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INDIAN SIGN LANGUAGE TO TEXT SPEECH TRANSLATION

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Abstract: Communication between hearing and non-hearing individuals has always posed a challenge, especially for those who are unable to speak or hear. Indian Sign Language (ISL) plays a crucial role in enabling members of the hearing-impaired community to express themselves and interact with others. However, a major barrier persists in translating ISL gestures into a format understandable by non-signing individuals, particularly in real-time settings.

With recent advancements in computer vision and deep learning, it is now possible to automate the recognition of ISL gestures, significantly improving the communication experience. Computer vision techniques, such as wrist and hand detection, are employed to isolate hand movements from images or video frames, regardless of varying lighting conditions or camera angles. These gestures are then processed by deep learning models—primarily Convolutional Neural Networks (CNNs)—which are capable of learning and identifying intricate spatial patterns within the gesture data.

Key words- *American Sign Language (ASL),Convolutional Neural Networks (CNN),Deep Learning,Computer Vision,Sign Language Recognition,Wrist Recognition*

1. INTRODUCTION

Communication is one of the most essential aspects of human interaction. However, individuals with speech or hearing impairments often face significant challenges in expressing themselves and connecting with others. Indian Sign Language (ISL) serves as a vital communication tool for the deaf and hard-of-hearing community, enabling them to engage in meaningful social interactions. Unfortunately, there are considerable barriers to communication between ISL users and those who are unfamiliar with the language. The absence of widespread knowledge of ISL, coupled with the limited availability of trained interpreters, creates communication gaps in various settings. This project aims to address these challenges by developing an automated ISL recognition system that converts ISL gestures into text, fostering more inclusive and accessible communication for individuals with hearing impairments.

The key benefit of this project is its potential to reduce the dependency on human interpreters, making communication faster, more reliable, and available at all times. It empowers individuals with hearing impairments to communicate independently, enhancing their autonomy and social integration. Moreover, it fosters mutual understanding between hearing and non-hearing communities, creating a more inclusive and empathetic society.

In conclusion, the proposed automated ISL recognition system represents a significant step toward promoting inclusivity and independence for individuals with speech or hearing impairments. By breaking down the communication barriers that many hearing-impaired individuals face, the system enables them to participate fully in society, whether in education, the workplace, or social settings. Ultimately, this project aims to contribute to a world where accessibility and communication are universal, allowing individuals of all abilities to engage with the world around them.

2. METHODOLOGY

Related Work:

Requirement Gathering and analysis – All possible requirements of the system to be developed are captured in this phase and

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documented in a requirement specification document.

System Design – the requirement specifications from first phase are studied in this phase and the system design is prepared. This system design helps in specifying hardware and system requirements and helps in defining the overall system architecture.

Implementation – with inputs from the system design, the system is first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing.

Integration and Testing – All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.

Deployment of system – Once the functional and non-functional testing is done; the product is deployed in the customer environment or released into the market.

Maintenance – There are some issues which come up in the client environment. To fix those issues, patches are released. Also, to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment.

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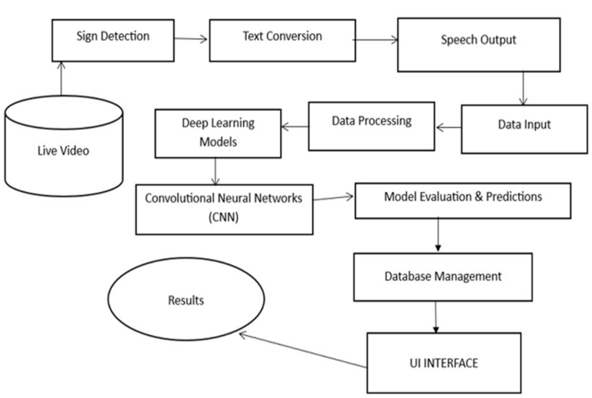
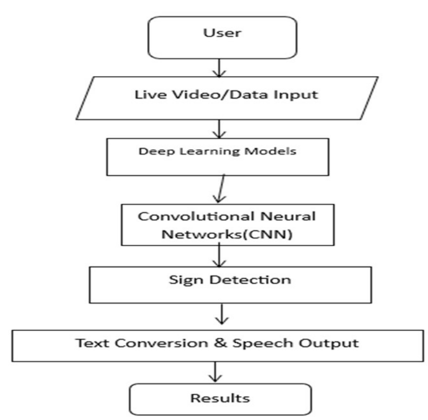
3. IMPLEMENTATION





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4. DATASETCOLLECTION

Training gestures: ISL Translate is a large-scale dataset developed to support research in translating Indian Sign Language (ISL) into English. It contains approximately 31,000 sentence and phrase pairs, where each ISL video clip is paired with an English translation. The dataset was curated with the goal of improving machine translation systems for ISL and includes pose features extracted using MediaPipe Holistic, which captures 3D key points of body, hand, and face movements. It is divided into training, validation, and test splits with 80%, 10%, and 10% of the data respectively. To ensure quality, a subset of 291 video-text pairs was validated by a certified ISL instructor. Benchmarking experiments using a transformer-based model showed moderate performance, with metrics such as a BLEU-4 score of 6.09 and a word error rate of 61.88%, indicating the complexity of ISL translation and the potential for further advancements.

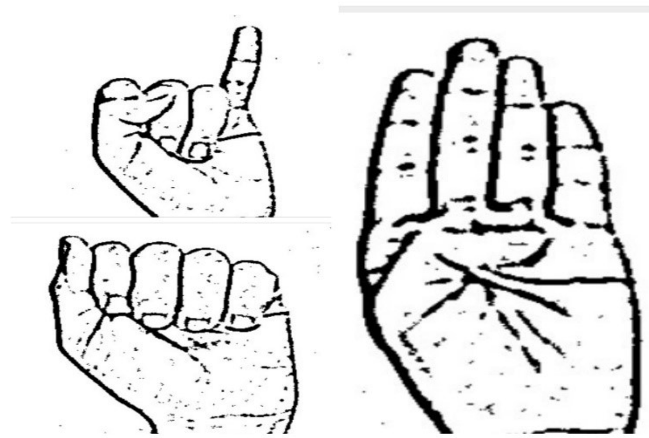


Fig 1 Classification dataset

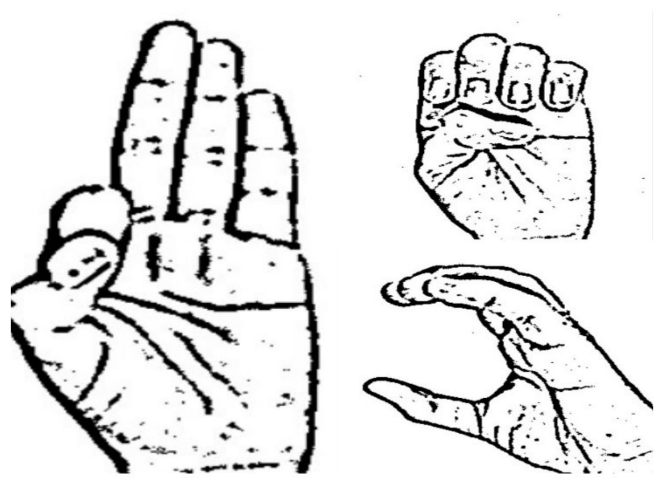


Fig 2 Detection dataset

5. ALGORITHMS

VGG and ResNet are two landmark CNN architectures that reflect different design philosophies in deep learning for computer vision. VGG, introduced in 2014, emphasizes architectural simplicity by using a series of 3×3 convolutional filters stacked on top of each other, followed by max pooling and fully connected layers. Its depth (VGG-16 and VGG-19) allows it to extract complex image features, and its uniform structure makes it easy to implement and modify. However, VGG networks are computationally expensive and require significant memory due to the large number of parameters, especially in the fully connected layers.

On the other hand, ResNet, which won the ILSVRC 2015 competition, brought a major innovation to deep learning with the concept of residual learning. Traditional deep networks often suffer from degradation problems, where adding more layers leads to worse training accuracy due to vanishing gradients. ResNet addresses this by introducing skip connections—shortcut paths that allow gradients to flow directly across layers. These residual blocks enable training of extremely deep networks, such as ResNet-152, without performance loss. This made ResNet a major advancement, not just in classification, but also in tasks like object detection (e.g., in Faster R-CNN), segmentation (e.g., in Mask R-CNN), and even in non-vision tasks.

In practice, VGG is often used as a strong baseline or a feature extractor in transfer learning due to its straightforward structure and pre-trained availability. It's especially useful when model interpretability or modularity is needed. In contrast, **R**esNet is preferred for high-performance applications and real-world deployment, as it offers better accuracy with fewer parameters and faster convergence during training. Additionally, ResNet's modular residual blocks have inspired the design of many newer architectures such as DenseNet and EfficientNet

6. EXPERIMENTAL RESULTS

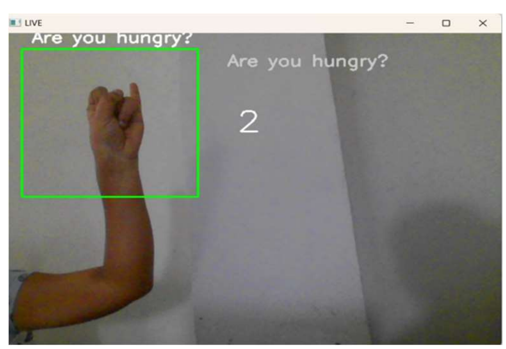
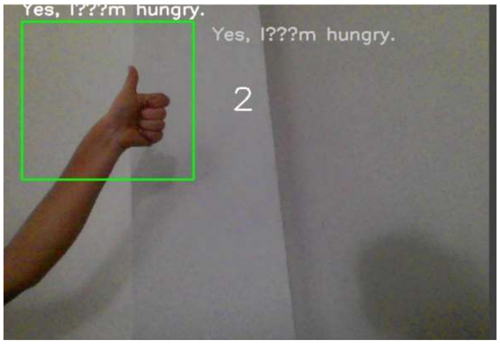


Fig 3 sign detection



The automated ISL recognition system translates gestures into text in real-time, providing an immediate and accessible form of communication for hearing-impaired individuals. Once recognized, the text can be displayed on a screen or converted into speech using text-to-speech (TTS) technology.

7. CONCLUSION

The robust performance of the system underscores its potential for deployment in real-world scenarios such as educational settings, healthcare facilities, and public service platforms. Furthermore, the solution is designed to be scalable and adaptable, allowing for future enhancements and expansion to include more complex gestures or continuous signing. With its high reliability and ease of implementation, this ISL recognition system serves as a valuable tool for empowering individuals with speech or hearing impairments—ultimately.

8. FUTURE SCOPE

Expanding the system to recognize dynamic gestures, including letters J and Z, will enhance its comprehensiveness. Incorporating real-time video recognition using continuous sign language recognition (CSLR) techniques can further improve practical usability. Additionally, integrating facial expression and body movement analysis could provide more contextual information for accurate sentence-level interpretation. Implementing multi-language sign recognition to accommodate different regional variations of sign language would broaden its accessibility. Moreover, optimizing the system for mobile and low-resource devices through model compression and quantization techniques can enhance its usability in real-world applications. Future developments may also explore incorporating natural language processing (NLP) to convert sign language gestures directly into spoken language for seamless communication. By addressing these aspects, the system can evolve into a more robust, inclusive, and user-friendly assistive technology

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