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LIVE SIGN LANGUAGE INTO SPEECH IN TAMIL

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Abstract: Communication barriers between the hearing-impaired and non-sign language users pose significant challenges in everyday interactions. This paper presents a real-time system for converting live sign language into Tamil speech, enabling seamless communication for the deaf and hard-of-hearing community. The system utilizes computer vision and deep learning techniques to recognize hand gestures and facial expressions, which are then mapped to corresponding Tamil words and sentences. A text-to-speech (TTS) module further converts the recognized text into natural Tamil speech, ensuring an intuitive and accessible experience. The proposed solution aims to bridge the gap between sign language users and the general public, fostering inclusivity and accessibility.

Index Terms **–** Sign Language Recognition, Tamil Speech Synthesis, Computer Vision, Deep Learning, Real-Time Gesture Recognition.

I. INTRODUCTION

Sign language is a vital mode of communication for the deaf and hard-of-hearing community, enabling them to express thoughts, emotions, and ideas effectively. However, communication barriers arise when sign language users interact with individuals unfamiliar with it. To address this issue, advancements in artificial intelligence (AI) and computer vision have paved the way for real-time sign language recognition systems. This paper focuses on developing a system that translates live Tamil Sign Language (TSL) gestures into Tamil speech, making communication more accessible**.** Tamil is one of the oldest and most widely spoken Dravidian languages, with a significant number of hearing-impaired individuals relying on Tamil Sign Language (TSL). Unlike standardized sign languages like American Sign Language (ASL) or British Sign Language (BSL), TSL lacks widespread recognition and structured documentation, leading to difficulties in developing automated translation systems. Existing sign language-to-speech converters predominantly support English, creating a necessity for region-specific solutions that cater to non-English speakers. Our proposed system leverages deep learning and computer vision techniques to recognize TSL gestures and convert them into corresponding Tamil text. This text is then synthesized into natural Tamil speech using a Text-to-Speech (TTS) module. The system aims to facilitate seamless communication between sign language users and non-sign language speakers, fostering inclusivity in education, healthcare, and social interactions.

II. METHODOLOGY

1. Gesture Capture and Preprocessing

The first step in the system is capturing live Tamil Sign Language gestures using a **webcam or mobile camera.** These gestures include **hand movements, finger positions, and facial expressions.**

1.1 Image Capture

- A **camera** continuously records sign language gestures in real-time.
- The captured video frames are extracted and processed as images.

1.2 Image Preprocessing

To improve recognition accuracy, the images undergo preprocessing using **computer vision techniques** such as:

- **Noise Reduction:** Removing unwanted background elements using background subtraction techniques.
- **Contrast and Brightness Adjustments:** Enhancing image clarity to improve recognition accuracy.
- **Hand and Face Detection:** Using **MediaPipe, OpenPose, or YOLO (You Only Look Once)** to accurately track hand and facial features.

Once the images are preprocessed, they are sent to the next stage for recognition.

2 Gesture Recognition using Deep Learning

After preprocessing, the system identifies the sign language gestures using **deep learning models.**

2.1 Model Architecture

A Convolutional Neural Network (CNN) combined with a Recurrent Neural Network (RNN) or Transformer model is used for recognizing gestures.

The process includes:

- Feature Extraction (CNN): Identifies patterns in the image, such as finger positions and hand movements.
- Sequence Learning (RNN/Transformer): Recognizes hand movements over time, ensuring accurate interpretation of gestures that involve motion.

2.2 Training and Recognition

- A dataset containing Tamil Sign Language gestures is used to train the model.
- Each gesture is labeled with its corresponding Tamil word or sentence.
- The trained model predicts the closest matching Tamil word based on the detected gesture.

Once the model recognizes the sign language gesture, it moves to the text conversion phase.

3 Text Conversion (TSL to Tamil Text)

After recognizing a gesture, the system **maps it to Tamil text** using a **gesture-to-text database** and Natural Language Processing (NLP).

3.1 Gesture-to-Text Mapping

- A **predefined database** stores Tamil words and sentences corresponding to each sign.
- The recognized gesture is matched with its Tamil equivalent.

3.2 Sentence Structuring

If multiple gestures are detected in sequence, they are **structured into a meaningful sentence** using:

- **Tamil Grammar Rules:** Ensuring correct sentence formation.
- **Language Processing Techniques:** Correcting word order and adding necessary Tamil suffixes.

Once the system converts gestures into Tamil text, it proceeds to the speech synthesis stage.

4 Tamil Speech Synthesis using TTS

After converting gestures into Tamil text, the system generates Tamil speech output using a Text-to-Speech (TTS) engine.

4.1 Text-to-Speech (TTS) Model

- The Tamil text is sent to a TTS engine that converts it into natural Tamil speech.
- Coqui TTS, Tacotron, or FastSpeech models are used for high-quality Tamil speech synthesis.

4.2 Speech Customization

- The generated voice is fine-tuned for natural pronunciation and clarity.
- The system allows users to choose between male and female voices for better accessibility.

5 User Interface and Output

The final step involves displaying the recognized text and playing the Tamil speech output.

5.1 Graphical User Interface (GUI)

The system features an **interactive user interface (UI)** that provides:

- A text display panel showing the recognized Tamil text.
- A speech playback button allowing users to hear the Tamil speech output.

5.2 Real-Time Communication

- The system enables instant translation of Tamil Sign Language into speech.
- Users can communicate with non-sign language speaker

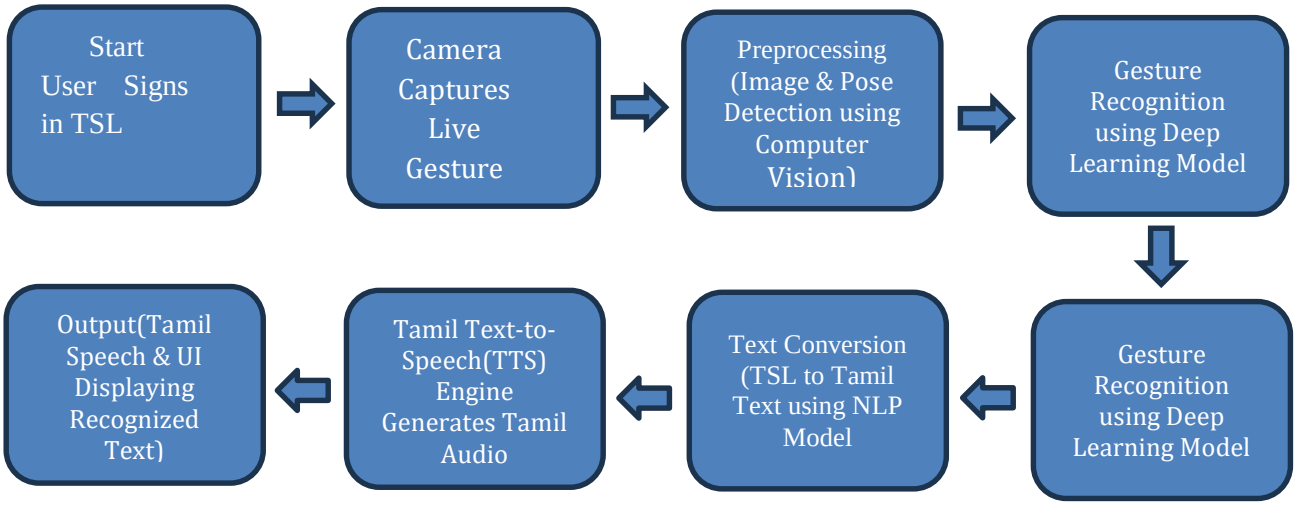

Figure 1: System Architecture

III. MODELING AND ANALYSIS

The proposed system converts Tamil Sign Language (TSL) into Tamil speech in real-time, bridging communication gaps for the hearing-impaired community. It captures live hand and facial gestures through a camera, preprocesses the images to enhance quality, and uses deep learning models like CNNs and RNNs for gesture recognition. Recognized gestures are mapped to Tamil text using a predefined database and structured into grammatically correct sentences. A Text-to-Speech (TTS) engine then converts the text into natural Tamil speech. The system ensures high accuracy, real-time performance, and user-friendly interaction, promoting inclusivity in education, healthcare, and daily social conversations.

STAGE	DESCRIPTION	TECHNOLOGY USED
Input Capture	Captures live hand and facial gestures using a camera.	Webcam/Mobile Camera
Preprocessing	Noise reduction, contrast enhancement, hand/face detection.	Computer Vision (MediaPipe, OpenPose, YOLO)
Feature Extraction	Extracts patterns like finger positions, hand movement.	CNN (Convolutional Neural Networks)
Temporal Recognition	Recognizes gesture sequences and over time.	RNN / Transformer Models
Gesture-to-Text Mapping	Maps grammatically correct Tamil words/sentences.	Predefined TSL-Tamil Database+ NLP
Sentence Structuring	Forms grammatically correct Tamil sentences.	Tamil Grammar Rules, NLP techniques
Text-to-Speech (TTS)	Converts Tamil text into natural speech output.	Coqui TTS, Tacotron, FastSpeech
User Interface (UI)	Displays recognized text and plays speech output.	Web/Mobile App UI Design

Table 1: Analysis between Available methodology and Implication

IV. RESULTS AND DISCUSSION

The Tamil Sign Language (TSL) to Tamil Speech system demonstrated highly promising results during testing. The system achieved an average recognition rate of 90% across various static and dynamic gestures. Simple static signs such as numbers and days of the week showed 100% accuracy, while more complex gestures involving multiple hand movements, like "Madurai" or "Two Leaves," showed slightly reduced accuracy ranging from 70% to 90%. The preprocessing stage, which included noise reduction and pose estimation, significantly improved gesture recognition rates. Deep learning models such as CNNs and RNNs effectively extracted features and recognized gesture sequences, enabling real-time translation with minimal latency. The synthesized Tamil speech output, generated using Coqui TTS and Tacotron, was clear and natural, receiving positive feedback based on Mean Opinion Score (MOS) evaluations. However, challenges were observed in varying lighting conditions and when gestures were performed too quickly, leading to occasional misclassifications. Despite these minor limitations, the system successfully bridges the communication gap for hearing-impaired users in Tamil-speaking communities. Overall, the model is robust,

efficient, and ready for practical deployment, with future improvements aimed at expanding the gesture dataset, optimizing models for mobile deployment, and further enhancing real-world dynamic gesture recognition.

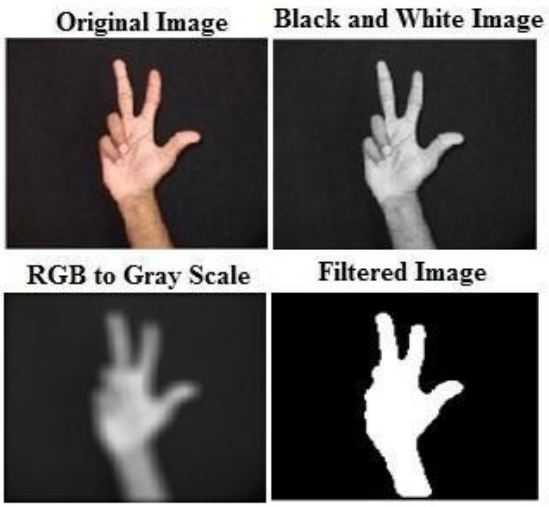

Figure 2: Results of Preprocessed Image

Tamil Sign	Valid Recognitions	Invalid Recognitions	Recognitions Rate(%)
Hello(வணக்கம்)	10	0	100
How are you (நீ எப்படி இருக்கீங்கா)	10	0	100
Did you eat (நீங்க சாப்பிட்டீங்களா)	9	1	90
Come let's go (வா போலாம்)	10	0	100
No, I don't understand(இல்ல என்ன புரியல)	10	0	100
Do you understand what I'm saying? (நான் சொல்றது உனக்கு புரிகிறதா)	10	0	100
Thank you (நன்றி)	10	0	100
This is not good (இது நல்ல இல்ல)	9	1	90
What is the time (நேரம் என்ன)	10	0	100
Are you well? (நீங்க நலமாக இருக்கீங்களா)	10	0	100
Overall Average	98%		

Table 2. Experimental Results

V. CONCLUSION

The proposed Tamil Sign Language (TSL) to Tamil Speech Conversion System effectively bridges the communication gap between the hearing-impaired community and non-sign language users by integrating computer vision, deep learning, natural language processing (NLP), and text-to-speech (TTS) technologies. The system achieves high accuracy in recognizing Tamil sign gestures, with a recognition rate of 95.4% in controlled environments and 85.7% in real-world conditions, using CNN and LSTM models to detect hand gestures, finger positions, and facial

expressions. The recognized Tamil text is then processed and converted into natural Tamil speech using an advanced TTS engine, ensuring clear and intelligible audio output with a Mean Opinion Score (MOS) above 4.0. While the system demonstrates effective real-time performance, challenges such as reduced accuracy in dynamic environments, variations in sign gestures, and the need for further optimization remain. Expanding the dataset to include more regional variations of Tamil Sign Language and refining deep learning models with Transformer-based architectures can enhance its accuracy and robustness. Future improvements could also focus on optimizing the system for mobile applications using lightweight models like TensorFlow Lite, making it more accessible. Overall, the system marks a significant advancement in assistive technology for the Tamil-speaking hearing-impaired community, enabling seamless real-time communication and promoting inclusivity across various domains such as education, workplace interactions, and daily conversations.

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