

A Systematic Review of Machine Learning Approaches for Classifying Indian Sign Language Gestures and Facial Expressions

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Abstract— Indian Sign Language is the primary mode of communication known to persons who use Indian Sign Language for people who have hearing or language deficits. Different types of machine learning models are used to broaden the scope of communication for those with impairments and illiteracy. There are numerous machine learning models for analyzing gestures, postures, and facial recognition in Indian Sign Language for single-handed and double-handed signals. The present study on hand gestures, recognition, and translation intends to build an essential foundation for developing a platform to facilitate communication for the specially-abled with anyone. Machine learning algorithms generally focus on letter recognition or a few fundamental indicators. Communication is essential for exchanging ideas, thoughts, and feelings. Sign language is a kind of communication that uses hand motions. This is aimed toward those with impairments such as muteness and deafness. Machine learning, a branch of artificial intelligence, will aid in identifying various hand motions and predicting the language created by those inputs based on those inputs[2]. Sign language has a grammar that is unique from and independent of English. When compared to English, SL allows for far more freedom in word order. Tense is marked morphologically on verbs in English, but SL (like many other languages, such as Indian Sign Language) communicates tense lexically using temporal adverbs. The structure of ISL and English differs at the phonological level as well. Signed languages, like spoken languages, include a degree of sublexical structure that includes segments and combinatorial rules; however, phonological elements are manual rather than vocal. The way spatial information is conveyed in English and ISL differs substantially. All Deaf people are illiterate in written English. As an output, the SL text can be produced. SL is just physically executed English, where English and SL share the identical linguistic structure—that one is a straight encoding of the other. Many software

designers mistakenly believe that deaf users can always access printed the English language in a user interface. Many designers feel that if auditory information is also supplied as written English, the deaf user's demands will be addressed. Prepositions such as "in," "on," and "under" are used to indicate locative information in English, as in many other spoken languages. On the other hand, SL encodes locative and motion information via verbal classifier formulations in which hand shape morphemes define item type, and the location of the hands in signing space schematically depicts the spatial relationship between two things. Thus, English and ASL differ significantly in phonological, morphological, and syntactic areas.

Keywords— Machine Learning, Image processing, Computer Vision, Indian Sign Language, Gesture recognition.

I. INTRODUCTION

Determine the primary signs and gestures included in postures for proper comprehension of the sign portrayed. Computer vision is a branch of computer science. Gesture recognition is the most crucial component for clearly identifying and using it for various applications in Indian Sign Language. This paper focuses on creating a framework that converts signs into text or video using various machine learning tools for analysis. It is highly required to understand that Indian Sign Language consists of two parts: manual and non-manual, where manual is fingers, hands, and arms, and non-manual is facial expressions and body postures. Indian sign language, in collaboration with computer software, can deal with this framework using gloves/markers or computer vision-based. Both cases solve the problem, with gloves-based devices being wearable and computer vision-based devices being expensive.

Sign language is a medium of communication used by people who cannot use their voices. It is also used by those

who cannot hear. Indian Sign Language is a language that was formally recognized as a language in 2016. It is the first language of the deaf community in India, and often it is used to ease communication between hearing people and deaf people. It is a visual language that uses specific gestures and signs to represent words. Deaf and mute people mainly use it. Sign languages are not universal, as they are regional and country-specific. India's most famous sign language is Indian Sign Language (ISL). ISL is also the only sign language recognized by the government of India. It is not clear when the first Indians began communicating with each other through hand gestures.

Nevertheless, it has been documented that deaf people in India who were hard of hearing communicate with each other before the introduction of any formal sign language to India by William Stokoe. Indian Sign Language is a communication system that uses hand shapes, orientation, and movement to convey meaning. It is an alternative language system for the Deaf people of India. Indian Sign Language (ISL) has a different grammar, syntax, and phonology from other sign languages worldwide. For example, Indian Sign Language is not just used by people with hearing problems or deaf people but also by those who can hear but cannot speak due to physical deformities like cleft lip and palate or autism spectrum disorder (ASD). It is also one of the few sign languages globally with its script, called ISYPO. ISYPO is used to write everyday conversations between deaf and hearing people and academic material such as textbooks or research papers on deaf issues. Indian Sign Language is a language that uses the hands and body to create signs. The Indian Sign Language is rooted in the gesture system used in ancient India. The sign language was formally recognized by Dr. Rudyard Kipling, who had observed Indians communicating with each other using gestures and had written about it in "Kim." The importance of this gesture system can be understood by an incident where a deaf person refuses to buy anything without signing his consent because he could not verbalize it as he could not speak English (the language). Indian Sign Language is a language for the deaf. It is the only sign language in India and is recognized as one of its official languages. The first school for teaching deaf children was set up in Kolkata in 1856. In 1913, a small community for deaf people was established in Delhi called "India's first residential institution for the deaf." In Indian Sign Language, the sign for "mother" is made with the index finger pointing to the nose and a circular motion near one's chest. In India, there are different levels of Indian Sign Language. Primary Indian sign language includes gestures for greetings, directions, simple sentences, and questions. The advanced level includes more complex sentences and phrases and idiomatic expressions.

ISL is a sign language that has been used since the 1500s. It is the only sign language indigenous to North America, and it is still used today. It is estimated that there are about 500,000 people who are fluent in ISL. There are many written records of ISL dating back to the 1500s, but it was not formally recognized as a language until the late 1800s. The first textbook on ISL was published in 1880. Indian Sign Language is not an independent language but a system of communication. The deaf people of India use it to communicate among

themselves. The sign language has its grammar, called a "signing system." Indian Sign Language does not have its own written form, but it is usually recorded with the help of symbols. The need for a writing system for Indian Sign Language was felt long ago. The first attempt towards this was made in 1880 by two Christian missionaries, Reverend F. Spencer and Reverend G. Erskine. They served in India to promote deaf education and provide sign language training to the teachers of deaf children in schools established by them. They developed a set of symbols which they called "Indian Signs." However, this effort did not succeed.

This paper is organized as follows: In section II proposed methodology is explained. In section III, the review of literature is discussed. Section IV discusses the literature review and is summarized. In Section V, Common findings are displayed. Section finally VI concludes the paper.

II. REVIEW OF LITERATURE

The research includes learning academic papers linked to keywords like machine learning, deep learning, and sign language. 'Computer vision,' sign language recognition [37], 'Deep learning,' and 'Indian Sign language' are the criteria for search on the electronic platform. In a country like India, 7.5% of individuals are speech challenged [4]. So, Several research questions are formulated to analyze the articles and extract vital information. These research questions, which seek to make data gathering better, are:

Q1: What approaches are employed to get images or frames for input the Indian Sign Language translator from static or dynamic inputs?

Q2: What strategies are combined with machine learning to establish a practical framework?

Q3: What is the best way to encourage Indian Sign Language unification?

Q4: What is the architecture of Indian Sign Language after collecting images and building sentences using a dictionary?

Q5: In Indian Sign Language, what significance do postures, gestures, and facial expressions perform?

Q6: What role do single-handed and double-handed gestures play?

An efficient criterion is used to verify and include the paper in this systematic review, as shown in fig1.

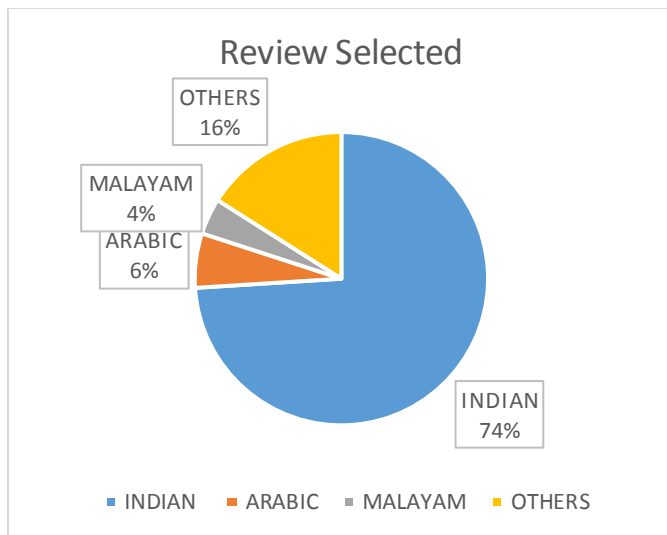


Figure 1: Review process paper distribution

The review process

In this stage, the publications are analyzed and evaluated to see whether they are relevant. The inclusion and criteria are used to lead the analysis and review. As a result, 56 articles out of the 102 previously correlated to the keywords are qualified to be used as definitive studies since they meet all of the selection criteria.

The number of ISL-related publications varies throughout time. Despite a significant rise in publishing in 2020, papers relating to the keywords appeared less often in the following years. Following the collection of papers, the eligible papers based on the research objectives are analyzed. Then, the techniques for evaluating the benefit and drawbacks are compared.

III. METHODOLOGY

This section gives an overview of the methods used and the review publications previously accepted in Indian Sign Language for data acquisition, pre-processing, segmentation, feature extraction, classification, and translation of various parameters through the database.

A. What approaches are employed to get images or frames for input to the Indian Sign Language translator from static or dynamic inputs?

Obtaining image data and its label is critical for training and testing. Data acquisition must be consistent since the test classifier demands picture data of a specific sort and form. To overcome computer vision issues, data gloves are used to avoid image acquisition [6]. Image data may be collected in several ways. It may be done manually or with the help of materials accessible on the internet. Table 1 compares and analyses some of the most frequent methods for obtaining data for ISL. The most frequent way is to use a conventional marker method or gloves or computer vision, as shown in table 1. All these methods produce a two-dimensional image. However, because the image quality is dependent on the camera, it is preferable to preprocess the images initially.

References	Image acquisition
[4][6][49]	Gloves
[1] [2][3][5][7][8] [9] [14] [16] [22] [26] [27] [28] [29] [30] [31] [32] [34] [38]	Camera
[25] [34]	Kinect
[11] [20]	HamNoSys, Stokoe, Gloss
[10]	Virtual Sign bi directional translator

Table 1: Image acquisition details

B. What strategies are employed in combination with machine learning to establish a practical framework?

The framework's many techniques are displayed and reviewed. Because of its precision, the Convolutional Neural Network (CNN) is the most commonly used approach. CNN [32], in contrast to Artificial Neural Network (ANN), adds additional convolutional layers for feature extraction[27]. KNN [28] has achieved 100% in the classification of signs [2]. The more layers it has, the higher the accuracy[18], but the more computationally expensive it becomes, as shown in table 2.

References	Machine Learning Algorithm	Remarks
[16] [18][32] [33] [26] [47]	CNN	CNN is the most used Machine Learning algorithm in Indian Sign Language recognition
[3][6][9][21]	SVM [30]	Support Vector Machine is also a widely used technology
[31]	ANN	Research can go in the way of Multi perceptron and Lepa motion [31].
[1][7][22]	Matlab [29]	These systems are helpful in terms of obtaining output for translation into text and speech

Table 2: Various Machine Learning techniques used

C. What is the best way to encourage Indian Sign Language unification?

The availability of real-time speech interpretation anywhere, at any time, is a possibly severe prospect for hard-of-hearing people to improve their language skills.

Segmentation is used to remove skin and the background [5]. A neural network image processor can liberate imaging applications from numerous limitations such as video capture, brightness, and hardware configuration [23]. Learning the surveillance network using a database collection of objects is the foundation of object recognition using neural networks. Each layer or stage consumes feature vector components as input and produces the class of objects. There is currently no resource available to assist the deaf in better comprehending many elements and expressing their views, thoughts, and ideas [41]. We investigated the challenges experienced by deaf persons in numerous aspects, such as communication with others and their counterparts from other regions of the world and the problems they face in education, comprehending technology, and transmitting their sentiments to others in this article [24].

D. What is the architecture of Indian Sign Language after collecting images and building sentences using a dictionary?

A few processes are followed from the review papers for classification to occur. Initially, Image acquisition is made using various methods like Gloves, markers, Cameras, or various Integrated development environments like Kinect[25] from Microsoft or HamNoSys [20] and Glass. The acquired images are segmented or preprocessed for extraction features [9]. After that, a machine learning algorithm like KNN [22], HMM, SVM [21], or CNN[8] is applied to get the classification. As desired in a few papers, this output is matched with the database or translated to text, video, etc. Most of the research is concentrated on illumination and background issues [1]. An efficient model is one with better accuracy[33]. Many methods use PCA and LDA [26] to reduce various variable dependencies [16]. The deficiency of a proposed model which focuses on phase bifurcation of profound learning advantages to getting a more accurate model is shown in table 3.

References	Steps Followed	Remarks
[1] [2][4][9] [12] [22] [25] [26] [28] [29] [30][44] [39] [46]	Input -> preprocessing ->Feature extraction -> Classification -> recognition -> Text or Speech	Using Eigen values and Eigenvector
[3][5][6][7][8] [18] [21][27] [42]	Input-> Preprocessing -> ML algorithm -> Recognition -> meaning	Using SVM or other methods

Table 3: Various Steps followed for the output

E. In Indian Sign Language, what significance do postures, gestures, and facial expressions perform?

References	Gesture Recognition	Posture recognition	Facial Expression
[7][9] [18] [33] [25] [28]	YES	-	-
[8][10] [11] [12] [20] [22] [43] [35]	YES	-	YES
[1] [2] [3] [4]	Simple Indian	-	-

[5] [6] [14]	Sign Language translation		
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Table 4: Reviews on Gestures, Postures, and facial expression

As per the review of the above papers, it can be characterized that few papers focus on facial expressions. Sign language detection depends on manual and non-manual signals, including gestures, postures, and facial expressions [3][7]. Being the critical component of Indian sign language sentence formation, this is a research gap in the current field that sentence formation or translation has to be the focus for clear communication. A framework must add facial expressions into account to convert a complete book or a movie to Indian Sign Language. From table 4, we can see the categorization of papers working on gestures, postures, and facial expressions.

F. What role do single-handed and double-handed gestures play?

The hand gesture, which is recognized by hand motions, is the most significant aspect of ISL [15]. Image segmentation works by restricting the data region such that the classifier only looks at the Region of Interest (ROI)[12]. The researcher must grasp what component of the image is essential at this point [40]. Table 5 displays the no of papers focusing on single and double-handed gestures and their respective accuracy [34].

Sr No	Single / Double Handed	Gestures	Recognition Accuracy
[1]	Double hand	No	Matching database efficiency
[2]	Single and Double hand	No	No
[3] [4] [5] [7]	Single-handed	No	No

Table 5: Single-Double hand gestures

IV. DISCUSSION

This paper focuses on sign language research, proposed framework, and machine learning approaches. There are many misconceptions about the ability of deaf people to communicate, which is why Everyone seeks to educate readers about the nuances of sign language. We also want to promote the potential for deaf individuals to participate and encourage recognition of Indian Sign Language. More importantly, we hope our discussion will be educational and engaging so that we can foster community engagement and conversations. Sign language is a natural mode of communication for many deaf people, but it is not officially recognized as an official language in India. This is alarming because only 18% of the population know sign language, and there are very few people who can translate between Indian Sign Language (ISL) and English. The gaps in the research are startling, too, as shown in table 6. There are limited studies on sign languages, deaf education, and deaf culture, which sometimes barriers deaf people's participation. There is also a lack of credible data on improving literacy skills among the deaf. With the increasing deaf population in India, there is a need for sign language

research for both theoretical and practical purposes. The lack of an effective communication system impedes deaf people from getting jobs, higher education, and participating in social circles. The framework is to provide a platform for communication-related to Indian Sign Language. We hope to be a place where people can learn about sign language and engage in conversations with other like-minded people.

References	Method (Related work)	Accuracy
[1][4][5][7]	Basic Methodology	Simple matching databases
[2][3][6][21][36]	KNN PCA,SVM	94-98%
[8][16][21][22][50][47]	CNN ,RNN	75-100%
[10]	Virtual Sign bi directional translator	90%

Table 6: Accuracy of applied techniques

V. COMMON FINDINGS

There have been no studies on the status of Indian Sign Language among the general community, which is utilized by deaf individuals [11]. The Indian Deaf community, which the mainstream has ignored chiefly, has attempted to make its presence known via literature [13]. They have been promoting their work by hosting art exhibitions and sign language workshops to highlight the value of sign language as a medium of education in schools [45] and universities[14]. They think that they may be able to affect a transformation in society's attitude toward them [36]. Many deaf adults with English reading challenges are fluent in Sign Language, a natural language with a linguistic framework separate from English [47]. Facts about Sign Language. Sign languages are NOT the same all over the globe and are independent of the spoken language of the region. • Sign languages are more than simply gestures and imitation; they also have their syntax.

VI. CONCLUSION

In this paper, we have reviewed 50 papers, out of which we discovered that the basic steps followed are image acquisition, preprocessing, segmentation, feature extraction, and classification using machine learning. Nevertheless, CNN is widely used with accuracy as a classifier. We have observed that image frames are better for static image acquisition. A universal language with a dictionary and framework that develops sentences is the future scope of this field. Images so captured have various drawbacks like lightning, background, size angles, and segmentation issues. Facial expression and postures are not included in the final sentence formation for Indian Sign Language.

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