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Real Time Sign Language Interpreter

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Abstract: ***Communication can be a significant challenge for individuals who are deaf or hard of hearing. Sign language serves as a vital tool for these individuals, utilizing hand gestures, facial expressions, and body movements to convey messages and emotions. In recent years, the development of sign language recognition systems and gesture-based controls has played a pivotal role in bridging the communication gap between deaf and non-deaf people. This paper focuses on the advancements in real-time sign language translation systems, which enable immediate conversion of sign language into other forms of communication, such as text or speech. A detailed review of various sign language recognition technologies and systems developed between 2017 and 2021 is presented. These systems leverage a range of techniques, from sensor-based technologies and machine learning algorithms to more advanced visual recognition and wearable devices. By analyzing the evolution of these systems, this paper highlights the progress, challenges, and future prospects of sign language translation technologies, offering a comprehensive understanding of their potential in improving accessibility and communication for the deaf and hard-of-hearing community.***
Index Terms: Sign Language, Sign Language Recognition, Assistive Technology, APIs (Application Program Interfaces), IoT (Internet of Things).

I. INTRODUCTION

Sign language is a vital communication tool for many deaf and hard-of-hearing individuals, incorporating hand gestures, facial expressions, and body movements to convey meaning. However, communication with non-signers remains challenging. Recent advancements in sign language recognition systems and gesture-based technologies, including machine learning, computer vision, and wearable devices, have helped bridge this gap by translating sign language into text or speech in real-time. This paper reviews sign language translation systems developed between 2017 and 2021, examining the technologies, challenges, and their potential impact on improving accessibility for the deaf and hard-of-hearing community.

A. Languages

Language is a system people use to communicate. It includes words, signs, and rules that are shared by a group of people and passed down through generations. Language changes over time and allows people to express many different ideas, emotions, and intentions. The symbols used in a language—like words or gestures—often don't look like what they mean. For example, the word "tree" doesn't look like an actual tree, but English speakers understand it to mean that object. This idea is called "arbitrariness," meaning there's no natural link between the symbol (like a word) and its meaning. This is true not only for spoken languages but also for other symbols like traffic lights or animal sounds, which also carry meaning by social agreement.

II. SIGN LANGUAGES

A. Applications of Sign language

Sign language software applications are designed to help people learn and communicate in sign language. A key feature of these applications is *interaction*, which allows users to participate actively rather than just watching or reading. This helps keep users engaged in the learning process. Since sign language relies on visual elements, videos are often included in these apps to make learning easier and provide better access to information for people who are hearing-impaired. Many applications are developed to support both learning and translation, allowing users to convert signs into spoken language or text, making communication more accessible and effective.

B. Sign Language Translation System Approaches

Sign language translation systems use two main methods to recognize signs: sensor-based and computer vision. In *sensor- based* systems, sensors are used to track hand movements. In *computer vision* systems, a camera captures images or videos of the hand movements to recognize signs. However, high-quality cameras require more memory, time for processing, and can be expensive,

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especially when combined with advanced technologies. These systems work best with a clear background and without any extra noise or movement, as this helps the system focus on the sign language movements accurately.

C. Hand Gesture Recognition Categories

There are two main types of hand gesture recognition systems: camera-based and wearable sensor-based systems.

1) Camera-Based Systems: These use cameras to capture hand gestures and can recognize movements accurately, but they require a lot of computing power. They also depend on certain conditions, like having a clear background, good lighting, and an ideal room setup, and are limited to what the camera can see.
2) Wearable Sensor-Based Systems: These use small sensors worn on the body, such as accelerometers, gyroscopes, and magnetometers, to detect movements. They are less expensive, don't rely on the environment (like lighting or background), and use less power because they use small, energy-efficient parts. The data collected from these sensors are analyzed using different methods, like machine learning, to recognize hand gestures accurately.

D. Data Gloves

A data glove is a special glove with sensors that can detect important hand movements, like how much the fingers are bent, the position of the wrist, and the motion of the hand. This glove collects data and sends it to a mobile device or computer. Data gloves are popular for sign language translation because they can easily capture details like finger positions and movements, which makes translation simpler and uses less computer power. However, data gloves also have some limitations.

1) Comfort and Fit: Not everyone's hands are the same size, so the gloves can feel uncomfortable for some users.
2) Limitations in Data: Data gloves can't capture facial expressions, lip movements, or eye movements, which are also important in sign language.
3) Environmental Sensitivity: They can be affected by surroundings, like lighting and background, which may impact data quality.
4) Cost: High-quality data gloves are very expensive, costing over $9,000. Cheaper gloves are available but often have fewer sensors, making them less accurate and more likely to pick up unwanted noise. In general, data gloves are often wireless, making them light, easy to use, and reliable. But while they can detect both still and moving signs, the price and data limitations remain significant challenges.

TABLE I

Advantages	Disadvantages
Wireless	Difficult to handle
Portable	Components are expensive

E. Visual based approach

In the visual-based approach for sign language translation, a camera captures images and videos of the signer to interpret their movements. This approach is flexible and can recognize not only hand movements but also facial expressions, head movements, and even lip reading. There are two main types of visual-based systems:

1) Color-Coded Gloves: In this approach, the signer wears regular gloves with different colors on the fingertips and palm. The colors make it easier for the camera to track hand movements. This setup is affordable because it only requires a webcam and the colored gloves.
2) Skin-Color Recognition: This method doesn't require gloves. Instead, the camera recognizes the signer's hand and skin color to track movements directly. The signer just needs to use a camera, but they may need to make a "stop" sign to let the system know when to start and stop tracking. This approach has become more popular because it avoids some of the challenges and costs of smart gloves. However, visual-based systems still have challenges. They can pick up unwanted "noise" in the background, and they often need complex algorithms to process all the data accurately.

F. Sign Language Translation Systems

Many sign language translation systems have been developed, often using methods that were first used in spoken language translation, such as statistical methods, example-based methods, and finite-state models. These systems aim to help people with hearing loss by translating signs into spoken or written language in real-time. Some systems even use 3D avatars, which are

animated characters that can perform sign language to make communication easier. However, there are some challenges in developing effective sign language translation systems:

1) Complex Movements: Sign language translation involves capturing not only hand movements but also full-body movements and facial expressions. Collecting and processing all this data is difficult but essential for accurate translation.
2) Real-Time Translation: For the system to be truly useful, it needs to translate signs quickly as they happen, which requires powerful technology that may be too large or expensive to be portable.
3) Static vs. Dynamic Signs: Some signs are "static," meaning they stay still, while others are "dynamic," involving continuous movement. It's easier to translate static signs, but translating dynamic signs accurately is still challenging.

G. *Hand Gesture Recognition Process*

Signers interact with computers by hand gesture recognition. Firstly, the input devices capture the hand region of the original images. Then, some features which can describe hand gestures are obtained. To retrieve the proper information, hand gestures are compared with the stored data in terms of similarity. When the region of interest is detected, features that are needed are retrieved. Finally, the output (text, voice, or video) is provided to the user. This process is depicted in figure 1.

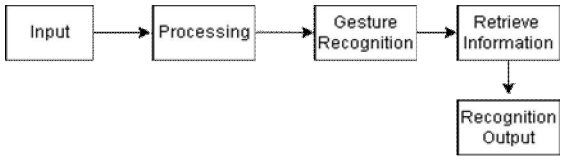


Fig. 1. Hand Gesture Recognition Process

III. RELATED WORKS IN SIGN LANGUAGE RECOGNITION USING REAL-TIME APPROACH

Many projects have been developed to recognize sign language in real-time, helping people communicate using sign language with the aid of technology. Here are a few examples:

1) Educational Game for American Sign Language: One study created a game for students to learn American Sign Language (ASL). This app can recognize both still (static) and moving (dynamic) signs. By using a method called k-Nearest Neighbour for classifying signs, the system achieved a very high accuracy of 99.44%.
2) "YSSA" Wearable Translator: Another project developed a wearable device, "YSSA," which translates ASL into spoken English in real-time. It's a lightweight, stretchy, and low-cost system that uses a smartphone app and machine learning for high accuracy. The device generates electricity from small movements or pressure, helping power the system. However, it requires a mobile device to play the spoken translation.
3) ASL Alphabet Glove: This glove translates ASL alphabet letters into text, sending data to a computer or smartphone. It's equipped with strain sensors and other electronics like digitizers, a microcontroller, and Bluetooth. This glove can translate all 26 letters of the ASL alphabet and costs less than $100.
4) "Dastaana" Glove: This glove includes flex sensors and other hardware for ASL translation. Users can communicate through the glove, and the data is sent to an app. The creators suggest future improvements like connecting the glove to home devices (using IoT) or allowing it to send emergency signals to hospitals or police stations.
5) Indian Sign Language System: This project created a standalone system that translates Indian Sign Language into speech. The system uses sensors, including flex sensors, gyroscopes, and accelerometers, to detect the position and movement of the hand gestures accurately.

These projects show how different technologies can be used for real-time sign language translation, from educational apps to wearable devices with various sensors

Table II. Real Time Sign Language Translators

Paper	Name	Language	Year
[35]	–	B.S.L.	2021
[30]	LSTM-RN	A.S.L.	2021
[31]	YSSA	A.S.L.	2021
[33]	Dastaana	A.S.L.	2019
[32]	–	A.S.L.	2017

[34]	Talking Hands	I.S.L.	2017

IV. CONCLUSIONS

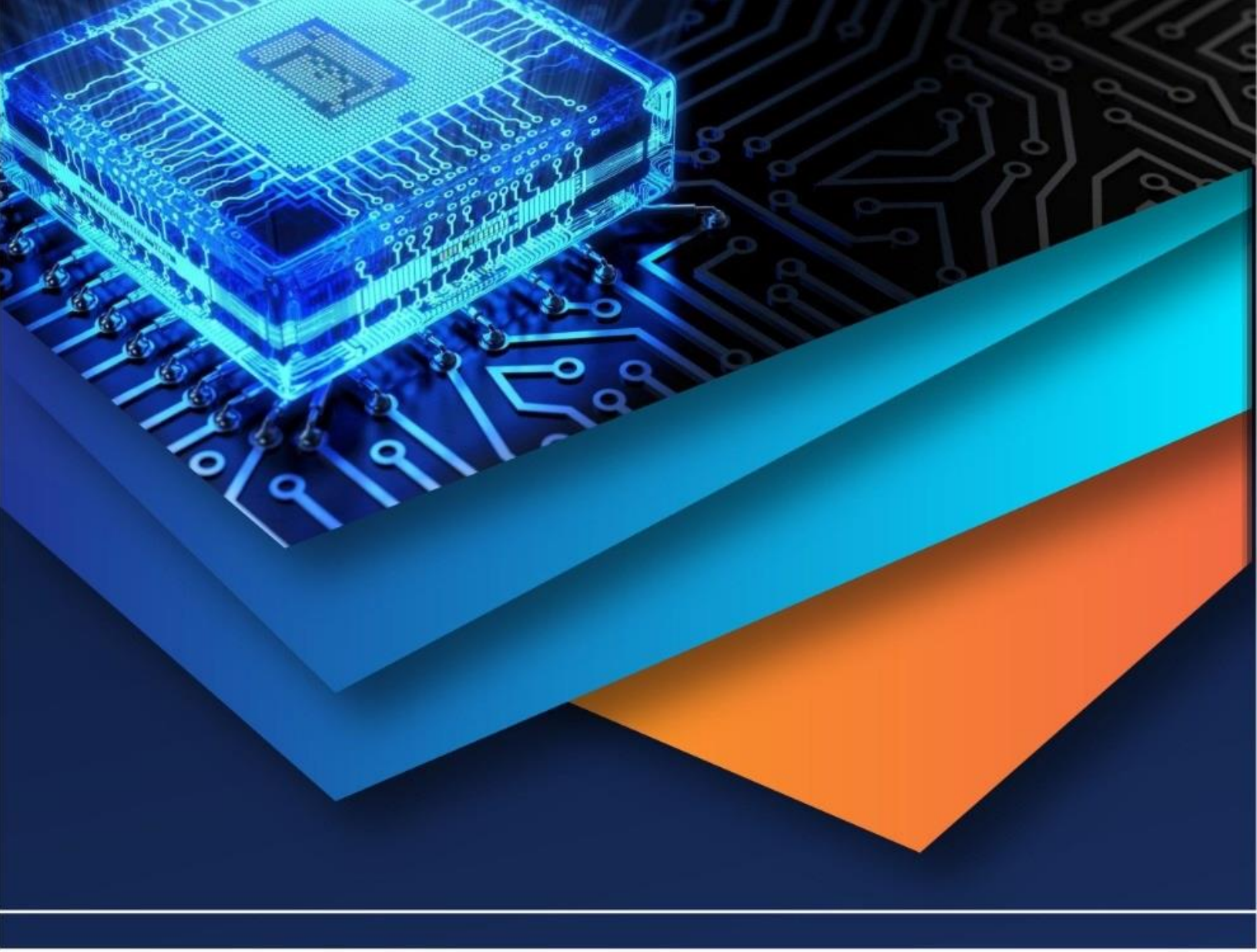
According to World Health Organization (WHO), more than 5% of the world's population has hearing loss, i.e., 466 million people, 432 million adults, and 34 million children. Deaf people also need a way to communicate and have developed a language that is directly accessible and useful for them that is called sign language [2]. Sign languages are the only languages that signers use for their communication in a familiar, effortless, useful, natural, and easy way. These problems prompted researchers to discover solutions for iden- tifying sign-language communication and predict how two- way communication can be done. The deaf/hard-of-hearing people are also affected by these rapid changes. The use of technology reduces isolation, increases independence, and offers social, economic, educational, and other opportunities to deaf/hard-of-hearing people. The current survey presented six studies conducted from 2017 to 2021 concerning real-time sign language translation systems. Future research will provide a more comprehensive review of sign language translators de- pending on their embedded technology [38]. The prospective study of translators using IoT and machine learning technology needs also to be mentioned as it is better adapted to the user. In addition, sign language translators can be connected to various online CMS systems such as [36], [37], and [16] while enabling deaf people to take exams and gain skills.

V. ACKNOWLEDGMENT

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