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SAMVAAD – SIGN AND MULTIMODAL VOICE ASSISTIVE ACCESS & DIALOGUE

AI-Powered Multimodal Accessibility Platform for Inclusive Communication

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Abstract:

SAMVAAD (Sign and Multimodal Voice Assistive Access & Dialogue) is an AI-powered accessibility platform developed to bridgecommunication gaps between individuals with hearing, speech, and visual impairments and the general public. Existingassistive systems generally focus on only one form of disability and fail to provide integrated communication support.SAMVAAD addresses this limitation by combining Sign Language recognition, Speech-to-Text (STT), Text-to-Speech(TTS), Braille translation, and 3D avatar-based sign visualization into a unified web-based platform. The system uses Artificial Intelligence, Computer Vision, and Natural Language Processing technologies such as OpenCV, MediaPipe, and Flaskto enable real-time multimodal communication. The proposed framework provides users with text, speech, sign, and Braille interaction modes while maintaining a lightweight and locally deployable architecture. The platform also includesan educational module for learning Sign Language and Braille, thereby promoting accessibility awareness and inclusiveinteraction. SAMVAAD demonstrates how AI can be ethically utilized for social good by improving communication accessibility and empowering differently-abled individuals.

Index Terms - Artificial Intelligence, Accessibility, Sign Language Recognition, Braille Translation, Speech-to-Text, Text-to-Speech, , OpenCV, MediaPipe.

I. INTRODUCTION

Communication is one of the most essential aspects of human life, enabling individuals to express thoughts, emotions, and ideas. However, people with hearing, speech, or visual impairments often face severe barriers in day-to-day communication. Most existing assistive systems are designed for a single disability, such as speech-to-text or Braille conversion, which limits their effectiveness in real-world communication scenarios. There is a growing need for a unified accessibility platform capable of integrating multiple communication modes into a single system.

SAMVAAD (Sign and Multimodal Voice Assistive Access & Dialogue) is an AI-powered multimodal communication platform developed to address this challenge. The system combines sign language recognition, speech processing, Braille translation, and 3D sign animation into a single integrated environment. By using technologies such as OpenCV, MediaPipe, and Flask, SAMVAAD enables seamless interaction between differently-abled individuals and the wider community.

The platform provides multiple input methods including text, speech, gesture, and image-based Braille recognition. Outputs are generated in the form of audio speech, Braille patterns, and animated sign gestures. The lightweight and offline-capable architecture ensures that the system can operate efficiently even in resource-constrained environments such as schools, healthcare centers, and rural areas. The project demonstrates how Artificial Intelligence can contribute toward inclusive and accessible communication.

II. PROBLEM STATEMENT

Despite advancements in assistive technology, communication between differently-abled individuals and society remains challenging. Most available systems focus on a single communication method and fail to provide integrated support for sign language, speech, text, and Braille together. Existing solutions are often expensive, dependent on internet connectivity, or require specialized hardware. Sign language recognition systems may suffer from limited vocabulary, low recognition accuracy, and poor real-time performance.

Similarly, Braille translation systems are often isolated from speech and sign-based interfaces, preventing effective multimodal communication. This creates barriers not only between differently-abled users and society but also among people with different forms of disabilities themselves. Therefore, there is a need for a cost-effective, lightweight, and integrated communication system capable of translating speech, text, sign language, and Braille in real time. SAMVAAD is proposed
to address these limitations by providing a unified AI-powered accessibility platform.

III. OBJECTIVES

Theprimary objective of SAMVAAD is to develop a unified communication platform that supports multimodal accessibility for hearing, speech, and visually impaired users. The system aims to provide real-time communication through Sign Language recognition , speech processing, and braille Translation.

There are objective we follow them below :

1. To develop an AI-based multimodal accessibility platform.
2. To enable real-time Sign Language recognition using OpenCV and MediaPipe.
3. To integrate Speech-to-Text and Text-to-Speech communication.
4. To provide Braille translation for visually impaired users.
5. To create a user-friendly and inclusive communication system.
6. To promote accessibility and awareness using assistive technologies.

IV. LITERATURE SURVEY

Recentadvancements in Artificial Intelligence and Machine Learning have significantly improved assistive communication systems. Researchers have explored gesture recognition, speech processing, and Braille translation to improve accessibility for differently-abled individuals.

Kumar et al. proposed a CNN-based Indian Sign Language recognition system capable of identifying static gestures with high accuracy. Kaur and Singh implemented a -based gesture recognition model that improved real-time performance and reduced latency. Sahu et al. combined MediaPipe hand tracking with LSTM neural networks for dynamic gesture interpretation.

Braille translation systems have also evolved through the use of Optical Character Recognition (OCR). Bharathi et al. developed a Braille-to-Text conversion system capable of identifying Braille patterns from images. Speech processing technologies such as Google STT and TTS have enabled voice-based accessibility, although most systems remain unimodal andinternet dependent.

The literature reveals that while significant progress has been made in isolated accessibility systems, there is still a lack ofintegrated multimodal platforms. SAMVAAD addresses this gap by combining Sign, Speech, Braille, and Text interfaces intoa single unified communication environment.

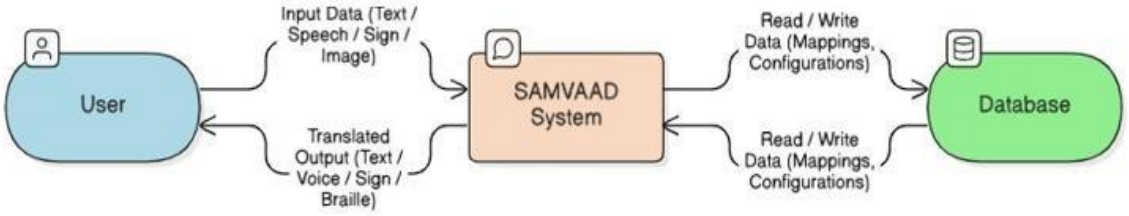

Fig 1 : Data Flow Diagram

V. SYSTEM ARCHITECTURE

SAMVAAD follows a modular client-server architecture consisting of Input, Processing, Output, and Database layers. The Input Layer accepts speech, text, gestures, and image-based Braille inputs through microphones, keyboards, and webcams. The Processing Layer performs gesture recognition, speech conversion, and Braille mapping using AI and NLP models.

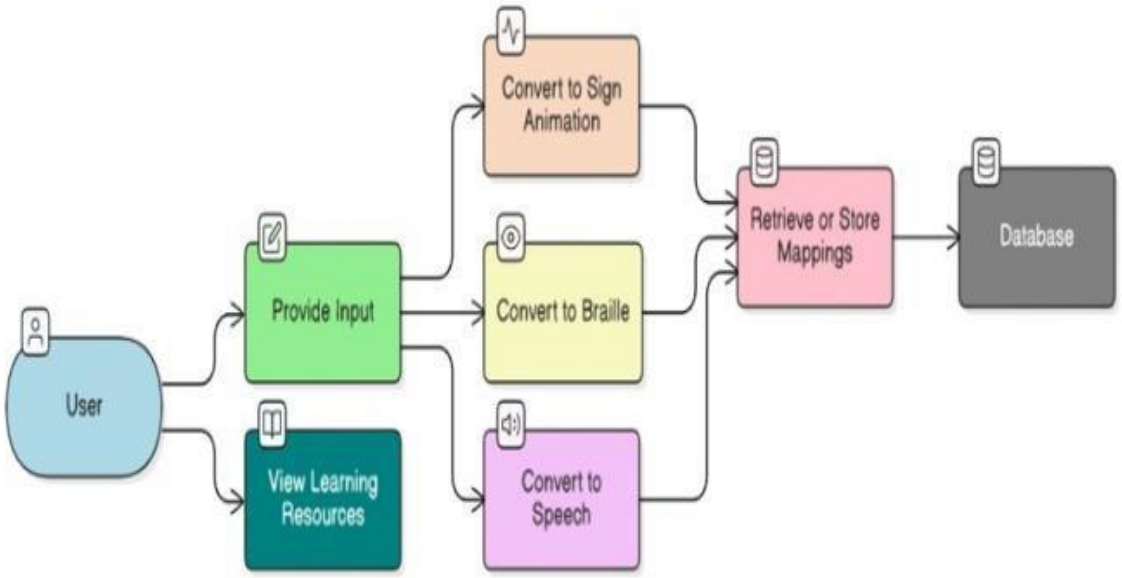

Fig 2 : DetailedSystem Flow

The Output Layer generates accessible outputs such as audio speech, sign animations, text responses, and Braille patterns. SQLite is used as the lightweight database for storing mappings and system configurations. Flask serves as the backend integration layer, enabling communication between frontend and backend modules.

The modular architecture ensures scalability and maintainability, allowing future integration of multilingual support, cloud deployment, and improved AI models.

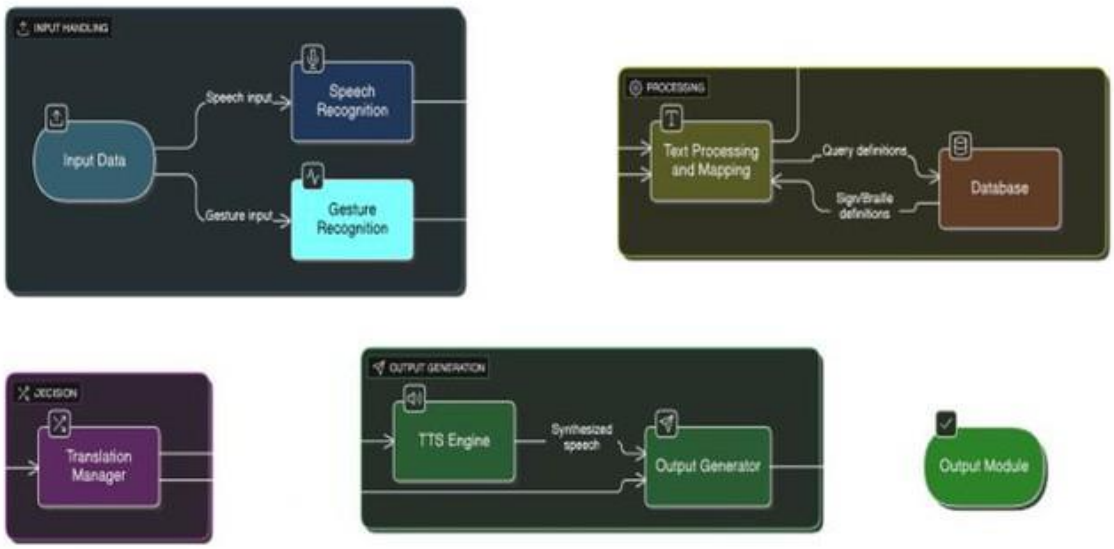

Fig 3 : System Architecture

VI. TOOLS AND TECHNOLOGIES USED

The development of SAMVAAD involves multiple software frameworks and libraries. Python is used as the primary programming language because of its flexibility and AI support. Flask is used as the backend framework to integrate all modules and manage system routing.

OpenCV, , and MediaPipe are used for computer vision and gesture recognition. SpeechRecognition and pyttsx3 enable speech-to-text and text-to-speech functionalities. HTML, CSS, and JavaScript are used for frontend interface design, ensuring responsive and accessible web interaction.

SQLite is used for local database storage, while Visual Studio Code and Jupyter Notebook are used for development and testing. These technologies collectively enable efficient implementation of multimodal accessibility features.

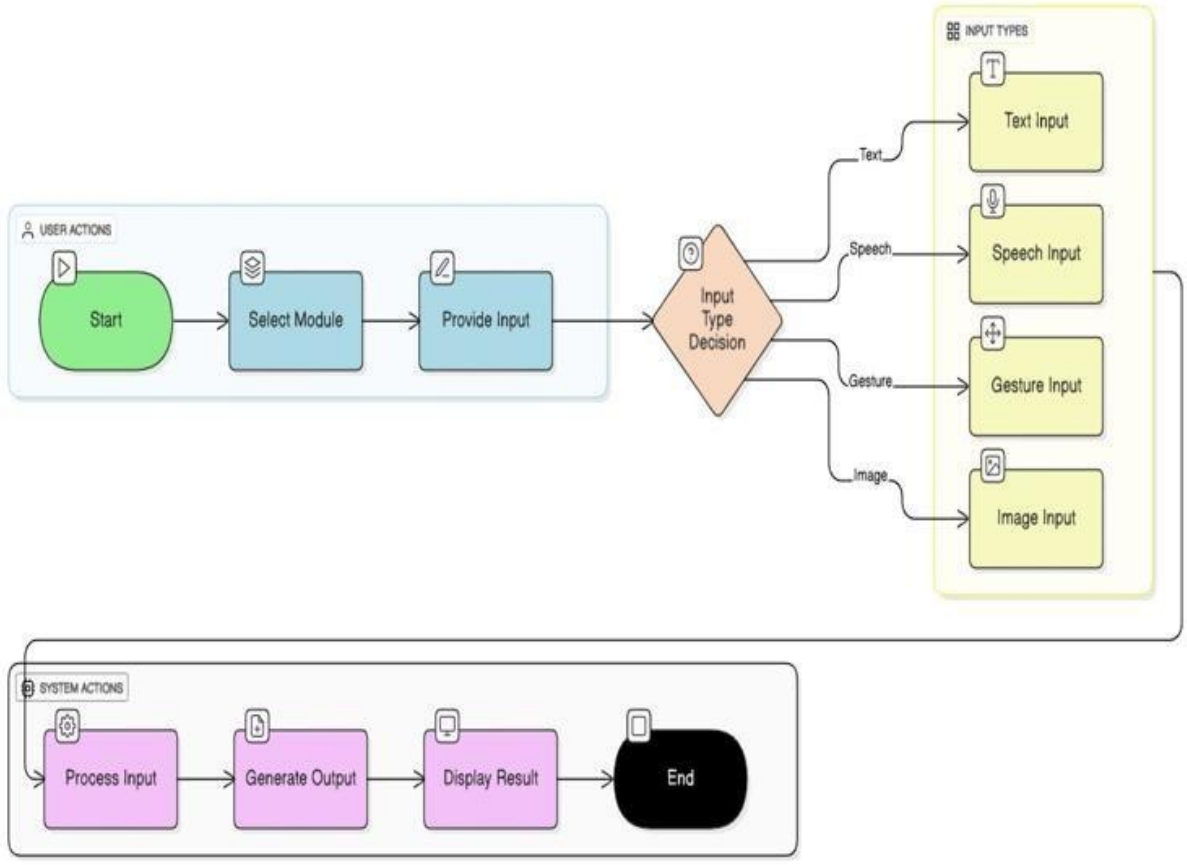

Fig 4 : Workingof used Tools

The development of SAMVAAD involves multiple software frameworks and libraries. Python is used as the primary programming language because of its flexibility and AI support. Flask is used as the backend framework to integrate all modules and manage system routing. OpenCV and MediaPipe are used for computer vision and gesture recognition. SpeechRecognition and pyttsx3 enable speech-to-text and text-to-speech functionalities. HTML, CSS, and JavaScript are used for frontend interface design, ensuring responsive and accessible web interaction. SQLite is used for local database storage, while Visual Studio Code and Jupyter Notebook are used for development and testing. These technologies collectively enable efficient implementation of multimodal accessibility features, helping the system provide seamless communication support for differently-abled individuals.

VII. RESULTS AND DISCUSSION

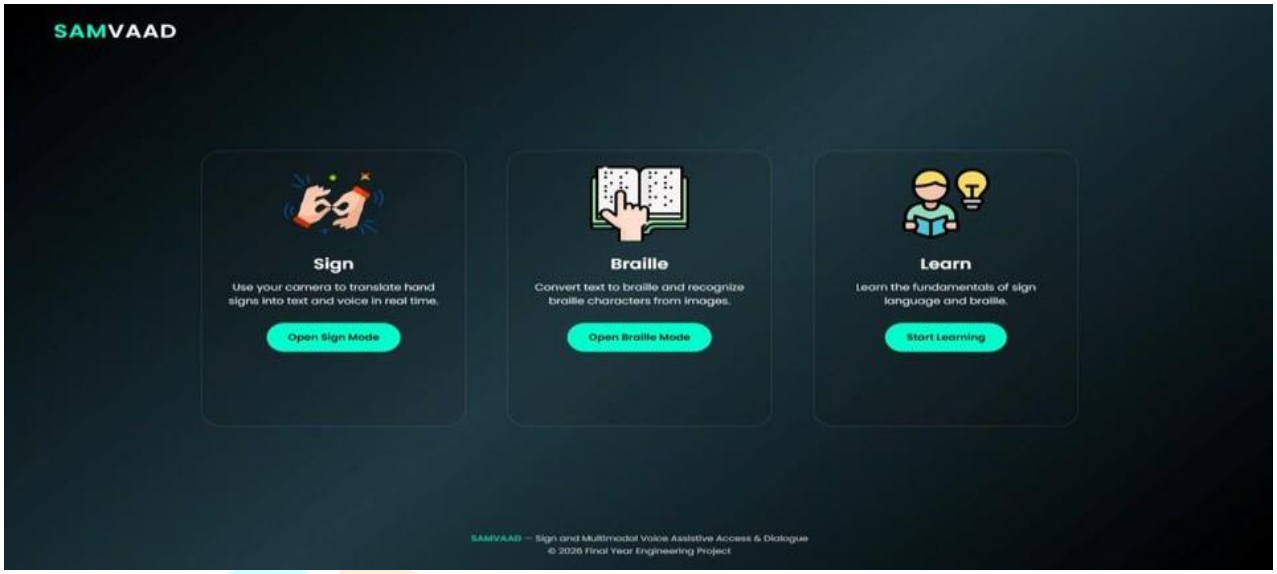

Fig 5 : Implementation

The developed SAMVAAD prototype successfully demonstrated multimodal accessibility through integrated speech, sign, text, and Braille communication. The Sign module effectively recognized hand gestures using AI-based computer vision models and translated them into English text. Speech input was accurately converted into text using speech recognition libraries, while text outputs were transformed into sign animations and Braille representations.

The Braille module successfully converted textual information into visual Braille dot patterns and extracted text from Braille images using OCR techniques. The Learn module provided an intuitive educational interface for understanding basic Sign Language gestures and Braille alphabets.

Experimental testing indicated that the system performs efficiently under normal lighting and controlled environmental conditions. The lightweight architecture enabled smooth operation on standard computer systems without requiring specialized hardware. The results demonstrate the practical feasibility of integrating multiple assistive technologies into a single communication platform.

VIII. LIMITATIONS

1. The Sign Language recognition module may be affected by poor lighting and camera quality.
2. The system currently supports limited gestures and vocabulary.
3. Real-time performance may decrease on low-performance devices.
4. Internet-dependent features may not work properly in offline environments.
5. The platform currently supports limited language translation.
6. Background noise can reduce the accuracy of Speech-to-Text conversion

IX. CONCLUSION

SAMVAADisanAI-powered multimodal accessibility platform developed to improve communication for individuals with hearing,speech,andvisual impairments. The system integrates Sign Language recognition, Speech-to-Text, Text-to-Speech, and Brailletranslationinto a single user-friendly platform. Using technologies such as Python, OpenCV, MediaPipe, and Flask,theprojectprovides real-time and accessible communication support.

Thedevelopedsystem promotes inclusivity, accessibility, and awareness by enabling interaction through text, speech, gestures,andBraille.SAMVAAD demonstrates how Artificial Intelligence can be effectively used for social good and assistivecommunication. Future improvements may include multilingual support, mobile application integration, and enhancedreal-timegesture recognition.

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