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Real Time Sign Language Translator Using Machine Learning

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Abstract: In today's interconnected world, effective communication is fundamental. For the deaf and mute community, communicating with those who don't understand sign language is challenging. To bridge this gap, we propose a web app translating sign language into spoken or written language and vice versa. Users capture gestures with a camera, and our system, powered by TensorFlow and advanced image processing, converts them into coherent text. Supporting various sign languages and spoken languages, it enables real-time two-way communication. This innovative solution fosters inclusivity by empowering meaningful interactions between the deaf and mute community and the general population, promoting understanding and integration through real-time communication and education initiatives.

Keywords: Inclusive communication, AI-driven, sign language translation, web application, deaf and mute community.

1. INTRODUCTION

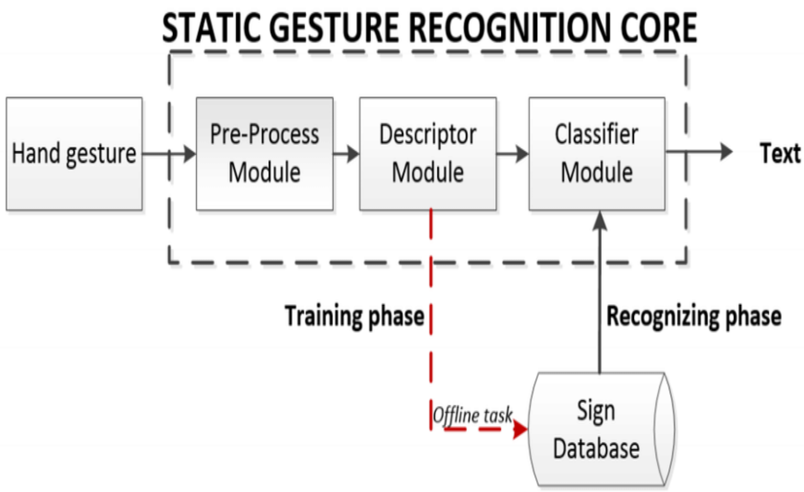
In today's interconnected world, effective communication serves as the cornerstone of human interaction, enabling individuals to exchange information swiftly and accurately. However, for the deaf and mute community, communicating with those unfamiliar with sign language poses a significant challenge. Sign language, a sophisticated system comprising gestures, body movements, and facial expressions, serves as the primary mode of communication for this community. Yet, its complexity often hinders understanding among those not proficient in it. To bridge this communication gap and foster inclusivity, we propose the development of a groundbreaking web application. This application's core concept revolves around seamlessly translating sign language into spoken or written language and vice versa, thereby enabling a two-way communication system that is accessible and inclusive for all. The web application facilitates meaningful conversations between the deaf and mute community and individuals who can hear and speak. Users can capture sign language gestures word by word using a camera or device.

Upon capture, the application leverages advanced technologies such as TensorFlow and other image processing libraries to analyze and translate these gestures into coherent sentences or phrases. The output is presented in text format, making it accessible to a wide range of users. Moreover, the system is designed to accommodate various sign languages, including Indian Sign Language, American Sign Language, and more, and can seamlessly translate them into different spoken languages such as English and Hindi. This versatility ensures that users from diverse linguistic backgrounds can benefit from the application's functionalities. One of the system's remarkable features is its ability to translate text into sign language format, thus completing the two-way communication loop. This versatile functionality enables effective interaction between those who can hear and speak and the deaf and mute community, as messages typed by users are rendered into sign language. In essence, our web application serves as a vital bridge between these two worlds, facilitating real-time, two-way communication and fostering greater integration and understanding in our society. It leverages state-of-the-art technology to break down communication barriers, making communication more accessible and inclusive for all individuals, ultimately contributing to a more integrated and understanding society.

2. RESEARCH METHODOLOGY

To realize the Sign Language Translation system, we have meticulously designed and implemented various functionalities to ensure seamless communication between users proficient in sign language and those using spoken language. The implementation is structured around three key modes: Sign Language to Text, Speech to Sign Language, and Learning.

2.1 Sign Language to Text:

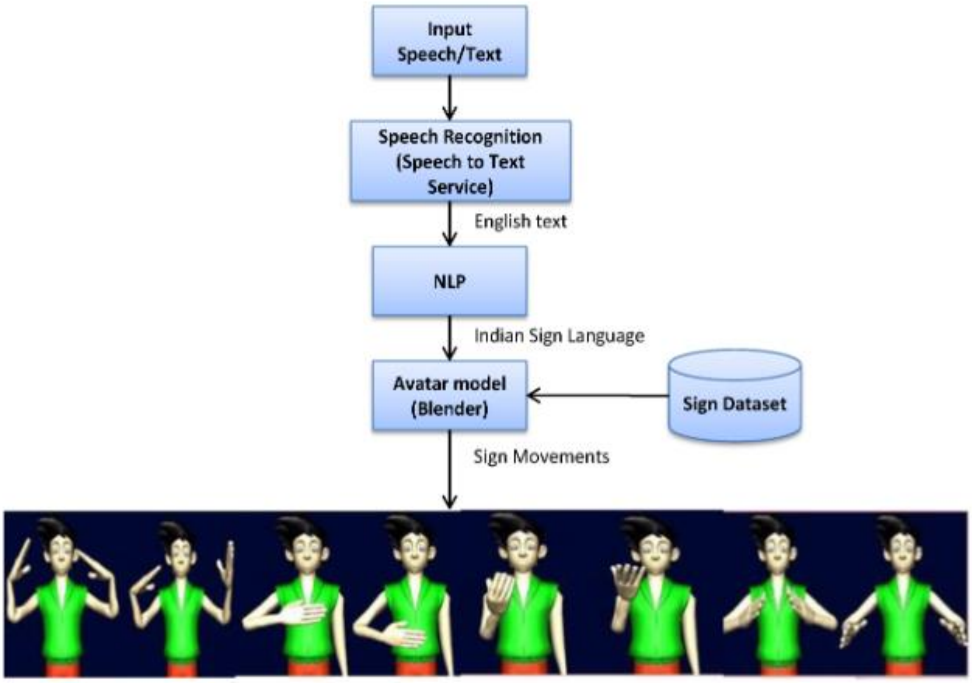


Users are given the flexibility to choose between using a webcam or uploading a pre-recorded video, ensuring convenience in input methods. When a video is provided, the application captures real-time video frames and employs MediaPipe's Hand module for precise hand gesture recognition. This module ensures accurate identification of hand movements, crucial for recognizing sign language gestures effectively. Once the gestures are detected, the application interprets them as sign language letters and displays them on the screen, enabling instant translation of sign language to text. To enhance the user experience, a real-time video display of the hand gestures is also provided, allowing users to see their gestures as they interact with the application. For users who want to keep a record of their interactions, the application offers the option to record the video as 'output1.mp4.' This feature enables users to review their interactions later, adding a layer of convenience and functionality to the application.

The sign-to-text translation process is supported by three key modules within the application. The preprocess module handles initial data preparation tasks such as image cropping and normalization. These preprocessing steps optimize the input data for subsequent processing, ensuring accuracy and efficiency in gesture recognition. Next, the descriptor module extracts relevant features from the preprocessed data, focusing on aspects like hand shape, movement patterns, and position. These extracted features serve as input for the classifier module, which leverages machine learning models such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). The classifier module plays a crucial role in interpreting recognized signs based on context and grammar rules. By analyzing the sequence of gestures and their meanings, the classifier translates them into corresponding text or spoken language output. This seamless integration of computer vision, machine learning, and natural language processing (NLP) technologies bridges communication gaps between sign language users and non-signing individuals, fostering inclusive and accessible interaction experiences.

2.2 Speech to Sign Language:

This Speech-to-sign language translation system simplifies communication by converting spoken words into text using the SpeechRecognition library, ensuring real-time accuracy. It employs the Google Speech API for speech-to-text conversion, identifying keywords corresponding to sign language gestures in a database. Algorithms consider context and grammar to select the right gestures, producing visual outputs like animated avatars for real-time translation, enhancing accessibility in communication platforms.Integrating Natural Language Processing (NLP) into this translation ensures accurate interpretation. Users speak into the microphone, providing audio input. The Google Speech API processes this input using advanced algorithms, accurately capturing the user's speech input in real time. The text undergoes NLP processing steps: it's tokenized into individual words or phrases for analysis, part-of-speech tagging assigns grammatical categories, and Named Entity Recognition (NER) identifies entities within the text, crucial for extracting vital information impacting sign language translation.Sentiment analysis gauges the emotional tone, adding contextual meaning to the translation and ensuring that sign language gestures accurately reflect the intended message, including emotional nuances.



Syntax and semantic analysis refine understanding, analyzing sentence structure and meaning, and enhancing the system's ability to map linguistic elements to corresponding sign language gestures effectively. With the processed text, the system performs database matching, comparing it against a comprehensive database of sign language gestures. Sophisticated algorithms select the appropriate sign language gestures that match the recognized text, ensuring accurate translation, accounting for context-specific meanings and variations in sign language gestures. Visual outputs, like animated avatars or videos depicting corresponding sign language gestures, are then displayed in real time, providing a seamless and accurate translation of spoken input into sign language. Overall, integrating NLP with Google Speech Recognition enhances the system's ability to understand and translate spoken language into sign language effectively, promoting accessibility and inclusivity for users of sign language

2.3 Learning here:

The learning mode is designed to facilitate users in learning sign language, focusing on alphabets and numbers. For alphabets, the application provides images and videos for each letter of the alphabet in American Sign Language (ASL), serving as a valuable educational resource. Similarly, for numbers, the application offers videos depicting numbers 0 to 9 in ASL, enhancing the learning experience and promoting sign language proficiency. By implementing these functionalities, our Sign Language Translation system empowers users to communicate effectively across different language modalities, fostering inclusivity and accessibility in communication. The methodologies adopted ensure accuracy, real-time processing, and user-friendly interactions, making the system a valuable tool for promoting understanding and integration in diverse communication settings

3. RESULT AND DISCUSSION

The user's web application for sign language translation and communication is groundbreaking, inclusive, user-friendly, and promotes real-time communication, two-way communication, and education. It is adaptable, uses advanced technologies, is affordable, and empowers individuals. The application breaks down communication barriers, fosters understanding, and integrates into society. Its practicality, feasibility, and potential for future enhancements position it as an innovative and impactful tool. In the future, the application holds promise for seamless integration into video calling platforms, offering real-time sign language interpretation and expanding its sign language dataset for broader user accommodation.

Figure 1: Webcam/Video Upload: Users can choose between webcam or video upload for input, ensuring flexibility in accessing the system and capturing sign language gestures for translation.

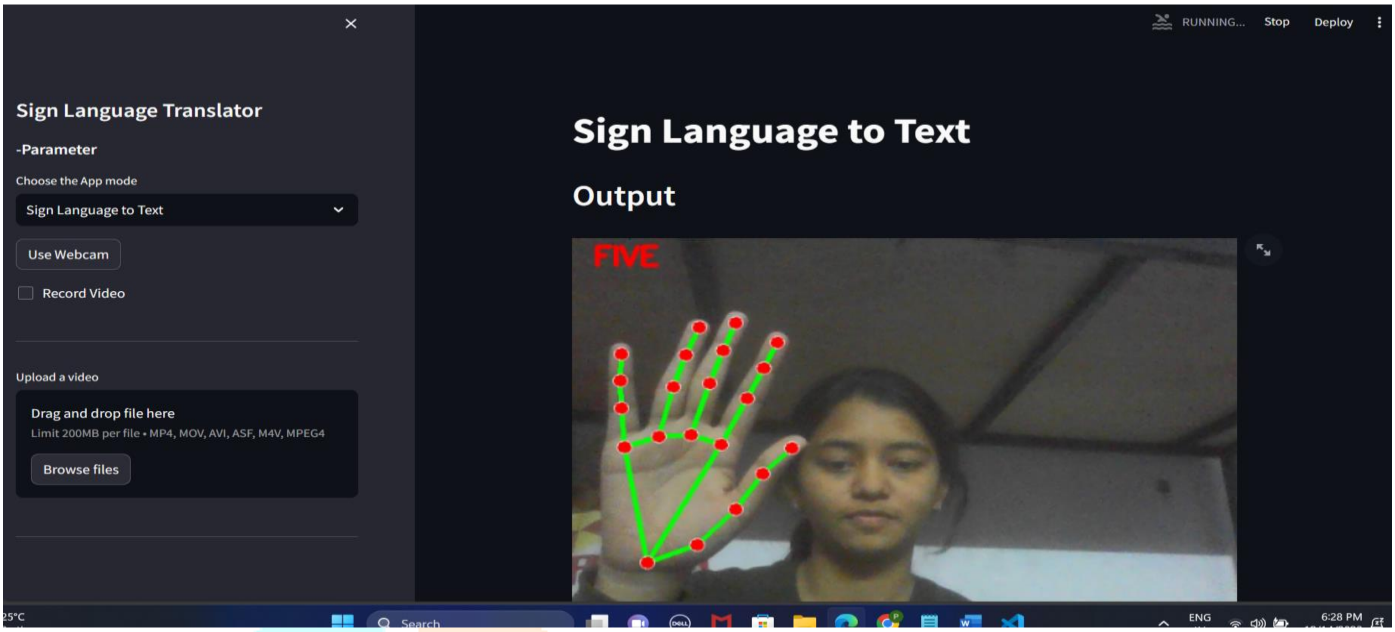


Figure 1. Sign Language to Text

By utilizing MediaPipe's robust hand tracking technology, the system can effectively interpret complex hand movements and gestures, ensuring accurate translation into text or spoken language. This feature significantly enhances communication accessibility for users, especially deaf and mute individuals, by providing a seamless and reliable method of translating sign language into comprehensible formats.

The integration of MediaPipe's Hand module underscores the system's commitment to leveraging cutting-edge technologies to bridge communication gaps and empower individuals with diverse communication needs.

Figure 2: Text /audio to Image format : It represents the conversion of text/audio into sign language format using avatars. Internally, this involves processing the input text/audio through algorithms that generate corresponding sign language gestures. These gestures are then mapped to predefined animations of avatars, creating a visual representation of sign language communication. It ensure converting into avatar/img format.

Figure 2. speech to sign language.

Figure 3: Alphabet/Number Learning: Users can select 'alphabets' or 'numbers' to access ASL images/videos for learning each letter and number, enhancing their sign language proficiency.

Figure 3. learning here

Users can easily navigate to the 'Alphabet' or 'Number' learning sections, where they can explore a comprehensive collection of ASL images and videos designed to facilitate effective learning of each letter and number. This interactive feature not only enhances users' sign language proficiency but also promotes a user-friendly and engaging learning experience within the platform.

Model Making Experiments: Conducted experiments to produce models with high accuracy by varying parameters.
Effect on the Number of Convolution Layers: Increasing epochs did not significantly improve accuracy but increased processing time.
Effect Optimizer: Adam optimizer yielded the best accuracy of 86%, outperforming SGD and RMSprop.
Effect of Learning Rate: A learning rate of 0.001 resulted in the highest accuracy of 86%, indicating better processing with a smaller learning rate.

4. ACKNOWLEDGMENT

The project successfully developed a groundbreaking sign language translation system, achieving high accuracy in recognizing hand gestures and converting them to text. This innovation promotes inclusivity and effective communication for deaf and mute individuals, breaking down communication barriers and fostering social integration. With real-time translation capabilities and a user-friendly interface, the system empowers users to engage in two-way communication seamlessly. Its impact extends beyond technology, contributing to a more inclusive society where everyone, regardless of communication differences, can interact and participate actively, promoting understanding and inclusivity on a broader scale.

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