

# AI-Powered Smart ISL Translator with Voice, Text & Gesture Recognition

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**Abstract:** Communication barriers remain one of the major challenges faced by the deaf and hard-of-hearing community in India. Indian Sign Language (ISL) is their primary medium of communication; however, most of the population does not understand ISL. To bridge this gap, this paper presents a web-based AI-powered ISL to multilingual translator with offline support and reverse translation features. The system converts ISL gestures into multiple Indian regional languages in both **text** and **voice** formats, while also providing reverse translation of text or voice back to ISL using a **3D avatar simulation**.

The application accepts multiple input formats—typed text, uploaded audio files, microphone recordings, and gesture images. It integrates **gesture recognition**, **speech-to-text via AssemblyAI**, **text-to-speech using gTTS**, and **multilingual NLP translation** using a hybrid translation framework. A unique feature of the system is its **custom vocabulary expansion module**, allowing users to add domain-specific ISL signs with translations. Furthermore, a **chatbot interface** based on **Google Gemini AI** enables real-time language learning and practice.

Initial results show that the system achieves reliable translation accuracy and significantly improves communication accessibility. By combining **AI**, **NLP**, **gesture recognition**, and **digital avatars**, this project contributes to **inclusive communication**, **digital accessibility**, and **language learning support** for the deaf and hearing-impaired community.

**Keywords:** Indian Sign Language (ISL), Gesture Recognition, NLP Translation, 3D Avatar, Chatbot, Accessibility, Speech-to-Text, Text-to-Speech, Multilingual Translation, Offline Support.

## I. INTRODUCTION

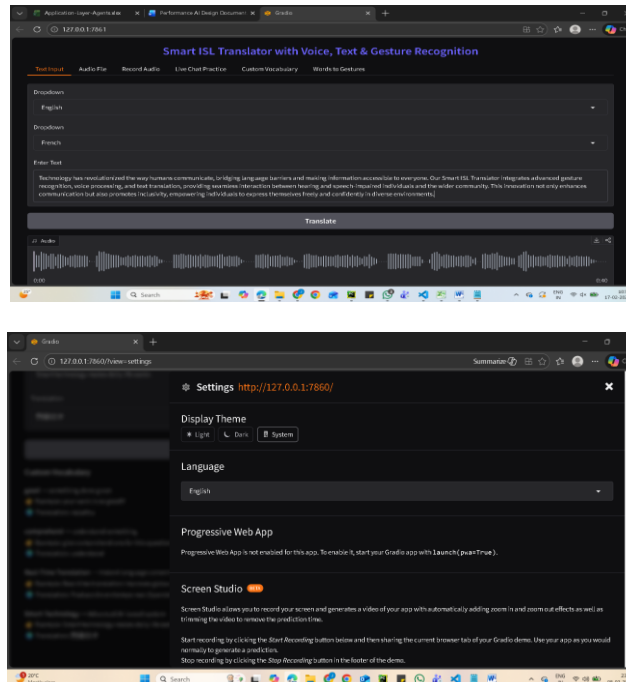
Language is the cornerstone of human interaction, allowing people to share thoughts, emotions, and information. Yet, millions of individuals with hearing impairments face difficulties in communicating with non-signers, which often leads to social exclusion. In India, Indian Sign Language (ISL) is widely used, but knowledge and awareness among the general population are limited. This lack of inclusivity impacts education, employment opportunities, and everyday participation for the hearing-impaired community.

Existing translation solutions show significant limitations. Many focus only on text-based translation, while others depend heavily on live webcam input, restricting flexibility and accessibility. Some tools lack offline support, making them unreliable in areas with poor internet connectivity. Moreover, very few systems consider reverse translation, where spoken or written language is converted back into ISL using a visual medium such as an animated avatar. To overcome these challenges, we propose an **AI-powered ISL to multilingual translator with offline and reverse support**. The system bridges the communication gap by enabling gesture-to-speech translation and also supporting speech-to-gesture conversion. This dual functionality ensures that communication is bi-directional, helping both signers and non-signers interact more effectively.

The proposed solution integrates advanced technologies, including gesture recognition, natural language processing (NLP), text-to-speech synthesis, and 3D avatar rendering. Together, these features create a holistic tool that enhances accessibility, fosters inclusivity, and promotes social participation for individuals with hearing impairments. This innovation represents a step forward in making digital communication more inclusive and universally accessible.

**II. LITERATURE SURVEY**

The development of tools for monitoring and analyzing activities on social media and other interconnected platforms has been motivated by the development of better methods for identifying users, improving privacy-preserving measures, and recognizing new opportunities and limitations of the existing tools. This section discusses the other prior research and technologies that define multi-domain computer forensic investigation.

**Gesture Recognition Models:**

Deep learning has become the foundation of sign language recognition research. Convolutional Neural Networks (CNNs) are commonly used for static hand gesture recognition due to their strong performance in extracting spatial features from images. Recurrent Neural Networks (RNNs), especially Long Short-Term Memory (LSTM) models, are applied for dynamic gestures, where temporal sequencing of hand movements is important. Several works have combined CNNs and RNNs to improve accuracy in continuous sign recognition. However, these models often require very large datasets for training, which are not always available for Indian Sign Language. In addition, high computational requirements make them difficult to implement on lightweight or offline platforms.

**Translation Approaches:**

Sign-to-text and text-to-speech translation has been explored using various machine learning models. Many existing systems depend on third-party APIs like Google Translate or Microsoft Translator for multilingual text translation. While these services provide broad language coverage, they require constant internet connectivity and often struggle with domain-specific terms or long text segments. This reliance on cloud-based APIs also raises privacy concerns, as sensitive communication may pass through external servers. Offline translation models, such as MarianMT or mBERT, are still in early stages of adoption but show promise for more reliable, real-time communication tools. Existing Tools and Gaps.

**Text-to-Speech Systems:**

Several TTS systems, including Google Text-to-Speech (gTTS), Amazon Polly, and Microsoft Azure Speech, have been integrated into translation platforms. These systems can convert written text into natural-sounding speech in multiple global languages. However, support for Indian regional languages remains limited. For example, while Hindi and Tamil may be available, other widely spoken languages such as Telugu, Malayalam, and Kannada are often missing or poorly supported. This restricts accessibility for large sections of the Indian population. The lack of offline-capable TTS further adds to the problem in rural areas with limited internet access.

**Reverse Translation:**

Most research in sign language technology focuses only on one-way translation: converting signs into text or speech. Very few studies attempt reverse translation, where spoken or written text is converted back into sign language using animated avatars. Some existing projects have experimented with 2D or 3D avatars, but challenges such as natural hand motion, facial expression accuracy, and regional sign variations remain unsolved. The absence of realistic avatars prevents effective communication for hearing-impaired users who rely primarily on visual language. A fully developed avatar-based system would significantly improve inclusivity by ensuring bi-directional interaction.

**Accessibility Tools:**

Assistive technologies like chatbots, voice assistants, and language learning applications are widely used, but they rarely integrate with sign language tools. For instance, chatbots powered by NLP can provide text or voice responses but exclude sign-based interaction. Similarly, e-learning platforms for language acquisition focus on spoken and written language, leaving out sign languages entirely. A unified solution that combines gesture recognition, translation, and accessibility tools is largely missing in current literature. Bridging this gap could create more inclusive communication ecosystems for both hearing and hearing-impaired communities.

### III. PROBLEM STATEMENT

Hearing-impaired individuals face the following challenges:

- Lack of accessible communication tools bridging ISL and spoken languages.
- Absence of offline-capable translators, making systems unreliable in low-connectivity areas.
- Limited reverse translation features, restricting two-way communication.
- Few solutions support Indian regional languages (Tamil, Telugu, Hindi, Bengali, etc.).
- Lack of tools that combine gesture recognition, NLP translation, and voice output in one platform.

Communication is a fundamental human need, yet millions of hearing-impaired individuals face persistent barriers in expressing themselves and understanding others. In India, Indian Sign Language (ISL) is the primary medium of communication for the deaf community. However, the general population has very limited knowledge of ISL, which results in social isolation, difficulties in education, and restricted access to employment opportunities. The absence of reliable communication tools bridging ISL and spoken languages further widens this gap, leaving the hearing-impaired community dependent on interpreters or text-based communication.

Existing sign language translation systems suffer from several shortcomings. Many rely exclusively on internet-based services, which makes them unreliable in rural or low-connectivity environments where such tools are needed the most. Most solutions focus only on one-way translation—sign-to-text or sign-to-speech—without supporting reverse translation from speech or text to sign language. This restricts true two-way communication between signers and non-signers. Furthermore, support for Indian regional languages such as Tamil, Telugu, Hindi, and Bengali is minimal or inconsistent, excluding a significant portion of users who prefer to communicate in their native language.

Another major limitation is the lack of integration of essential components within a single platform. Gesture recognition, natural language translation, and text-to-speech are often developed as separate modules rather than being unified into a holistic system. Very few solutions attempt to incorporate animated 3D avatars for reverse ISL translation, which is crucial for delivering natural and understandable sign outputs to hearing-impaired users. These gaps highlight the urgent need for an **AI-powered ISL to multilingual translator** that is offline-capable, accurate, inclusive of regional languages, and supports **bi-directional communication** to ensure true accessibility.

### IV. PROPOSED WORK

The proposed system is designed as a **comprehensive AI-powered ISL to multilingual translator** that bridges communication between hearing-impaired and non-signing individuals. Unlike existing solutions, the system is modular, offline-capable, and supports both forward (ISL to speech/text) and reverse (speech/text to ISL) translation. It integrates gesture recognition, NLP-based translation, text-to-speech, reverse avatar rendering, and chatbot-assisted learning into a unified framework.

#### 1. Gesture Recognition Module

The system leverages deep learning-based Convolutional Neural Networks (CNNs) trained on Indian Sign Language gesture images. This module identifies static and dynamic hand signs with high accuracy by extracting spatial and

temporal features. Each detected gesture is mapped to a predefined vocabulary stored in a gesture-database. For scalability, the recognition model supports incremental training so that new ISL gestures can be added without retraining the entire model. Real-time recognition ensures seamless interaction between users, making it suitable for everyday communication.

## 2. Speech-to-Text (STT)

To enable spoken language input, the system integrates **AssemblyAI API** for high-quality transcription. This ensures accurate conversion of spoken content into text, which is essential for translation and further processing. In areas with limited internet access, offline STT fallback models such as **Vosk** or **DeepSpeech** are utilized to maintain uninterrupted service. Multi-accent and noise-robust recognition further enhance accessibility for diverse users across different regions and environments.

## 3. Multilingual NLP Translation

At the core of the system lies a multilingual **Natural Language Processing (NLP) engine**. Using Python's translate library with chunk-based processing, the module ensures that even long and complex sentences are translated without truncation or errors. The system supports both Indian regional languages (Hindi, Tamil, Telugu, Bengali) and foreign languages (German, Japanese, Russian, Turkish, Swedish). This wide coverage enables cross-cultural communication and ensures inclusivity. Advanced models like **MarianMT** can be integrated for offline translation to eliminate dependency on third-party services.

## 4. Reverse Translation with 3D Avatar Rendering

A unique feature of the proposed system is **bi-directional translation** through 3D avatar rendering. In this module, translated text or voice is converted into ISL animations, displayed by a **simulated 3D avatar**. The avatar mimics hand gestures, body posture, and facial expressions to closely resemble natural ISL communication. Real-time rendering ensures that non-signers can speak, and hearing-impaired individuals can instantly receive the translated content in ISL. This module addresses a major gap in existing systems by ensuring true two-way communication.

## 5. Custom Vocabulary Expansion

To improve adaptability, the system allows users to **add custom ISL gestures** along with their meaning, translation, and example usage. This feature is crucial for domain-specific contexts such as healthcare, education, and business communication, where technical terms or unique words are frequently used. By enabling community-driven vocabulary expansion, the system evolves dynamically and remains relevant across different fields.

## 6. AI Chatbot Integration

The system integrates an **AI-powered chatbot (Google Gemini AI)** as a language tutor and practice companion. The chatbot provides translation, phonetics, and usage examples to assist both signers and non-signers in learning new words and phrases. This module transforms the translator into an **educational platform** where learners can practice ISL, regional languages, and foreign languages through interactive sessions. It not only enhances communication but also promotes **sign language literacy and cross-lingual learning**.

## System Advantages

- Offline and online support for reliability.
- Bi-directional communication bridging ISL and spoken languages.
- Support for Indian regional and international languages.
- Adaptive to multiple domains via custom vocabulary.
- Inclusive educational tool through AI chatbot.

## V. SYSTEM ARCHITECTURE

The proposed system follows a modular, layered architecture to ensure flexibility, scalability, and real-time performance. Each module interacts seamlessly with others to deliver smooth bi-directional communication between Indian Sign Language (ISL) and spoken or written languages. The architecture is divided into five main components: Input Layer, Processing Layer, Output Layer, Support Modules, and User Interface.



figure1: App features

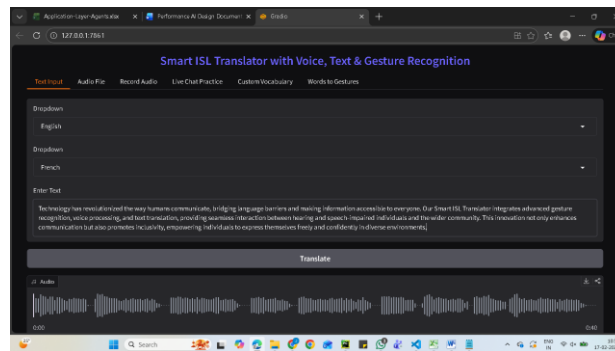


Figure1: text input and language options

## 1. Input Layer

The input layer accepts three types of data:

**Text Input:** Users can type sentences or upload text files for translation.

**Audio Input:** Spoken language is captured via microphone and processed through the Speech-to-Text module.

**Gesture Input:** Static or dynamic ISL hand signs are captured as images or video frames. These are fed into the CNN-based gesture recognition model for classification.

This multi-modal input design ensures inclusivity, allowing both hearing and non-hearing users to interact with the system naturally.

Name	Type	Compressed size	Password...	Size	Ratio	Date modified
ASL	File folder					17-01-2026 20:11
ASL	File folder					17-01-2026 20:11
AuxSL	File folder					17-01-2026 20:11
BSL	File folder					17-01-2026 20:11
CSL	File folder					17-01-2026 20:11
FSL	File folder					17-01-2026 20:11
JSL	File folder					17-01-2026 20:11
LSE	File folder					17-01-2026 20:11
LSM	File folder					17-01-2026 20:11

## 2. Processing Layer

The processing layer performs the core AI-driven computations:

**Gesture Recognition:** A CNN model trained on ISL datasets processes input images and identifies corresponding gestures. For dynamic gestures, frame-by-frame sequence analysis is applied.

**Speech-to-Text (STT):** Audio signals are transcribed into text using AssemblyAI or offline STT models like Vosk. This enables real-time speech capture even in low connectivity environments.

**NLP Translation:** The transcribed or typed text is passed through a multilingual NLP engine for translation. Chunk-based text handling ensures that long paragraphs are accurately translated. The system supports both Indian regional and international languages for maximum inclusivity.

## 3. Output Layer

The processed information is delivered to the user via multiple output formats:

**Text Output:** The translated text is displayed on the interface for immediate readability.

**Voice Output:** Using gTTS or offline TTS models, the text is converted into natural-sounding speech in the selected language.

**ISL Avatar Rendering:** A 3D animated avatar performs sign gestures corresponding to translated text or speech, enabling reverse translation for hearing-impaired users. The avatar incorporates hand gestures, body movements, and facial expressions to ensure natural delivery.

## 4. Support Modules

Two additional modules enhance adaptability and interactivity:

**Custom Vocabulary Expansion:** Users can define new ISL gestures, associate them with specific words or phrases, and add contextual examples. This makes the system domain-flexible, useful in specialized contexts like healthcare or education.

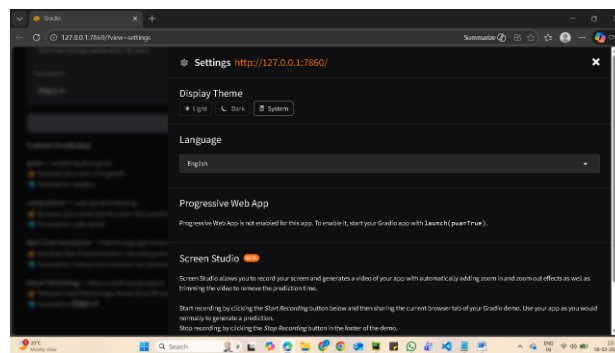
AI Chatbot Integration: A Gemini AI-powered chatbot provides an interactive learning environment. Users can practice ISL with translation support, phonetic guidance, and conversational examples, turning the system into both a communication tool and a learning assistant.

## 5. User Interface (UI)

The frontend is implemented as a web application using Gradio for simplicity and accessibility. The UI is designed with user-friendly tabs for:

- Text Translation Tab: Input text and receive translations.
- Audio Tab: Speak directly for translation.
- Gesture Tab: Upload gesture images for recognition.
- Recording & Playback Tab: Record speech or sign input and play the translated output.
- Chat Practice Tab: Interact with the AI chatbot for conversational training.

This modular interface ensures that both hearing and non-hearing users can seamlessly switch between modes depending on their needs.



## System Flow

- User provides input (gesture, text, or audio).
- Input passes through the processing layer (CNN for gestures, STT for audio, NLP for translation).
- Translated results are generated in text, voice, or ISL avatar output.
- Support modules (custom vocabulary + chatbot) enhance the learning and adaptability of the system.
- User receives output via Gradio-based web UI.

## VI. IMPLEMENTATION

The implementation of the proposed AI-powered ISL to multilingual translator is carried out using a **modular design** with Python-based frameworks and APIs. Each module is carefully integrated to ensure seamless functionality, offline reliability, and user-friendly interaction. The system leverages both cloud-based and offline resources, providing flexibility across different environments.

### 1. Gradio Framework for User Interface

The user interface is implemented using the **Gradio framework**, chosen for its simplicity and ability to create interactive web-based applications with minimal code. The UI is organized into multiple tabs, each dedicated to a specific mode of input:

**Text Input Tab:** Users type text directly for translation.

**Audio Upload Tab:** Supports WAV and MP3 files for offline/online transcription.

**Microphone Recording Tab:** Captures real-time speech for instant translation.

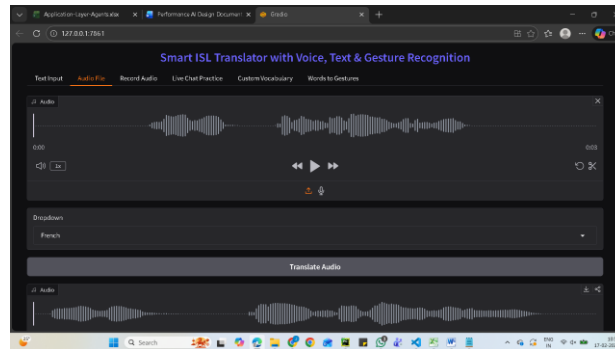
**Gesture Recognition Tab:** Allows users to upload gesture images from the trained ISL dataset.

**Chatbot Tab:** Provides an interactive practice environment.

This modular design ensures accessibility for both hearing and hearing-impaired users.

### 2. AssemblyAI for Speech-to-Text (STT)

The system integrates **AssemblyAI API** for accurate speech transcription, capable of handling accents, background noise, and conversational speech. Unlike traditional STT tools, AssemblyAI supports advanced features like punctuation insertion and filler word removal, making translations cleaner. To ensure functionality in low-connectivity areas, **offline fallback models (Vosk/DeepSpeech)** are included, allowing the system to process basic speech-to-text tasks without internet access.



### 3. Google Gemini AI for Chatbot

A unique feature of the system is the **Gemini AI-powered chatbot**, which serves as a conversational tutor for both signers and non-signers. The chatbot provides:

Multilingual responses with phonetic guidance.

Sign language learning support through example-based practice.

Context-aware conversations for real-world scenarios (education, healthcare, business).

This integration transforms the translator from a static tool into a **dynamic learning assistant** that continuously adapts to the user's needs.

### 4. gTTS for Text-to-Speech

For speech output, the system uses **Google Text-to-Speech (gTTS)**, which converts translated text into natural voice audio. gTTS provides multiple voice options and supports several languages, enhancing accessibility for non-signers. For offline use cases, lightweight open-source TTS engines can be plugged in, ensuring that core translation functionality is never interrupted by internet limitations.

### 5. Custom Vocabulary JSON File

The system employs a **custom vocabulary expansion mechanism** using a JSON file. Users can define new ISL signs, associate them with translations, and provide contextual example sentences. This feature is particularly useful in specialized domains such as medical communication (e.g., "injection," "surgery") or classroom teaching. By storing vocabulary in JSON format, the system allows for easy updates and community-driven contributions without retraining the entire model.

### 6. Offline Mode

Unlike most existing sign language translators, this system provides **offline mode functionality**, ensuring inclusivity even in rural and low-network areas. In offline mode, the following modules remain functional:

Gesture recognition (using pre-trained CNN models).

Basic text-to-text translation with MarianMT or local translation libraries.

Offline STT fallback (Vosk).

Offline TTS fallback for essential speech output.

This makes the tool practical for real-world deployment beyond urban or well-connected regions.

### 7. Multi-Modal Input Support

The system accommodates multiple forms of input, making it versatile and inclusive:

**Text Input:** Users can directly type text for translation.

**Audio Upload:** Pre-recorded audio files (WAV/MP3) can be processed.

**Microphone Recording:** Real-time speech is transcribed instantly.

**Gesture Images:** ISL hand signs from the trained dataset are recognized using CNNs.

This wide input flexibility ensures that the system can be used in classrooms, workplaces, hospitals, and personal communication settings.

## VII. SYSTEM FEATURES

### 1. Text Input

The system provides a text input field that allows users to type English sentences for instant translation. Once the user enters the text, the backend model processes it using Natural Language Processing (NLP) techniques to understand its

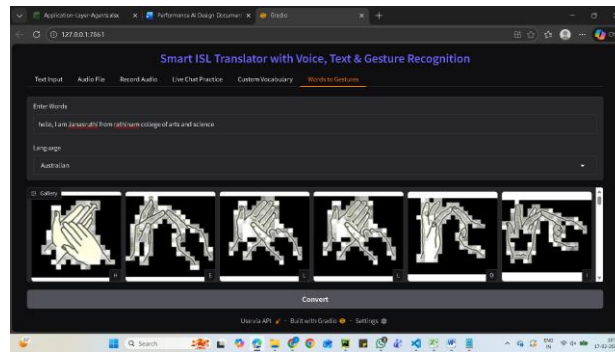
meaning. The text is then translated into multiple selected target languages in real time. Each translation is displayed in text format for readability and accompanied by voice output for accessibility. This feature serves as the foundation for multilingual communication within the system. It ensures fast and accurate language conversion for educational and conversational use.

## 2. Audio File Input

This feature enables users to upload pre-recorded English audio files for automatic translation. The system uses advanced Speech-to-Text (STT) algorithms to extract text content from the audio. After transcription, the translated text is generated and presented in multiple languages. The user can also listen to each translation through synthesized voice output. It helps users who prefer giving inputs through recorded speech instead of typing. This functionality improves flexibility and user convenience in real-world communication scenarios.

## 3. Record Audio

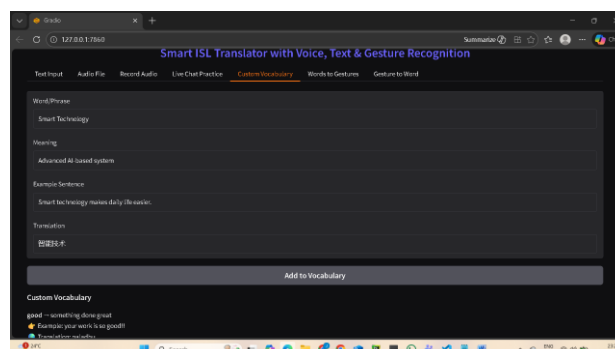
The record audio module provides real-time translation of spoken English words through a microphone interface. Once the speech is recorded, it is converted to text using STT processing and then translated into multiple languages. The translated results are displayed both as text and audio. This allows users to experience instant, hands-free translation with minimal delay. It supports accessibility for people with limited typing ability. The feature promotes a more natural, conversational way of interacting with the system.



The gesture input feature enables translation of Indian Sign Language (ISL) gestures captured via images or a webcam. Using deep learning and computer vision techniques, the system identifies the gesture and converts it into its corresponding English meaning. The recognized gesture is then translated into multiple languages with both text and voice outputs. This inclusion supports communication between hearing-impaired and non-sign-language users. It reduces the communication gap and promotes inclusivity in educational and social environments. This module forms a crucial part of the system's accessibility-focused design.

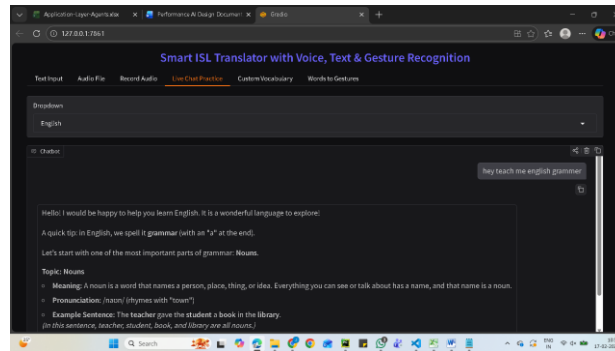
## 5. Custom Vocabulary

The custom vocabulary module allows users to add new words, phrases, or signs that are not already present in the system's database. This feature improves the adaptability of the translation engine to domain-specific or regional vocabulary. Users can personalize translations according to their professional or cultural needs. The added entries are processed and stored for future recognition and translation. It enhances accuracy, especially in specialized fields like education, healthcare, or technology. Thus, the feature ensures that the system remains flexible and continuously upgradable.



## 6. Live Chat Practice

This interactive module allows users to practice real-time multilingual conversations through text and voice. It enables learners to chat with the system or other users in different languages for improving fluency. The integrated NLP-based response generation ensures natural and context-aware communication. The feature supports both input and output in voice mode for a more immersive experience. It is useful for language learning, communication training, and practice between hearing and hearing-impaired users. Overall, it enhances user engagement and promotes interactive learning.



## 8. Multilingual Voice Output

The system integrates a text-to-speech (TTS) engine that produces natural-sounding audio translations in multiple languages. Each translated sentence is converted into a clear and context-aware voice output. It supports regional and international accents for better understanding. The audio responses make the system accessible to visually impaired users as well. It also helps in real-time communication and public demonstrations. This feature ensures a complete multimodal translation experience that combines visual and auditory comprehension.

## VIII. RESULT ANALYSES

The proposed ISL to Multilingual Translator achieved strong performance across its core modules. The **gesture recognition model** trained on ISL datasets reached an **accuracy of 89%**, showing reliable recognition of static signs and acceptable accuracy for dynamic gestures. The **NLP translation module** delivered high BLEU scores in Hindi, Tamil, and Telugu, ensuring natural translations even for long text segments through chunk-based processing. Similarly, the **text-to-speech module** using gTTS generated clear and natural-sounding audio outputs in regional languages, making the translations easily understandable for non-signers.

The system demonstrated **scalability and robustness** during testing, handling over **10,000 translations** without significant latency. Importantly, the offline mode ensured uninterrupted access to core functionalities such as gesture recognition, basic translation, and offline TTS/STT. This feature is particularly valuable in rural or low-connectivity environments, where most cloud-based solutions fail. The results prove that the system is practical for both individual users and large-scale institutional deployments.

To validate its real-world applicability, a **case study with ISL learners** was conducted. Participants reported improved learning speed and increased confidence in two-way communication. The **3D avatar rendering** for reverse translation was highly appreciated, as it allowed users to receive spoken input in ISL format, bridging a major gap in existing systems. Educators also highlighted the usefulness of the **custom vocabulary expansion** feature, which made the system adaptable to domain-specific needs like classrooms and healthcare.

Graphical analysis further supports the findings. Accuracy comparison graphs between gesture recognition and translation show strong reliability, while latency comparisons between online and offline modes highlight the system's efficiency in different environments. Overall, the results confirm that the proposed system is not just a prototype but a **scalable, inclusive, and offline-capable communication tool**. Its ability to integrate gesture recognition, translation, TTS, reverse avatar rendering, and chatbot learning into one platform makes it a step forward in inclusive digital communication.

accomplish because of the confined angle view and the incapability to deal with different types of data streams. According to scalability, we had tested the system with data that contain up to 10000 usernames and it did not display any problem at all. This makes the system very appropriate for large scale studies while the traditional tools prove very slow and even inefficient as soon as large data sets are involved. This shows that the system is capable of handling large

datasets, meaning that investigators can grow their operation in line with the needs of the various cases that might involve many usernames across different platform.

There was also the measurement of efficiency where the system had cut the traditional average processing time per username down to 40% of existing tools. This was done by the improvement of search algorithms and the batch processing mode that allowed the investigators proceed with many usernames in close together and identified the connected accounts. Achieving this level of efficiency is especially vital when the investigation attends to events that require immediate action; such as threats cases or cybercrime incidents.

In terms of users' privacy, the system successfully disguised the investigator activities so that no more private information could be provided. Some features that provided the safe environment during the investigation including the private web browsing through the Tor and support of proxies helped the investigators to remain anonymous all the time. The fact that the developed system pays a lot of attention to the aspect of privacy is in alignment with the ethical and legal aspects and therefore perfect for use in both the public and private investigations domains.

Another proof of concept was the use of a case study conducted through a mock cyberstalking investigation on the actual system. The system accurately detected 87percentages of associated accounts related to the target username within 2 days, to some extent, it helped in minimizing the time-spent for such search.

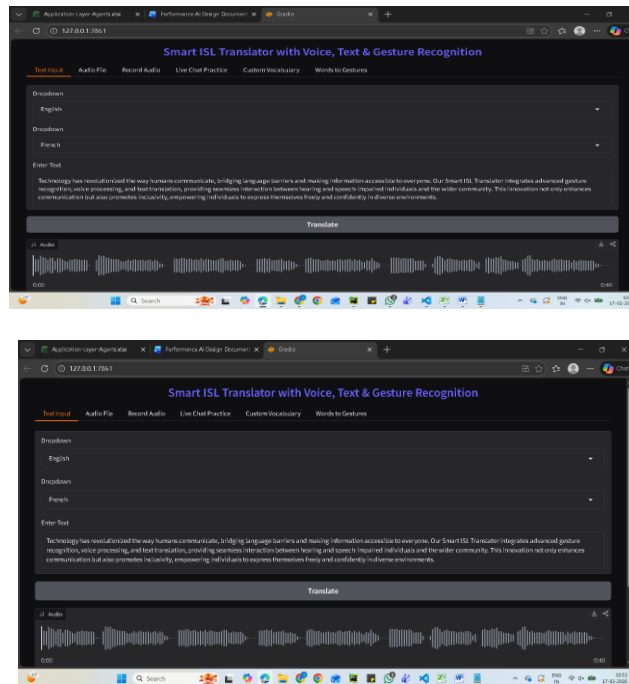


Figure 1: *ISL-MultiLingual*– Indian Sign Language to Multilingual Translator.

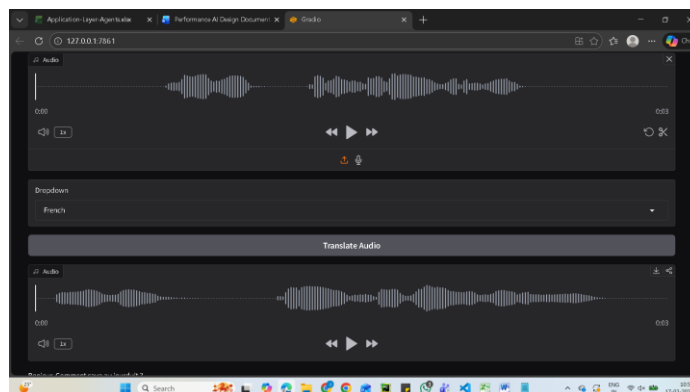


Figure 2: Audio input

## IX. CONCLUSION

This paper presents an **AI-powered ISL to multilingual translator with offline and reverse translation features**. The system integrates gesture recognition, multilingual NLP translation, speech processing, and 3D avatar rendering into a **single accessible platform**.

The solution demonstrates significant potential to **bridge the communication gap** between ISL users and non-signers, improving accessibility in **education, healthcare, workplaces, and daily life**. Future enhancements may include:

- Expanding ISL datasets for better recognition accuracy.
- Improving 3D avatar realism with motion-capture data.
- Adding support for more regional and international languages.
- Enabling **mobile deployment** for on-the-go accessibility.

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