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Analysis of the Efficacy of Real-Time Hand Gesture Detection with Hog and Haar-Like Features Using SVM Classification

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Abstract—The field of hand gesture recognition has recently reached new heights thanks to its widespread use in domains like remote sensing, robotic control, and smart home appliances, among others. Despite this, identifying gestures is difficult because of the intransigent features of the human hand, which make the codes used to decode them illegible and impossible to compare. Differentiating regional patterns is the job of pattern recognition. Pattern recognition is at the heart of sign language. People who are deaf or mute may understand the spoken language of the rest of the world by learning sign language. Any part of the body may be used to create signs in sign language. The suggested system employs a gesture recognition system trained on Indian sign language. The methods of preprocessing, hand segmentation, feature extraction, gesture identification, and classification of hand gestures are discussed in this work as they pertain to hand gesture sign language. A hybrid approach is used to extract the features, which combines the usage of Haar-like features with the application of Histogram of Oriented Gradients (HOG).The SVM classifier is then fed the characteristics it has extracted from the pictures in order to make an accurate classification. A false rejection error rate of 8% is achieved while the accuracy of hand gesture detection is improved by 93.5%.

Keywords-Hand Gesture, Sign language, Support Vector Machines,Indian Sign Language, Histogram of Oriented Gradients

I. INTRODUCTION

Nowadays artificial intelligence (AI) become predominant, hence the necessity has increased for an interface that supports Man-machine interaction (MMI)[1]. MMI decodes the process of creating machines that can do remarkably human jobs by studying the phenomena that surround their creation and use [2]. Progression in the field MMI researcher's succession in various similar fields, as represented in Fig. 1. The demand increases rapidly for interaction with virtual resources in play station games and virtual reality, for AI robotic teleportation surgery, complex machinery operations, Manet's and augmented reality are all grown important to next level.[3]

MMI systems merely depend on the gesture identification.[4]While the unimodal channel excels at things like body movement tracking, facial expression identification, gaze detection, and gesture recognition, the multimodal channel, which comes later, combines these and other inputs to create novel forms of human-to-human communication [5]. Though multimodal can be applicable in robotic surgery, virtual classroom, e-commerce, sign language recognition etc,[6].

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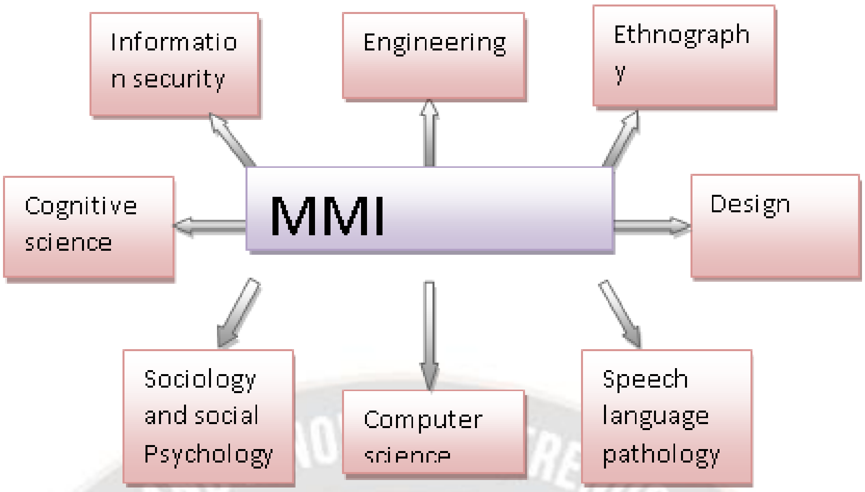

Fig. 1. Man-Machine interaction and relevant research fields

Communication that we use in our daily life is vocal.[7]The Deaf and the Dumb utilise Sign Language as a means of communicating with hearing people.[8] The research in sign language hand gesture recognition can be classified in to contact based method or vision-based method.[9] Contact based or data glove method uses gloves or instrumental methods for data collection whereas Vision based method uses bare hands or images from database or images captured by using camera.[10] Gestures can be of different forms like hand gestures, facial expressions, iris gesture etc.[11] Sign language deals with hand gesture recognition. Gestures can be static or dynamic. Static gestures include posture of hands and dynamic gestures uses motion of the hand.[12], [13]Body language, including facial emotions and hand movements, are important to sign language. There are several sign languages to choose from, including American Sign Language (AMSL), British Sign Language (BSL), Spanish Sign Language (SL), Pakistani Sign Language (PSL), Taiwanese Sign Language (TSL), Indian Sign Language (ISL), South Korean Sign Language (SKSL), etc.[14], [15]. Figure 2 represents different types of hand gestures alphabets used in sign languages. In our work, we mainly concentrate on Indian sign language alphabets from 0 to 9. From the captured images a video format is made and given as input.

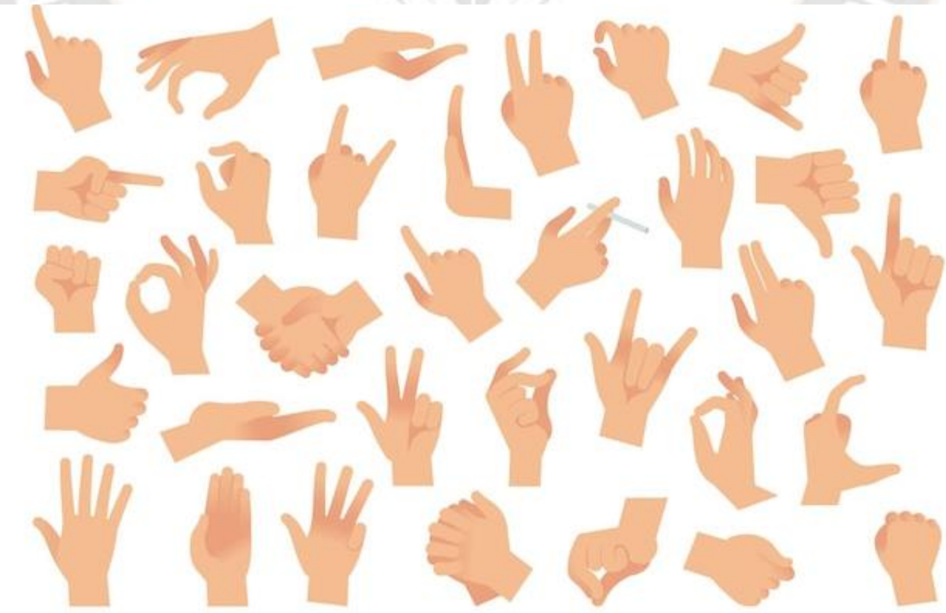

Figure 2: Different types of hand gestures used in sign language

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Medical, gaming, appliance, vehicle, sign language representation, computer, and many more communication uses are just a few of the many potential destinations for a hand gesture detection system.

a.Identifying Sign Language

Deaf and mute persons utilise a language called sign language [16]. They are able to interact with the outside world thanks to sign language. Famous sign languages include Spanish Sign Language (SSL), Indian Sign Language (ISL), British Sign Language (BSL), etc. [17], [18] The Indian Sign Language (ISL) is used by the country's inhabitants; it has regional variations in signs but is otherwise grammatically consistent. People with disabilities use this sign language to communicate, whereas the general public uses a separate set of signs [19]. Sign languages use hand motions as their written characters. A translator is essential for effective communication between hearing and deaf individuals [42]. A robotic arm is a major project in the modern computing industry [43].

b. Regulating Play

Augmented reality with 3D modelling allows gamers to manipulate in-game 3D features using hand motions. An appropriate, effective, and user-friendly interface is provided through the use of virtually controlled hand movement. [20]

c. *uses in medicine*

Medical applications and healthcare increasingly rely on wearable hand motion detection systems. Controlling medical equipment from a distance and navigating through a contactless MRI or X-ray machine are also possible using hand gestures [21]. For real-time interpretation of user gestures in a medical data visualisation context, a vision-based hand gesture recognition system is deployed. [22]

d. Management of domestic machinery

Home electronics like televisions, stereos, and music players can all be operated with a simple wave of the hand thanks to hand gesture recognition technology. Gesture controls for the TV are available. Switching channels, turning up the volume, and turning it off can all be done with a wave of the hand. It also functions as a music player remote, allowing the user to play, pause, skip tracks, etc [23].

e. Robotics Management

Using gestures to direct a robot's movements is one of the field's most intriguing use cases. Robots may be directed to move ahead, stop, perform activities, etc. via simple hand gestures. [24] They may be operated using a variety of finger writing movements. [25].

f. Management of the Visual Editor

Pre-processing procedures for drawing and altering graphics are tracked and located using a hand gesture detection system controlled by the graphic editor's control system. Gestures are used for drawing forms like as rectangles, ovals, circles, etc., and lines such as verticals and horizontals, as well as for editing commands such as copy, delete, move, swap, II. LITERATURE SURVEY

In order to improve the user experience with computers, a lot of researches are going on hand gesture recognition and are continuously working towards bringing the static and dynamic gesture recognition approaches, when interacting through the gestures. Background alterations as a result of lighting shifts, noise, etc., are studied in literature reviews, as data glove based and vision-based techniques are available depending upon the application some require physical touch and some variations include dealing with special expressions etc.

In 2016 Cheok Ming Jin et al proposed a mobile application which translates American Sign Language and uses SURF features[27]. 16 classes of alphabets are used as input images and SVM classifier [28] is used for classification purpose. They obtained an accuracy rate of 97.13%. Some researchers use Kinect sensor [29], [30] for capturing the image which gives better image acquisition as there occur different complication in image capture due to illumination changes, different background, noise etc., this in turn affect the accuracy level as it classifies correctly. Jayashree et al, in the work proposed hand gestures that are static in nature and uses American Sign Language system were used 26 alphabets of ASL using feature extraction method like Edge Orientation Histogram (EOH) [31] and obtained an accuracy of 88.2%.

In 2015 J. Wu, Z. Tian, L. Sun et al, proposed real time sign language using EMG signal for American Sign Language [32]. They used data acquisition device with many wires. So it is not comfortable and uses 10 features for extraction, obtained accuracy of 91.73%.Many algorithms like Principal component analysis (PCA) [33], Otsu's algorithm [34], KNN algorithm [35], feature fusion [36] etc. are used for feature extraction methods. In 2021 Neethu P S et al., uses SVM classification and distance transform method to classify hand gesture recognition and obtained an accuracy of about 97 to 99 % in three different datasets[37].

Different classification techniques were utilised, including support vector machines (SVMs), support vector machines (HMMs), and support vector entropies (SIFTs). The SVM model achieved 97% accuracy, the ANN model 86%, and the HMM model 79%. [38].

Nyirarugira et al. (2016) offered hidden Markov model, logistic regression, and particle swarm optimization classifiers. HMM had 93.3% accuracy, LCS 94%, and PSO 94.2% [39]. PCA-based reduced deep CNN features were proposed for

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immobile hand gesture recognition (Sahoo et al., 2019). This reduces unneeded traits in their feature vector. They used American Sign Language (ASL) numbers and alphabets and attained 95% and 92.6% accuracy [40]. Translators help hearing and deaf people communicate. [43].

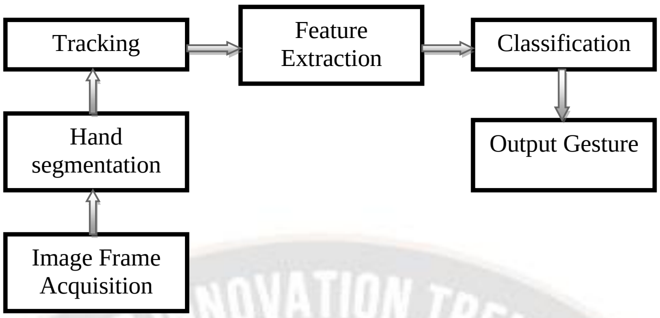

Fig. 2: General stages used in Hand Gesture Recognition System

III. Methods And Materials

The dataset used for this work is created by our own. We have captured single hand sign images of 5 different persons considering 0-9 numerals of 10 classes with total of 500 images. 350 photographs were used in the training phase and 150 images were used in the testing phase. Figure 3 displays a sample of the photographs that were used.

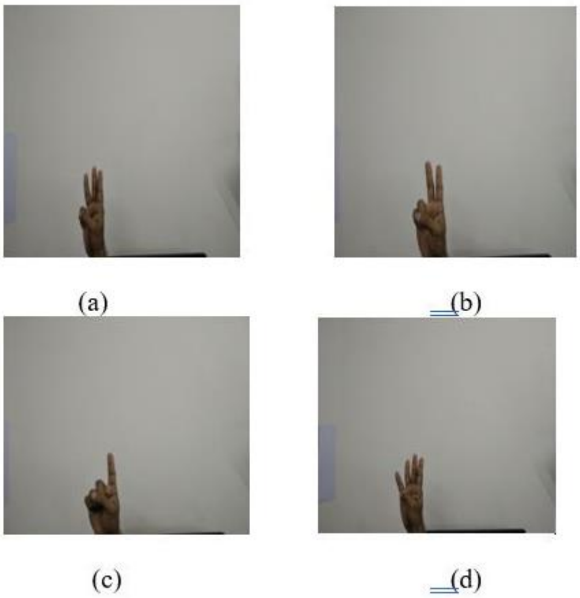

Figure 3 Sample of input images

3.1 Preprocessing

The categorization rate must be improved, thus this is a crucial step. The gesture must be separated from the background in a finger gesture recognition system in order to be processed effectively.In various systems, extraction of region of interest has been a major problem which in turn affects the recognition accuracy. The above drawback can be overcome by utilizing better pre-processing technique along with proper feature extraction strategy which enables the system to recognize gesture effectively. Using edge detection and morphological procedure, hand gesture is extracted from the main image. Morphological operation can be of two categories. It includes basic operations and the derivative. The basic morphological operations are dilation, erosion etc. and the derivative operations include close, open skeleton etc. Edge detection includes finding the boundary region from the neighbouring region that differs from each other in their grey level value.

3.2 Extraction of features

Finally, we extract features from that picture after doing pre-processing. Haar-like features and Histogram of Oriented Gradients (HOG) [41] features may be coupled for feature extraction, improving hand gesture recognition accuracy from 85% to 93.5% while reducing the false-negative rate to 8%.

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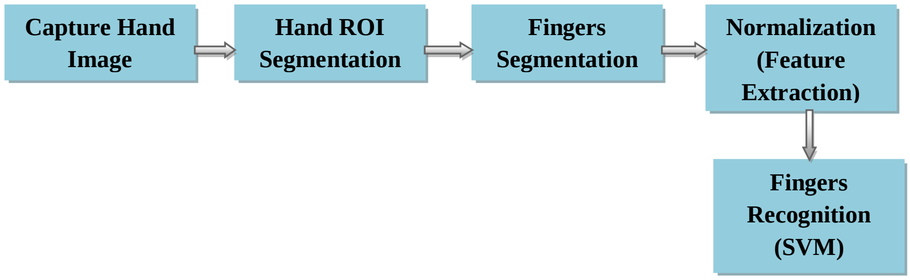

Figure 4 Stages of hand gesture recognition system

Features of a hand picture are retrieved during the process of feature extraction and the step wise procedure used for extracting the image and classification method is shown below:

- Take a video of hand gestures by webcam and store it in a PC
- Divide the video into number of frames
- Read the data from images by using in read as keyword in Matlab (will be appear as a matrix).
- Remove the noise in images by using filters
- Gesture has to be extracted from the background for effective processing using edge detection and morphological procedure.
- Feature extraction can be performed using histogram of oriented gradients, will be appear as single array for an each and every input image.
- Then we have to give all the features as input to multiclass support vector machine and trained
- Finally compare with trained data of SVM with original images and print the results as in the form Indian sign language

3.3 Classification

The classification is a major step required in gesture recognition system. Classification accuracy remains to be a major consideration in any recognition system. Less classification accuracy leads to misclassification of gesture which in turn deflects in proper communication of messages. To overcome the drawback, effective classification technique has to be developed. Classification will be accomplished with the help of a multiclass support vector machine (SVM). When it comes to classification, SVM has a wide margin of error. It is a machine learning technique that makes use of a decision boundary between classes that is geographically separated from any given location in the training data. The classification results are then used with Indian Sign Language (ISL).

For tasks like classification and regression, try using a Support Vector Machine (SVM), a supervised learning technique. Support vector machine excels in high dimensional settings, which is one of its many benefits. It employs a smaller selection of training points (called support vectors) and requires less memory than other methods. When the number of dimensions exceeds the number of samples, this may be a useful tool.

IV. Results And Discussion

The suggested approach was evaluated on our own picture library with 5 distinct people displaying varied motions.The total images in the database includes 500 images where 350 images are used in training and 150 images in testing phase. The images are divided in to 10 different classes.

The suggested method was tested using a variety of hand gesture indications. The system's output is shown in the image below. Figure 2 depicts the ROC curve for several classes.

Figure 4: Stages of hand gesture recognition system

Figure 5: Training hand gestures with different gestures

Table 1 The prediction rate on test images

Class	Accuracy in %
0	100
1	100
2	90.3
3	93.75
4	93.75
5	96.9
6	78.1
7	64.5
8	93.5
9	96.77

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Class 6 and class 7 has lower prediction rates compared to other classes. Class 6 and class 7 are erroneously recognized as class 4 and class 3 respectively. The comparison of performance metrics such as precision, recall and f1-score are shown in Figure 6

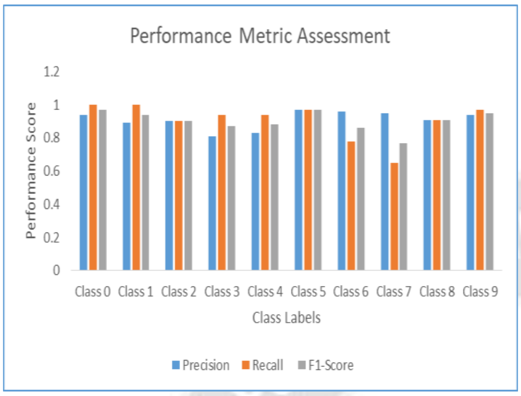

Figure 6. Comparison of performance metrics among classes

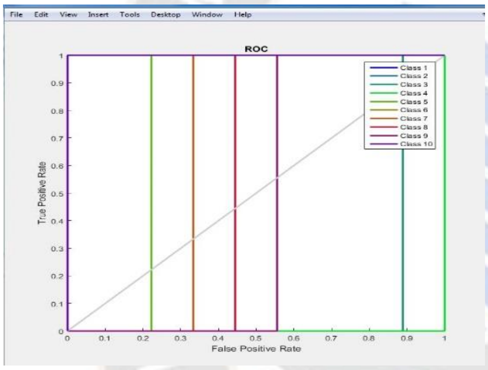

Figure. 7. Graph between false positive rate and true positive rate for different class

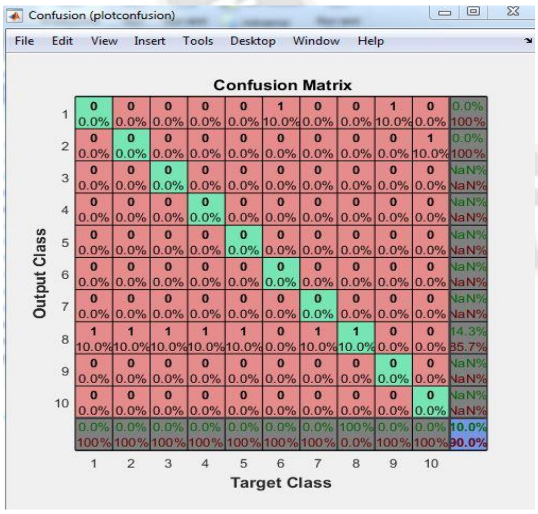

Fig. 8. Confusion matrix between target class and output class

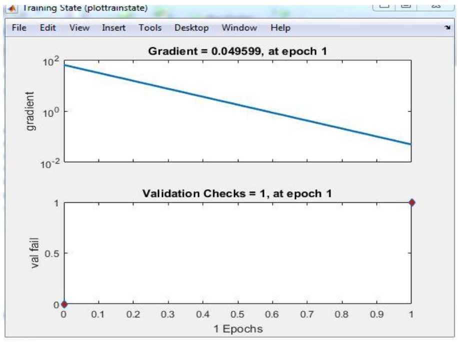

Figure 9. Plot of training state validation check

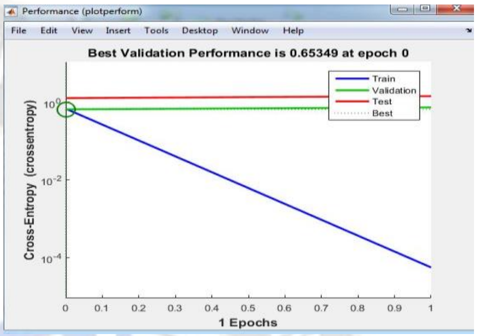

Figure 10. Performance plot

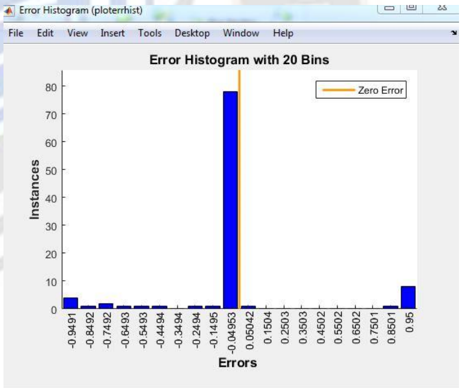

Fig.ure11. Error Histogram

Table 2 Comparisons of proposed methodology in terms of evaluation parameters with state of art methods

Authors and Year	**Methodology**	**Performance evaluation parameters (%)**		
		Sensitivity (%)	**Specificity (%)**	**Accuracy (%)**
Methodology used (In this paper)	Haar like features+ histogram-oriented features + SVM classification approach	96.5	97.1	98.4
Kalam et al., 2019	2-layer CNN	95.2	96.8	97.28
Chaikhumpha et al. (2018)	Hidden Markov Models	90.5	91.7	91.6
AthiyaMarium et al. (2017)	Convexity algorithm	87.4	80.1	85.6
Neethu P S et al. (2021)	Support Vector Machine	87.1	77.5	97.8
Zuocai Wang et al. (2018)	Particle Filtering Method	92.1	84.7	90.6

Comparisons of the proposed work's performance to the state of the art are taken into account for metrics such as sensitivity, accuracy, and specificity. Also, the planned work is seen to be more accurate than the alternatives.

V. CONCLUSION

Hand gesture identification leads in the research area in man-machine interaction, utilization of gesture based concepts have a efficient organizing in helping humans in their daily works. Accurately identifying gestures is time-consuming due to factors such as variations in the complicated structure of the backdrop, shadowing effect, reflection, etc. People who are deaf or otherwise unable to utilize spoken language communicate with the outside world via the use of hand gestures in a kind of sign language. Numerous alphabets and numerical systems are used in Indian sign language. Using support vector machines, we suggested a new method for recognizing Indian Sign Language hand gestures in real time.In the proposed work, the numerals from 0 to 9 are considered and from the images of the input a video is created and is given as input. Feature extraction methods like Haar like features and Histogram oriented gradients is used. Then it is given to SVM classifier for classification and the output is obtained. The hand gesture recognition rate is 93.5% and error rate is decreased to 8%. The major difficulties in obtaining the input image is that there is a greater similarity between the alphabets. Our future work will include more alphabets that use dynamic recognition.

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