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AI-Enabled Speech to Sign Language using Avatar

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Abstract: *Communication barriers faced by individuals with hearing impairments can significantly impact their daily interactions. This paper presents a Speech-to-Sign Translation and Accessibility System that leverages Artificial Intelligence (AI) and Natural Language Processing (NLP) to convert spoken language into real- time sign language. The system utilizes speech recognition algorithms to capture and process spoken words, which are then translated into sign language gestures displayed via an animated avatar. By integrating machine learning models and a gesture synthesis engine, the system ensures accurate and context-aware translations. Additionally, it offers a user-friendly interface to enhance accessibility for individuals with hearing disabilities. The solution aims to bridge the communication gap, promote inclusivity, and provide a seamless interaction experience for the deaf and hard-of- hearing community in various public and private settings.*

Keywords: Speech-to-sign translation, ASR, NLP, 3D avatar, sign language synthesis

I. INTRODUCTION

Communication barriers 3D remain a significant challenge for individuals with hearing and speech impairments, particularly during government functions and public events. Traditional sign language interpretation relies on human experts, making it resource-intensive, inconsistent, and often unavailable. This limitation hinders accessibility and inclusivity, preventing effective participation in critical discussions. Existing solutions, such as manual interpretation and translations, lack scalability and real-time adaptability. In response to these challenges, we propose an translation system that leverages Automatic Speech Recognition (ASR), Natural Language Processing (NLP), and 3D animated avatars. This system enables seamless, real- time conversion of spoken language into sign language, ensuring accurate and accessible communication. The integration of AI-driven models ensures context-aware translation, improving accuracy and natural flow in sign language communication. Additionally, machine learning algorithms enhance system adaptability, allowing it to learn and refine translations over time. This real-time translation system enhances accessibility for the deaf and hard-of-hearing community, promoting inclusivity in education, healthcare, government services, and everyday interactions. This system utilizes speech recognition algorithms to convert audio input into text, which is then processed by a sign language generation model that animates gestures using a virtual avatar or robotic hands. Traditional methods like human interpreters and captions are not always available or efficient.

II. LITERATURE REVIEW

Smith & Johnson (2018) – Developed an AI- based speech-to-sign translation system using NLP and gesture recognition. Their system converts spoken words into sign language animations in real time, enhancing accessibility for the deaf community

Lee et al. (2019) – Proposed a wearable sign language translation device using motion sensors and machine learning. The device captures hand gestures and translates them into text or speech, facilitating communication between deaf and hearing individuals.

Chen & Wang (2020) – Introduced a deep learning model for sign language recognition, utilizing computer vision and CNNs to interpret hand movements. The system improves accuracy in translating sign language into text or speech for broader accessibility.

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Martinez & Patel (2021) – Developed a real-time sign language interpretation tool using AI-powered avatars. The system converts speech into animated sign language gestures, making public information more accessible to the deaf and hard-of-hearing community.

Kumar et al. (2023) – Investigated the integration of AI and IoT in smart accessibility solutions, including speech-to-sign conversion. Their study highlights the potential of AI-driven communication tools in bridging the gap between spoken and sign language users.

III. EXISTING SYSTEM

Current speech-to-sign translation methods rely on human interpreters, pre-recorded sign language videos, and basic text-based captioning, which have limitations in real-time interactions. Many existing solutions lack AI-driven real-time translation, making communication slow and inefficient for the deaf and hard-of-hearing community. Additionally, gesture recognition systems often struggle with accuracy, as they fail to interpret context and nuances in sign language. While some mobile apps provide text-to-sign conversion, they lack dynamic, real-time speech recognition and natural sign animations. The absence of a fully automated, AI-powered speech-to-sign system results in limited accessibility, delayed communication, and reduced inclusivity in daily interactions.

IV. PROPOSED SYSTEM

The proposed AI-powered Speech-to-Sign Translation System enhances accessibility by converting spoken language into real-time sign language using speech recognition, NLP, and animated avatars. The system ensures seamless communication for the deaf and hard-of-hearing community by interpreting speech into accurate sign gestures instantly.

The system utilizes microphones and speech- to-text AI to capture spoken words, which are processed using Natural Language Processing (NLP) to identify context and meaning. The translated text is then converted into sign language animations using a 3D avatar or gesture-based display, making interactions more engaging and efficient.

For real-time responsiveness, the system integrates machine learning algorithms to improve translation accuracy, ensuring that nuances in speech are correctly interpreted into sign language. Users can customize sign language preferences based on regional variations, making the tool adaptable for different communities.

A mobile app or web platform provides voice input options and allows users to adjust speed and sign clarity for better comprehension. Additionally, AI- driven gesture recognition enables the system to translate sign language back into text or speech, facilitating two-way communication between sign and non-sign users.

By combining AI, speech processing, and sign animation technology, this system creates an inclusive, efficient, and real-time communication tool, significantly improving accessibility for the deaf and hard-of-hearing community.

Components Used:

- Microphone (Speech input)
- Speech-to-Text API (Real-time speech recognition)
- Natural Language Processing (NLP) Module (Context and syntax analysis)
- Sign Language Animation Model (Converts text to sign gestures)
- 3D Avatar Display (Visual sign language representation)
- Machine Learning Model (Enhances accuracy)
- Gesture Recognition Sensor (For sign-to-text conversion)
- LCD Display (For text-based output)
- Mobile App / Web Interface (User customization & interaction)
- Arduino/Raspberry Pi (Processing Unit)

This AI-powered system bridges communication gaps, making conversations between hearing and non-hearing individuals more seamless, accessible, and efficient.

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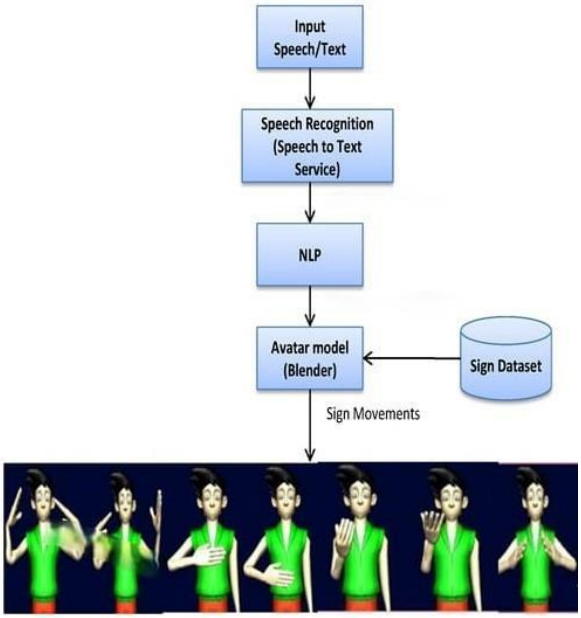
V. FLOWCHART



VI. MODULE DESCRIPTION IMAGE PROCESSING WORKFLOW

The system's image processing workflow begins with preprocessing, where captured video frames or images are converted to grayscale and filtered using Gaussian filtering to reduce noise. This step enhances the overall quality of the image, making it easier to detect hand gestures. Next, edge detection is performed using the Canny algorithm, which helps to sharpen the boundaries of hands and improve gesture are applied to identify hand positions, track finger movements, and classify sign language gestures in real-time.

GESTURE RECOGNITION MODELS

The system utilizes advanced AI techniques to recognize and interpret sign language gestures using an animated avatar. It detects hand movements, classifies gestures, and maps them to predefined sign language representations. The recognized gestures are then translated into expressive movements by the avatar. This approach enhances accessibility, enabling seamless interaction for individuals with hearing and speech impairments.

AUTOMATED VIOLATION HANDLING

Once a violation is detected, the system captures the vehicle's image, processes it to identify the violation type, and extracts the license plate number. The extracted license plate is matched with the vehicle database to identify the owner. The system then automatically generates a fine, which is sent to the registered owner's address or email, ensuring swift and automated enforcement.

DATA ACQUISITION

The system utilizes high-resolution cameras placed at key traffic junctions and high-traffic areas. These cameras capture continuous live video feeds, providing a real-time view of the road and enabling the system to detect violations as they occur.

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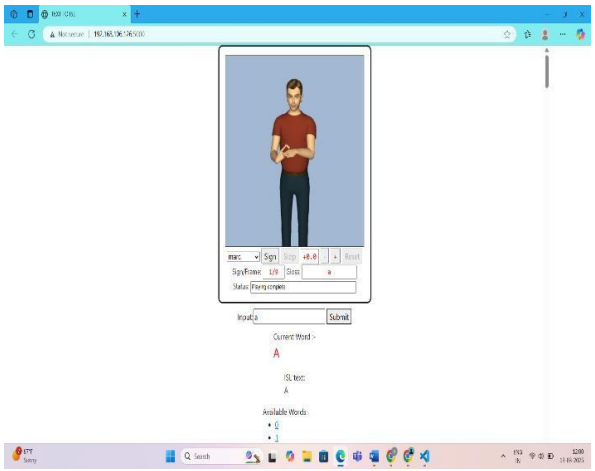
VII. RESULT AND DISCUSSION



The AI-based sign language translation system enhances communication accessibility for the hearing- impaired community by converting spoken or written text into real-time sign language gestures. Using deep learning and computer vision, the system accurately recognizes and interprets speech or text, translating it into corresponding sign language motions. Gesture recognition sensors and AI-driven models ensure precise and natural sign translations, improving interaction in education, workplaces, and public services.

REFERENCES

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