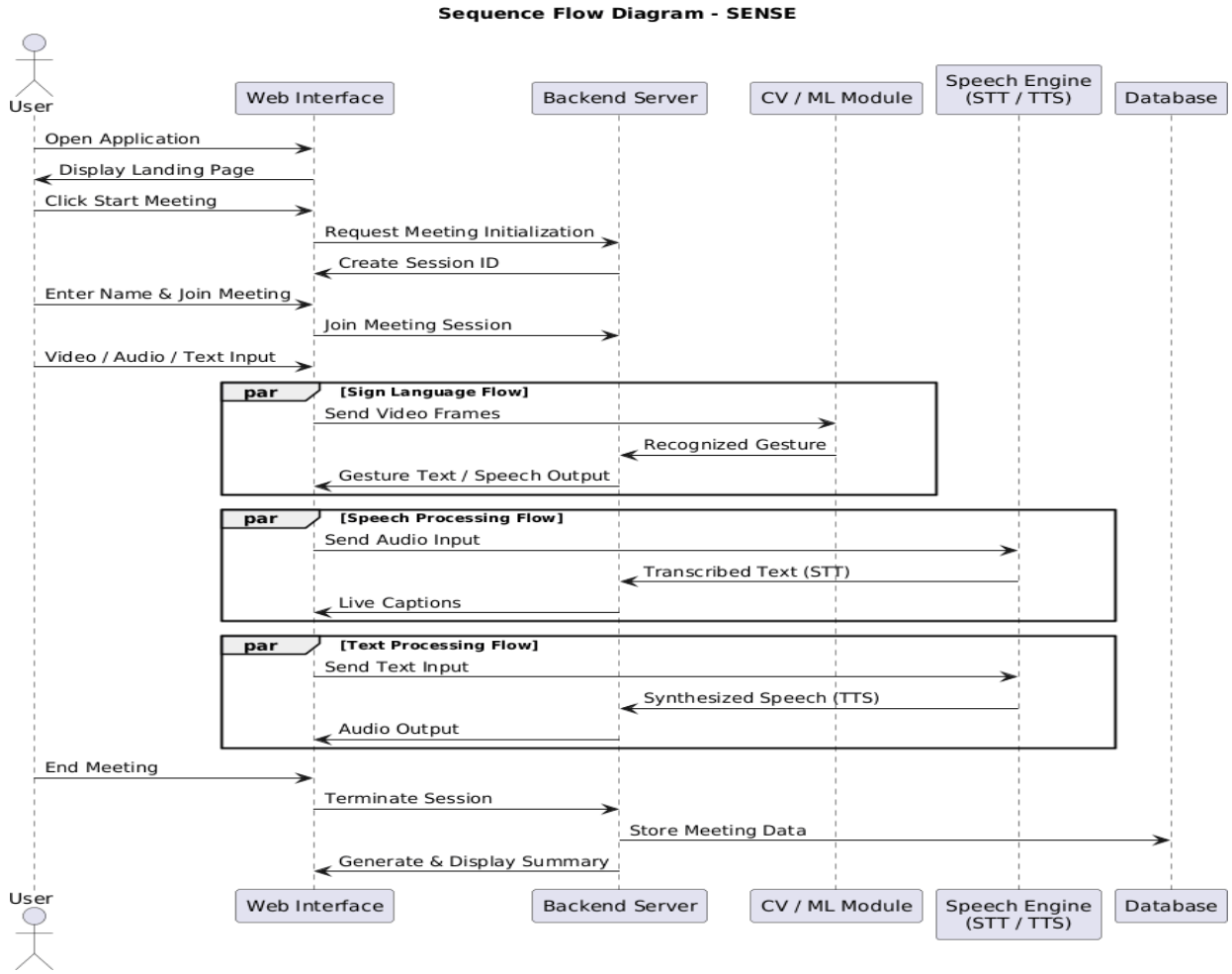

Fig 2 Sequence Flow

The sign language recognition module captures live video input through a webcam and processes it using computer vision techniques to extract hand landmarks. These landmarks are classified using a trained machine learning model to generate corresponding text or speech output.

Speech-to-Text (STT) functionality is implemented to convert spoken audio into live captions, while Text-to-Speech (TTS) functionality converts typed text into synthesized speech. Real-time communication and synchronization between participants are achieved using persistent connections to minimize latency. After meeting termination, all interaction data is stored and processed to generate a structured meeting summary.

The implemented system successfully enables real-time, two-way communication between speech-impaired, hearing- impaired, and normal users. Experimental testing demonstrates accurate conversion of sign language gestures into readable text and audible speech. The Speech-to-Text module provides live captions with minimal delay, improving accessibility for hearing-impaired users, while the Text-to- Speech module allows speech-impaired users to communicate effectively through voice output.

The system ensures smooth interaction during meetings with synchronized audio, text, and gesture-based communication. The post-meeting summary feature effectively compiles interaction data into a clear and structured format. Overall, the results validate the effectiveness of the proposed system in reducing communication barriers and enhancing inclusive digital communication.

VIII. FUTURE ENHANCEMENTS

The SENSE system provides an effective solution for bridging communication gaps between speech- and hearing- impaired individuals and normal users. However, several enhancements can be incorporated in future versions to further improve system capability, accuracy, and real-world usability.

Future work may include the development of dedicated mobile applications for Android and iOS platforms, enabling greater portability and accessibility. The integration of offline gesture recognition models can ensure uninterrupted functionality in environments with limited or no internet connectivity.

Support for multilingual translation can be introduced to allow communication across diverse linguistic regions, thereby expanding the system's applicability. The gesture vocabulary can be extended to include complex sentence-level recognition and region-specific sign languages for improved expressiveness.

Incorporating facial expression and upper-body pose recognition can enhance the interpretation of emotional cues and advanced sign language structures, resulting in more natural communication. Additionally, AI-based personalized learning mechanisms can be implemented to adapt to user- specific gesture variations over time, improving recognition accuracy.

Future versions may also focus on improving performance in low-light conditions using enhanced image-processing techniques or infrared sensing. Furthermore, integration with smart devices and IoT ecosystems, such as smart speakers, wearables, and AR devices, can extend the system's use in real-world scenarios including education, healthcare, and public services.

IX. CONCLUSION

The SENSE: The New Light of Communication system presents an effective and inclusive solution to bridge communication gaps between speech-impaired, hearing-impaired, and normal users. By integrating computer vision, machine learning, and speech processing technologies, the system enables real-time two-way communication through sign language recognition, Speech-to-Text, and Text-to- Speech conversion within a unified platform.

The proposed system eliminates reliance on specialized hardware and human interpreters, providing a cost-effective and scalable approach using standard devices. Experimental evaluation demonstrates reliable performance with low latency and accurate synchronization across multiple communication modes. Overall, the SENSE system highlights the role of assistive technology in promoting accessibility and digital inclusion, with strong potential for future expansion across educational, professional, and social domains.

REFERENCES

[1] T. Bharti, S. Gupta, S. Singh, S. Sharma, V. P. Chaubey, and S. Gochhait, "Next-Gen Assistive Technology: AI Applications for Deaf- Mute and Blind Communities," in Proceedings of the 2024 International Conference on Innovation and Intelligence for Informatics, Computing, and Technologies (3ICT), 2024.

[2] N. A. Elgeme, R. M. Marimi, and Z. A. Rezkallah, "Smart Speaking Glove with One Hand for Deaf and Dumb," University of Zawia Journal of Engineering Sciences and Technology (UZJEST), vol. 2, no. 1, 2024.

[3] K. Raghuvanshi, M. P. Singh, H. Yadav, B. Singh, and U. Kaur, "A Comprehensive Review on Indian Sign Language for Deaf and Dumb People," International Journal for Research in Applied Science and Engineering Technology, vol. 10, no. 4, Apr. 2022.