IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Review of An Inclusive System for Sign Language & Sentiment Detection

Atharv D. Khawale
Department of Information Technology
Prof. Ram Meghe College of Engineering & Management
Badnera, Amravati, Maharashtra, India

Swara V. Malviya
Department of Information Technology
Prof. Ram MegheCollege of Engineering & Management
Badnera, Amravati, Maharashtra, India

Abhinandan R. Kharbade
Department of Information Technology
Prof. Ram Meghe College of Engineering & Management
Badnera, Amravati, Maharashtra, India

Atharva A. Hingmire
Department of Information Technology
Prof. Ram Meghe College of Engineering & Management
Badnera, Amravati, Maharashtra, India

Under the Guidance of
Dr. Pravin S. Choudhary
Department of Information Technology
Prof. Ram Meghe College of Engineering & Management
Badnera, Amravati, Maharashtra, India

Abstract — **In a world where communication is a fundamental right, individuals with hearing and speech impairments still face major barriers. Language is an essential aspect of human socialization, which poses difficulties for many hearing and speech-imperiled individuals. This paper presents an advanced AI-based system for Indian Sign Language recognition with integrated emotion fusion, aimed at improving real-time communication for individuals with hearing and speech impairments. Developed using Python and a Tkinter-based GUI, the system captures live video through a webcam, processes frames, and utilizes a Machine Learning (ML) to identify hand signs (a–z) alongside seven emotional states. By combining gesture recognition with emotion analysis, the system generates more expressive and context-aware sentences, which are further translated into Hindi or Marathi for regional accessibility. The approach leverages publicly available datasets from Kaggle for training and ensures a low-cost, efficient, and user-friendly solution that enhances inclusivity and bridges communication barriers in social, educational, and professional settings.**

Index Terms - **Emotion Fusion, Machine Learning (ML), Real time, Sign Language Recognition.**

I. INTRODUCTION

Communication has always been the cornerstone of human interaction, allowing us to share ideas, emotions, and knowledge. However, for millions worldwide with hearing or speech impairments, conventional forms of communication like verbal conversation remain inaccessible.

Sign languages, also known as visual-gestural languages, constitute a unique and rich mode of communication primarily utilized by hard-of-hearing individuals around the world. Unlike spoken languages, which rely on auditory stimuli, sign languages employ visual and gestural elements to convey meaning. Sign languages play a crucial role in fostering natural interaction, breaking down communication barriers between the hearing impaired and society.

With the rise of artificial intelligence and computer vision technologies, automated sign language recognition systems have emerged as promising tools to facilitate seamless interaction and inclusivity. The integration of emotion recognition with sign language understanding further enhances the system's ability to convey context and sentiment, making communication more expressive and natural. This paper leverages Machine Learning (ML) to simultaneously detect hand signs and facial emotions, generating meaningful sentences that can be translated into regional languages such as Hindi and Marathi. By combining real-time processing, deep learning, and intuitive GUI design, the system aims to provide an accessible, cost-effective, and efficient solution for improving communication for the differently-abled community, paving the way for smarter assistive technologies in the future.

II. LITERATURE REVIEW

1. Boobal A, et al. proposed a paper which focuses on addressing communication barriers between hearing-impaired and hearing individuals by leveraging artificial intelligence techniques for real-time sign language recognition and speech conversion. Existing literature highlights the use of computer vision, machine learning, and deep learning models—such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs)—to accurately recognize hand gestures and convert them into text or audio output. Prior studies have explored vision-based systems using cameras and sensor-based approaches using gloves, but challenges remain in achieving real-time performance, high accuracy under varying lighting conditions, and support for continuous sign language. This work builds upon earlier research by emphasizing real-time processing and bidirectional communication, integrating sign-to-audio and audio-to-sign conversion to enhance accessibility and inclusivity. By combining AI-driven gesture recognition with speech processing techniques, the study contributes to the growing body of assistive technologies aimed at improving human–computer interaction and social integration for the deaf and hard-of-hearing community.

2. Kambhampati Sai Sindhu, et al. proposed a system built on a substantial body of research focused on bridging communication gaps between deaf and hearing communities through automated sign language processing. Current literature in this domain emphasizes computer vision and machine learning approaches for gesture recognition and translation, leveraging techniques such as Convolutional Neural Networks (CNNs), deep learning models, and real-time video processing to convert sign language into text or speech and vice versa. These studies reflect ongoing challenges in handling the unique grammatical structures and semantic complexities of sign languages, the scarcity of comprehensive datasets, and the need for systems that can operate robustly across varying environments and sign dialects. By situating their work within this context of vision-based recognition, AI-driven translation, and accessibility-oriented assistive technologies, the authors contribute to evolving efforts that aim for more inclusive, accurate, and real-time communication tools for the hearing impaired, acknowledging both technological advances and persisting limitations noted in recent surveys and implementations.

3. D. Shofia Priyadharshini, et al. The paper proposes an integrated application aimed at enhancing both *sign language learning* and *communication* by combining multiple functionalities—alphabet and word recognition, text-to-action conversion, multi-language support, and voice output—into a single user-oriented system, addressing the gap in existing tools that often focus on isolated tasks. It situates itself within the broader field of sign language recognition and assistive technologies, where prior research has leveraged computer vision, machine learning, and deep learning to transform visual gestures into text or speech to aid interactions between hearing-impaired users and non-signers. Many existing studies emphasize real-time gesture detection and translation accuracy but often lack comprehensive learning support or adaptability across different languages; this work builds upon such methods by integrating advanced recognition algorithms and user-friendly features to simultaneously support learners and facilitate everyday communication. By emphasizing accessibility and inclusivity through multi-language and voice capabilities, the authors extend the scope of assistive sign language systems beyond basic recognition toward a more versatile educational and communicative tool, reflecting ongoing trends and challenges in the literature regarding robust, scalable, and user-centric sign language technologies.

4.Shreya Daga, et al. The paper situates itself within the broader research trend of AI-based sign language recognition systems that aim to bridge communication gaps for the deaf, non-speaking, and hard-of-hearing community, particularly in the Indian context where Indian Sign Language (ISL) has been underrepresented in technology solutions. Prior work in this domain has explored machine learning and deep learning methods—including support vector machines (SVM), recurrent neural networks (RNNs), and Long Short-Term Memory (LSTM) architectures—for gesture and sign recognition and translation, with varying accuracies and scopes ranging from static alphabet detection to dynamic gesture interpretation. This study builds on such efforts by employing an LSTM network combined with convex hull-based feature extraction to recognize not only static alphabets but also dynamic and emergency signs, expanding upon earlier systems that often focused primarily on basic gesture recognition or lacked emergency alert functionalities. Furthermore, the integration of an alert mechanism that automatically conveys the user's emergency type and location to services differentiates this work, aligning with literature emphasizing real-time communication support and enhanced accessibility for sign language users.

5. Arpita Acharya, et al. proposed a method that advances the literature on sign language assistive technologies by integrating emotion recognition into the translation pipeline, addressing a gap in many traditional systems that focus solely on manual gesture interpretation. Prior research in sign language translation has predominantly concentrated on computer vision and deep learning models (e.g., CNNs, RNNs) to classify hand gestures and convert them to text or audio, often overlooking the non-manual cues such as facial expressions and emotional context that are essential for fully accurate communication. Recent works have highlighted the importance of incorporating affective information to better capture the semantic richness of signed messages, as emotional expressions can significantly alter meaning and intent. By fusing emotion detection with sign translation, this paper extends foundational approaches in multimodal recognition and contributes toward more naturalistic and context-aware communication systems for the deaf and hard-of-hearing community, aligning with emerging research that emphasizes the synergy of gesture and emotional analysis to improve translation fidelity and user engagement.

6. Dongping Guo, et al.This research contributes to the growing field of AI-driven assistive technologies by developing a deep learning-based web application aimed at facilitating sign language recognition and raising awareness among broader audiences.

Building on extensive prior research in vision-based sign language recognition—where convolutional and recurrent neural networks have been widely used to classify hand gestures and convert them into interpretable outputs—the authors fine-tune an LSTM model on established sign language datasets and integrate it into an accessible online platform to support learners and users in real-world contexts. This work aligns with literature emphasizing user-oriented applications that go beyond algorithmic innovation to address practical accessibility and education, as many traditional models focus solely on offline or laboratory settings. By deploying a functional web interface and promoting awareness of sign language, the study extends existing research on gesture recognition systems toward inclusive, publicly reachable applications, reflecting an emerging trend of translating deep learning advances into tools that foster social engagement and communication equity for hearing-impaired communities.

7. Dhruvin Gandhi, et al. The research builds on a significant body of research in real-time sign language recognition and affective computing, combining gesture interpretation with emotional context to improve communication technologies for the deaf and hard-of-hearing community. Prior studies in the field have commonly used computer vision and deep learning to detect hand shapes and movements, leveraging frameworks like MediaPipe for efficient landmark extraction and models such as CNNs and LSTMs to classify gestures from video streams. However, many traditional systems focus solely on manual gesture recognition without addressing non-manual cues such as facial expression and emotional state, which are crucial for fully understanding signed communication. By employing MediaPipe to capture dynamic hand and body landmarks and integrating deep learning for both sign classification and emotion detection, this work extends earlier approaches that treat gesture and affective analysis separately, reflecting a growing research trend to develop multimodal systems that capture richer semantic and emotional information for enhanced accessibility and more natural human–machine interaction

8. Atra Akandeh et al. The paper addresses a key challenge in sign language recognition research—continuous sentence-level translation—by proposing deep learning models that map full sign language video sequences directly to corresponding gloss sequences without the need for manual segmentation between individual signs. Unlike earlier systems that focused primarily on isolated sign recognition or required temporal boundaries between words, this work employs Connectionist Temporal Classification (CTC) to learn the alignment between video frames and gloss labels in an end-to-end fashion, reflecting broader trends in continuous sign language recognition (CSLR) research that leverage weak supervision to handle unsegmented inputs. Two distinct architectures are explored: an LRCN-based model that feeds raw frames through a CNN-LSTM pipeline, and a Multi-Cue Network that incorporates domain-specific features—hand shape, position, and movement detected via MediaPipe—to enrich representation and combat limited data resources. By evaluating these models on benchmarks such as RWTH-PHOENIX-Weather, this study builds on recent advances in deep neural approaches for CSLR and highlights the importance of multimodal feature integration to improve recognition accuracy and address the complexity of dynamic gesture sequences.

9. Xuebin Xu, et al. The paper contributes to the evolving research on sign language recognition by incorporating semantic awareness of textual labels into the recognition process, addressing limitations in traditional vision-only approaches that often treat sign classification purely as a visual pattern problem. Traditional sign language recognition research has heavily relied on deep learning models such as CNNs and RNNs to extract spatiotemporal features from video frames, yet these methods can struggle with semantically similar signs and ambiguous visual features. By proposing a two-stage method that emphasizes the semantic features associated with label text—thereby aligning visual representation learning with linguistic meaning—the authors extend growing literature that integrates language understanding into gesture recognition to improve model discrimination and contextual accuracy. This work aligns with recent efforts that leverage semantic and language-assisted strategies in sign recognition and translation to enhance performance, suggesting that grounding visual signals in semantic label information can better capture linguistic subtleties inherent in sign languages and ultimately improve recognition efficacy.

10. Soma Shrenika, et al. The paper contributes to early sign language recognition research by implementing a template-matching-based vision system that captures static hand gestures via a camera and processes them through classical image processing pipelines to convert signs into readable text, thus facilitating communication between deaf users and non-signers. Unlike many contemporary approaches that employ machine learning and deep neural networks for feature learning and classification, this work uses pre-processing (e.g., edge detection and filtering) followed by a template matching algorithm to compare input gestures with a stored set of gesture templates and identify the best match, a method known for simplicity and interpretability in pattern recognition tasks. While template matching is effective for recognizing predefined static gestures and is easily implemented using OpenCV and Python, it reflects limitations noted in the literature—such as sensitivity to variations in lighting, hand pose, and background—that later studies address using more robust, learning-based models. By demonstrating a practical, low-complexity alternative to learning-heavy classifiers, this study highlights the utility and constraints of template-driven techniques within the broader evolution of sign language recognition research.

11. Anshul Mittal, et al. proposed the study that advances the field of sign language recognition by integrating sensor-based motion capture with deep learning to address challenges in continuous sign interpretation—extending beyond isolated sign classification toward more fluid and temporally complex sequences. Building on earlier research that employed hidden Markov models and conventional recurrent networks, this work leverages the Leap Motion sensor to precisely capture three-dimensional hand and finger trajectories and proposes a modified long short-term memory (LSTM) architecture tailored to handle the temporal dependencies inherent in sign language. Compared with purely vision-based systems, sensor-based approaches have been shown to reduce occlusion issues and improve spatial accuracy, but they often require specialized hardware; by combining these motion capture capabilities with deep learning, the paper aligns with literature exploring multimodal inputs to enhance recognition robustness. The modified LSTM effectively models the dynamic nature of signed sequences, addressing limitations in prior works related to temporal segmentation and continuity, and contributes to the broader research trajectory aimed at improving continuous sign language recognition through hybrid sensor–AI frameworks that balance spatial precision with sequence learning.

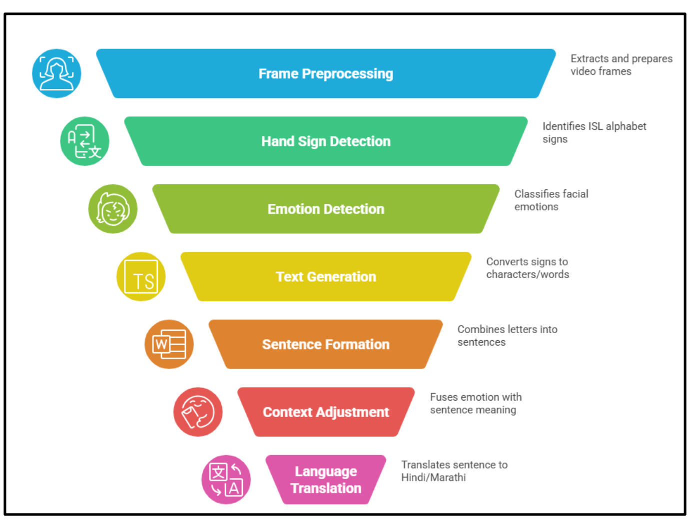
12. Amrutha K et al. proposed a paper that contributes to the growing literature on automated sign language interpretation by applying machine learning techniques to recognize static sign gestures captured via a camera, aiming to facilitate communication between hearing-impaired users and non-signers. Unlike deep learning-centric studies that employ convolutional or recurrent neural networks for hierarchical feature extraction, this work focuses on traditional ML classifiers such as SVM, k-NN, or Random Forests, using engineered features derived from hand shape, orientation, and spatial relationships to identify signs. Earlier research in the field established the efficacy of such classical learning methods for simple gesture recognition, particularly in resource-constrained environments, though these approaches often struggle with variations in lighting, background, and dynamic gestures. By implementing a machine learning-based pipeline and comparing classifier performance, this study aligns with foundational work that emphasizes cost-effective and interpretable sign recognition, highlighting both the potential and limitations of classical ML techniques relative to modern deep learning models in achieving scalable, accurate sign language recognition systems.

III. METHODOLOGY

The proposed system is a desktop application developed in Python with a Tkinter GUI that enables real-time recognition of Indian Sign Language integrated with emotion detection. The webcam captures live video frames, which are preprocessed and passed to a trained Machine Learning (ML) model for classification of hand signs (a–z) and facial emotions (seven classes). The recognized sign is converted into text format, and emotions are fused to add contextual meaning to the communication. As signs are continuously detected, they are combined to form meaningful sentences, which can then be translated into Hindi or Marathi for better regional understanding. The dataset for both signs and emotions is collected from Kaggle, and the ML model is trained and optimized to achieve accurate prediction, ensuring an efficient, user-friendly, and real-time assistive communication system for the hearing and speech-impaired community.

Fig 1. Shows the System Architecture Diagram of the system

FLOW CHART



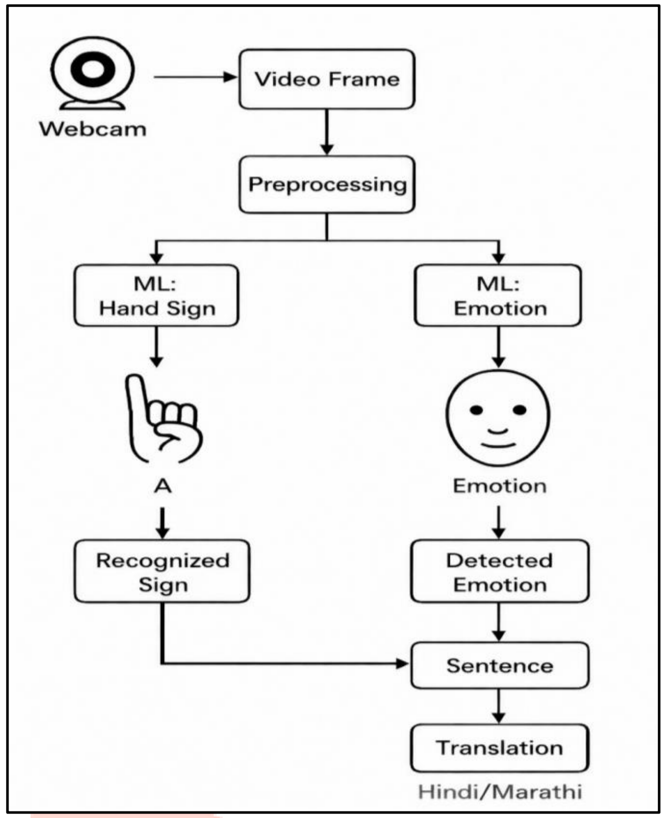


Fig. 2 Shows the Flow Chart of the System

WORKING

The system operates by continuously capturing live video from the webcam and processing each frame through two parallel modules—hand sign recognition and facial emotion detection. The hand region is segmented and fed into a trained ML model that identifies the corresponding Indian Sign Language alphabet, while the facial region is analyzed to determine the user's emotional state. The outputs from both modules are fused, allowing the system to interpret not only the sign but also the context conveyed through emotions. Detected signs are appended sequentially to build meaningful words and sentences, which are displayed on the Tkinter interface in real time. Once a complete sentence is formed, the system provides optional translation into Hindi or Marathi, enabling clearer communication for regional users. This integrated workflow ensures smooth, interactive, and real-time assistance for individuals with hearing or speech impairments.

IV. SYSTEM REQUIREMENT

SOFTWARE REQUIREMENTS

1. Python 3.8.4 Language

MODULES USED

1. Tkinter

V. CONCLUSION

This paper demonstrates the potential of integrating sign recognition with emotion detection to create a more natural and expressive communication bridge for the hearing and speech-impaired community. By combining vision-based recognition with language translation, the system not only interprets gestures but also captures emotional context, making the interaction more human-like and effective. The approach highlights the role of deep learning in enhancing accessibility tools and sets a foundation for future improvements such as larger vocabulary support, real-time mobile deployment, and integration with voice synthesis for seamless communication in diverse environments.

VI. REFERENCE

[1] Boobal A, Loyola jasmine J, Chennama Charan Kesava Reddy, Challa Akshay Reddy, Chaluvadi Bala Venkata Sai Rohith. “Real-Time Sign Language and Audio Conversion Using AI”. 2024 International Conference on Communication,Control and Intelligent Systems(CCIS) 2024, DOI: 10.1109/CCIS63231.2024.10932061.

[2] Kambhampati Sai Sindhu, Mehnaaz, Biradar Nikitha, Penumatsa Likhita Varma, Chandrasekhar Uddagiri. 2024 1st International Conference on Cognitive, Green and Ubiquitous Computing. “Sign Language Recognition and Translation Systems for Enhanced Communication for the Hearing Impaired”, DOI:10.1109/ICCGU58078.2024.10530832.

[3] D. Shofia Priyadharshini, R. Anandraj, K. R. Ganesh Prasath and S. A. Franklin Manogar 2024 International Conference on Science Technology Engineering and Management. “A Comprehensive Application for Sign Language Alphabet and World Recognition, Text-to-Action Conversion for Learners, Multi-Language Support and Integrated Voice Output Functionality”. Apr. 2024, DOI: 10.1109/ICSTEM61137.2024.10561024.

[4] Shreya Daga, Atharva Dusane, Dyuti Bobby 2024 International Conference on Emerging Smart Computing and Informatics (ESCI) AISSMS Institute of Information Technology, Pune, India. Mar 5-7, 2024. “With You - Indian Sign Language Detection and Alert System”. Mar. 2024, DOI: 10.1109/ESCI59607.2024.10497366.

[5] Arpita Acharya, Navin Patil, Utkarsh Pathak, Sumedha Bhagwat 2024 8th International Conference on Computing, Communication, Control and Automation (ICCUBEA) Pimpri Chinchwad College of Engineering (PCCOE), Pune, India. Aug 23-24, 2024. “Sign Language Translation with Fusion of Emotion Detection”. Aug. 2024, DOI: 10.1109/ICCUBEA61740.2024.10774760.

[6] Dongping Guo, Arsh Parmar, Jianye Ge, Hongmin Li, Ayush Sharma ICDLT 2024, July 15– 17, 2024, Suzhou, China. “Promoting Sign Language Awareness: A Deep Learning Web Application for Sign Language Recognition”. DOI: 10.1145/3695719.3695723. PRMCEAM, Badnera Page 13 SignTalk: An Inclusive System for Sign Language & Sentiment Detection

[7] Dhruvin Gandhi, Kushal Shah, Madhav Chandane ."Dynamic Sign Language Recognition and Emotion Detection using MediaPipe and Deep Learning ". 2022 13th International Conference on Computing Communication and Networking Technologies (ICCCNT). DOI: 10.1109/ICCCNT54827.2022.9984592.

[8] Atra Akandeh. "Sentence-Level Sign Language Recognition Framework". 2022 International Conference on Computational Science and Computational Intelligence (CSCI). DOI: 10.1109/CSCI58124.2022.00256.

[9] Xuebin Xu, Jun Fu."A two-stage sign language recognition method focusing on the semantic features of label text ".2024 20th CSI International Symposium on Artificial Intelligence and Signal Processing (AISP) 21-22 February 2024, Mazandaran University of Science and Technology, Babol,Iran. DOI: 10.1109/AISP61396.2024.10475205.

[10] Soma Shrenika, Myneni Madhu Bala ."Sign language recognition using template matching technique” DOI: 10.1109/ICCMC51019.2021.9418370.

[11] Anshul Mittal, Pradeep Kumar , Partha Pratim Roy, Raman Balasubramanian, and Bidyut B. Chaudhuri."A Modified LSTM Model for Continuous Sign Language Recognition Using Leap Motion ". (IEEE SENSORS JOURNAL, VOL. 19, NO. 16, AUGUST 15, 2019) DOI: 10.1109/JSEN.2019.2909837.

[12] Amrutha K, Prabu P."ML Based Sign Language Recognition System". (2021 International Conference on Innovative Trends in Information Technology (ICITIIT)) DOI: 10.1109/ICITIIT51526.2021.939959.