

# Lingua Hands: AI Sign Language Translator with Reverse Mode

**Dr. Waseema Masood**<sup>1</sup> Associate Professor, Department of Computer Science and Engineering Deccan College of Engineering and Technology, Aghapura, Hyderabad, 500001 Osmania University

**Sumaita Fatima**<sup>1</sup>, **Shaista Muzammil**<sup>2,2</sup>UG Scholar, Department of Computer Science and Engineering Deccan College of Engineering and Technology, Aghapura, Hyderabad, 500001 Osmania University

Accepted 24-04-2026

*Author(s) Retains the Copyrights of This Article*

## Abstract

*LinguaHands is an AI-powered sign language translator designed to bridge the communication gap between hearing-impaired individuals and the general public using multimodal inputs such as video and gesture recognition. The system integrates advanced technologies including MediaPipe for hand landmark detection, a deep learning model for gesture classification, and text-to-speech systems for generating human-like voice responses. Users can perform sign language gestures in front of a camera, and the system analyzes these gestures to deliver real-time, context-aware text and audio translations. The system also supports a reverse mode where spoken or typed text is converted into animated sign language output. Built with a simple and interactive interface, LinguaHands aims to improve accessibility and inclusivity for the hearing-impaired community, especially in public and educational environments. The system serves as an efficient, scalable solution for real-time sign language interpretation and awareness.*

## 1. INTRODUCTION:

Communication barriers between hearingimpaired individuals and the hearing community remain a major challenge in society. Existing digital solutions for sign language translation are mostly unimodal and fail to provide real-time, bidirectional communication support, limiting converts them into text and speech in real time. The system also integrates a reverse mode for converting spoken or typed text into sign language animations, communication. enabling two-way It serves as a lightweight and accessible solution their practical effectiveness. LinguaHands addresses this gap by providing a multimodal AI-powered sign language translator that captures hand gestures via camera and for real-time sign language interpretation, especially in resource-constrained and public environments.

## 2. LITERATURE SURVEY:

Existing research in AI-based sign language recognition highlights the growing use of computer vision and deep learning technologies for improving assistive communication. Studies on vision-based gesture recognition demonstrate that combining skeletal landmark detection with classification models can enhance translation accuracy, though challenges remain in real-time processing and diverse signing styles. Hand landmark detection frameworks such as MediaPipe have been widely adopted in sign language systems to extract precise finger and wrist positions. While effective, they face limitations in handling rapid gestures and variations in lighting conditions. Similarly, textto-speech systems like gTTS and neural voice models improve user interaction by generating human-like voice output, but often depend on stable internet

connectivity. User interface frameworks like Gradio and Streamlit enable rapid development of interactive AI applications by integrating multiple components such as video, text, and audio into a single platform. However, customization and scalability can be limited. Overall, current systems either lack bidirectional communication or fail to provide seamless, real-time interaction. LinguaHands builds upon these approaches by combining gesture recognition, natural language processing, and sign language animation into a unified and efficient translation system.

## 3. EXISTING SYSTEM:

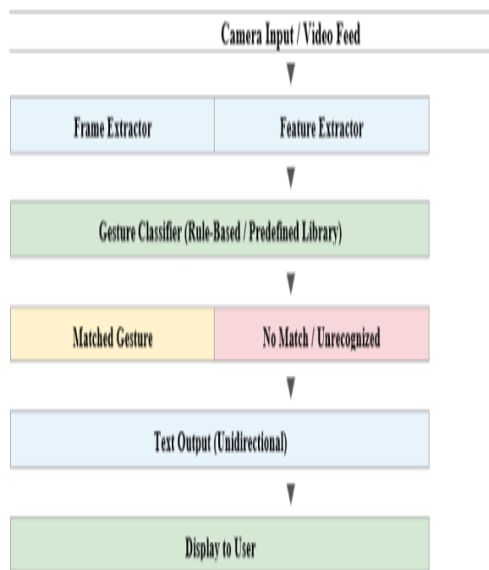
Current sign language translation systems are primarily unimodal and rely on predefined gesture libraries or basic machine learning models. These systems can handle simple, isolated gestures but struggle with continuous, real-world signing scenarios. Most existing solutions do not support bidirectional communication, meaning they cannot translate text or speech back into sign language animations. Additionally, many platforms depend on specialized hardware such as data gloves or depth sensors, limiting accessibility and raising deployment concerns. As a result, these systems provide limited accuracy, reduced user interaction, and are not fully effective for comprehensive and inclusive communication assistance.

## 4. LIMITATIONS:

Current sign language translation systems have several limitations that reduce their effectiveness. They are mostly unidirectional and cannot translate text or speech back into sign language, restricting real communication. Many systems rely on predefined gesture datasets, making them less

flexible and unable to understand continuous or context-dependent signing. They often lack accuracy when dealing with regional sign language variants or complex expressions. Dependence on specialized hardware increases costs and reduces accessibility for everyday users. Additionally, these systems may not provide real-time or context-aware responses, resulting in a less engaging and less reliable user experience.

**EXISTING SYSTEM ARCHITECTURE:**



**5. PROPOSED SYSTEM:**

The proposed system, LinguaHands, is a multimodal AI-powered sign language translator communication through an interactive platform. It allows users to perform sign language gestures designed to provide real-time bidirectional in front of a camera, enabling a more natural and real-world interaction for hearing-impaired individuals. The system integrates hand landmark detection, gesture classification, and natural language processing to understand user inputs and generate informative text and audio responses. It also includes a reverse mode that converts spoken or typed text into animated sign language output, enabling full two-way communication.

LinguaHands is designed to be lightweight, accessible, and easy to use, making it suitable for academic purposes, public institutions, and everyday communication support. It offers a more flexible and user-friendly solution compared to existing systems by combining multiple AI capabilities into a single unified platform.

**Advantages:**

1. Supports bidirectional communication by accepting both gesture input and text/speech input, making the system practical for real-world use

2. Generates human-like voice responses and animated sign language output using text-to-speech and avatar animation, improving accessibility and user experience

3. Lightweight and easy to deploy on standard systems without requiring specialized hardware such as data gloves or depth sensors

4. Cost-effective as it uses open-source tools and frameworks, reducing development and operational expenses

5. Modular architecture allows easy customization, maintenance, and future feature enhancements including multilingual sign language support

6. Provides faster, context-aware, and more interactive responses compared to traditional unimodal sign language translation systems

**6.IMPLEMENTATION:**



The implementation of LinguaHands is based on integrating multiple AI components into a single workflow. Users interact with the system through a simple interface where they can provide input via hand gestures captured by a webcam or upload pre-recorded videos. The video frames are processed using MediaPipe to extract hand landmark coordinates, which are then fed into a deep learning model for gesture classification. The classified gestures are mapped to their corresponding text labels and passed through a language model to generate contextually meaningful sentence outputs. These text responses are further converted into speech using text-to-speech technology to create a more interactive and accessible experience for users. The reverse mode accepts spoken or typed text input, which is processed through a natural language understanding module to identify the corresponding sign language gestures. These gestures are then rendered as animated avatar outputs, providing a complete bidirectional communication experience.

**System Integration & Local Hosting:**

The system is designed to run in a local hosting environment using tools such as XAMPP or a Python-based server. It operates on localhost, allowing developers to test and interact with the application through a web browser without requiring internet deployment. The platform can also be configured to run over a local area network (LAN), enabling access from multiple devices within the same network for testing or demonstration purposes. This allows seamless interaction across systems without external hosting. The system integrates all components, including gesture processing, animation rendering, and response generation, within a unified environment. Temporary data such as video frames and audio clips are handled locally to ensure privacy and efficient processing.

**8. CONCLUSION AND FUTURE SCOPE:**

LinguaHands demonstrates how multiple AI technologies can be integrated to create an intelligent and accessible sign language translation system. By combining hand landmark detection, gesture classification, and natural language processing, the system provides a more interactive and user-friendly approach to bridging the communication gap for hearingimpaired individuals. It addresses key limitations of existing systems by enabling bidirectional interaction and delivering context-aware responses in both text and animated sign language formats. In the future, the system can be enhanced by integrating support for regional and international sign language variants such as ISL, ASL, and BSL, adding real-time collaborative translation features, and developing a mobile application for on-the-go accessibility. Further improvements may include multilingual support, advanced security mechanisms, and an admin dashboard for managing user sessions and improving model accuracy through continuous retraining.

**9. REFERENCES**

1. S. Koller, O. Zargaran, H. Ney, and R. Bowden. "Deep Sign: Hybrid CNN-HMM for Continuous Sign Language Recognition." in Proc. BMVC, 2016, pp. 1–12.
2. C. Camgoz, S. Hadfield, O. Koller, and R. Bowden. "SubUNets: End-to-end Hand Continuous Shape Sign and Language Recognition." in Proc. ICCV, 2017, pp. 3075–3084.
3. Google MediaPipe Team. "MediaPipe: A framework for building perception pipelines." MediaPipe [Online]. Documentation, Available: <https://mediapipe.dev/> [Accessed: May 12, 2025].
4. ElevenLabs Inc. "Neural TTS with human-like voice synthesis." ElevenLabs Developer Portal, [Online]. Available:

5. A. Abid and D. Khan. "Gradio: Interactive interface for ML applications." Journal of Open Source Software, vol. 6, no. 64, pp. 2341, Jun. 2021.
6. O. Koller, J. Forster, and H. Ney. "Continuous recognition: sign language Towards large vocabulary statistical recognition systems handling multiple signers." Computer Vision and Image Understanding, vol. 141, pp. 108–125, 2015.
6. P. Molchanov, X. Yang, S. Gupta, K. Kim, S. Tyree, and J. Kautz. "Online detection and classification of dynamic hand gestures with recurrent 3D convolutional neural network." in Proc. CVPR, 2016, pp. 42074215.
7. H. Cooper, E. Ong, N. Pugeault, and R. Bowden. "Sign language recognition using sub-units." Journal of Machine Learning Research, vol. 13, pp. 2205–2231, 2012.
8. T. Brown, B. Mann, N. Ryder, et al. "Language models are few-shot learners." Advances in Neural Information Processing Systems, vol. 33, pp. 1877–1901, 2020.
9. J. Devlin, M. Chang, K. Lee, and K. Toutanova. "BERT: Pre-training of deep bidirectional transformers for language understanding." in Proc. NAACL-HLT, 2019, pp. 4171–4186.
10. Z. Zhang, P. Xie, and E. Xing. "BioBERT: A pre-trained biomedical language representation model." Bioinformatics, vol. 36, no. 4, pp. 1234–1240, 2020.
11. A. Radford, J. W. Kim, T. Xu, et al. "Robust speech recognition using Whisper Large V3." OpenAI Research Blog, vol. 8, pp. 1–11, Dec. 2022.
12. N. Neidle, C. Vogler, and A. Thangali. "New approaches to the development of sign language corpora." in Proc. LREC Workshop on the Representation and Processing of Sign Languages, 2014, pp. 5–12.