Available online at www.elixirpublishers.com (Elixir International Journal)

Image Processing

Elixir Image Processing 66 (2014) 20526-20534

ISSN: 2229-712X

An Efficient method for Sign-Gestures Language Data acquisition and Recognition

Pravin R Futane[1,*], R. V. Dharaskar[2] and V. M. Thakare[3]

[1]Department of Computer Engineering, Amravati University, Amravati, Maharashtra, India and Department of Computer Engineering, Sinhgad College of Engineering, Pune, Pune University, Maharashtra, India.

[2]Department of Computer Engineering, MPGI Group of Institutions, Nanded, Maharashtra, India.

[3]Department of Computer Science, Amravati University, Amravati, Maharashtra, India.

ARTICLE INFO

Article history:

Received: 7 November 2013;

Received in revised form:

22 December 2013;

Accepted: 2 January 2014;

Keywords

Data Acquisition,
Neural Network,
Shape Features,
Aspect ratio,
Sign,
Gestures.

ABSTRACT

Fast and robust analysis of hand gestures has received increasingly more attention in the last two decades. Sign language forms a major communication channel among the deaf people. Although they successfully communicate with each other when using sign language, they face many difficulties when they try to communicate with hearers, especially those who are unfamiliar with the sign language. In this paper we have designed a frame work for analyzing and recognizing the sign gesture language. The proposed method comes across different steps where image acquisition is done first. After image acquisition, segmentation process is carried out. The segmentation process used is the HSI segmentation. Next the images are made free from noise by performing the noise removal process using median filters. Next step is the feature extraction and recognition. For feature extraction, the feature vectors containing information about the aspect ratio, holes etc are extracted along with the shape features. The proposed method proves to be more efficient in data acquisition using sign gesture.

Introduction

Sign language is the natural language of deaf and hard of hearing people used for everyday communication among themselves. Although different in form, it serves the same functions as a spoken language. Spread all over the world, it is not a universal language. Regionally different languages have been evolved such as American Sign Language (ASL) and German Sign Language (DGS) [7]. The American Sign Language (ASL) is a visual-gestural language used by deaf people in North America and in other countries around the globe. Over half a million people use ASL to communicate with each other as their primary language. ASL recognition systems can be used for education of children or newly hearing impaired [18]. Sign Language is a communication system using gestures that are interpreted visually. Many people in deaf communities around the world use sign language as their primary means of communication. These communities include both deaf and hearing people who converse in sign language. But for many deaf people, sign language serves as their primary language, creating a strong sense of social and cultural identity [17]. Wherever communities of deaf people exist, sign languages develop. As with spoken languages, these vary from region to region and represent complete languages not limited in expressiveness [3].

Linguistic research in sign language has shown that signs mainly consist of four basic manual components hand configuration, place of articulation, hand movement, and hand orientation. Additionally, non-manual components like facial expression and body posture are used [8]. Since early childhood is a critical period for language acquisition, early exposure to Automatic Sign Language is key for deaf children's linguistic development. Ninety percent of deaf children are born to hearing parents. Most of these parents do not know or are not fluent in sign language. Often a child's first exposure to signing is at school [4]. Generally there are two ways to collect gesture data for recognition. Device based measurement which measures hand gestures with equipment such as data gloves which can archive the accurate positions of hand gestures as its positions are directly measured. Secondly, vision-based technique which can cover both face and hands signer in which signer does not need to wear data gloves device [9]. Gestures are destined to play an increasingly important role in human-computer interaction in the future. Humans use gestures in their everyday communication with other humans, not only to reinforce the meanings that they convey through speech, but also to convey meaning that would be difficult or impossible to convey through speech alone. Furthermore, gesture recognition is a requirement for the virtual reality environments, where the user must be able to manipulate the environment with his/her hands [10].

There is an extensive literature about methods and systems for gesture recognition in general, and hand gesture recognition in particular, such as, systems for the recognition of 3-D and 2-D gestures captured by different devices (data gloves, cameras etc.) , methods based on fuzzy logic and fuzzy sets ,neural networks ,hidden Markov models, hybrid neuro-fuzzy methods [1]. The gesture recognition is also used in various types of process. In microcontroller based gesture recognition, the use of computer interfaced data gloves worn by a disabled person who makes the signs. The computer analyzes these gestures, minimizes the variations and synthesizes the sound for the corresponding word or letter for normal people to understand [16]. Gesture recognition with a time-of-flight camera, a camera based gesture recognition system for automotive applications are performed [2].Vision based Taiwanese Sign Language, a sequence of signs and non-signs are employed. Continuous sign language consists of a Hold and Movement segments [15]. Hand

Tele:
E-mail addresses: pravinfutane9@gmail.com

Gesture Recognition using a Range Camera, this gesture recognition method has wide applications including human robot interaction, intelligent rooms, virtual reality and game control [12]. Hand-gesture Extraction and Recognition from the Video Sequence Acquired by a Dynamic Camera, focus on dynamic gesture analysis, i.e. extracting the trajectories of hand gestures (both one hand' and two hands' gestures) and recognizing the hand gestures from the extracted trajectories. More specifically, hand gestures are observed by the camera attached to a mobile robot [11].

The rest of the paper is organized as follows. Section II explains the researches that are related to our proposed method. Section III shows our proposed method for data acquisition and recognition using sign gesture. Section IV explains the result of the proposed methodology and finally Section V concludes our proposed method with suggestions for future works.

Related Researches

Numerous researches have been proposed by researchers for acquisition and recognition of data from sign gesture. In this section, a brief review of some important contributions from the existing literature is presented.

Farid et al.[5] have proposed an approach for recognizing static and dynamic hand gestures by analyzing the raw data streams generated by the sensors attached to the human hands. They utilized the concept of 'range of motion' in the movement of fingers and exploit this characteristic to analyze the acquired data for recognizing hand signs. Their approach for hand gesture recognition addresses two major problems: user-dependency and device-dependency. Furthermore, they showed that their approach neither requires calibration nor involves training.

Malassiotis et al. [6] have proposed a hand posture recognition system using 3D data. The system relies on a 3D sensor that generates a dense range image of the scene. The main advantage of the proposed system, compared to other gesture recognition techniques, was the capability for robust unconstrained recognition of complex hand postures such as those encountered in sign language alphabets. This was achieved by explicitly utilizing 3D hand geometry. Moreover, the proposed approach does not rely on color information, and guarantees robust segmentation of the hand under varying illumination conditions, and scene content. Several 3D image analysis algorithms are presented, covering the complete processing chain: 3D image acquisition, arm segmentation, hand–forearm segmentation, hand pose estimation, 3D feature extraction, and gesture classification.

Sign language forms a communication channel among the deaf; however, automated gesture recognition could further expand their communication with the hearers. Vasiliki et al. [13] have proposed a data from five-channel surface electromyogram and 3-D accelerometer from the signer's dominant hand were analyzed using intrinsicmode entropy (IMEn) for the automated recognition of Greek sign language (GSL) isolated signs. Discriminant analysis was used to identify the effective scales of the intrinsic-mode functions and the window length for the calculation of the IME that contributes to the efficient classification of the GSL signs.

Ayoub et al. [14] have proposed an automatic gesture recognition system using different types of cameras in order to compare them in reference to their performances in segmentation. The acquired image segments provide the data for further analysis. The images of a single camera system are mostly used as input data in the research area of gesture recognition. In comparison to that, the analysis results of a stereo color camera and a thermal camera system are used to determine the advantages and disadvantages of these camera systems. On this basis, a real-time gesture recognition system was proposed to classify alphabets (A-Z) and numbers (0-9) with an average recognition rate of 98% using Hidden Markov Models (HMM).

Corneliu Lungociu [19] have proposed a method on the problem of recognizing in real time the sign language used by the community of deaf people. The problem was addressed using digital image processing methods in combination with a supervised learning approach to recognize the signs made by a deaf person. For the recognition step, an artificial neural network would be used. The main goal was to show that a good performance could be achieved without using any special hardware equipment, so that such a system could be implemented and easily used in real life. An experiment was provided and directions to further improve their work are also emphasized.

Automatic speech processing systems are employed more and more often in real environments. Although the underlying speech technology was mostly language independent, differences between languages with respect to their structure and grammar have substantial effect on the recognition systems performance. Riad et al. [20] have presented a review of the latest developments in the sign language recognition research in general and in the Arabic sign language (ArSL) in specific. They also presented a general framework for improving the deaf community communication with the hearing people that was called SignsWorld. The overall goal of the SignsWorld project was to develop a vision-based technology for recognizing and translating continuous Arabic sign language ArSL.

Proposed Methodology For Sign Gesture Data Acquisition And Recognition

Sign language is the usual language used by the deaf people for communication purpose. Even though they properly communicate with each other by using Sign Language, they face many difficulties when they try to communicate with people who can hear, especially those who are not familiar in Sign Language it is like sensing the existence of an invisible communication wall. Hence an efficient method should be developed to acquire and recognize the sign gesture languages. In our proposed work we have designed a frame work for analyzing and recognizing the sign gesture language. Here inputs are selected from multiple input sources. The input gestures are taken with the help of image acquisition process where camera is used to acquire the image of the sign gesture. Our proposed system aims at bridging communication gaps between the deaf community and other people. The flow diagram of various steps involved in our sign gesture recognition is shown in Fig 1.

Image Acquisition

The first and foremost step involved in our proposed method is the conversion of video into frames which is used for the further process. From the input video the frames are separated and those frames are processed in the further steps like noise removal and feature extraction. The acquired image which is in RGB is then converted into HSV. The HSV (Hue, Saturation, Value) color components are more related to human perception and hence the color histogram extraction is based on HSV color space. Normally based on S component, the color quantization in HSV color space separate gray bins from others and divides the other equally.

The general transformation is given by

$$\begin{cases} H_y = H_x \\ S_y = S_x \cdot V_x \\ V_y = V_x \end{cases} \quad (1)$$

Once the image acquisition process is completed the next step of our proposed method is followed which is the noise removal stage from the acquired image.

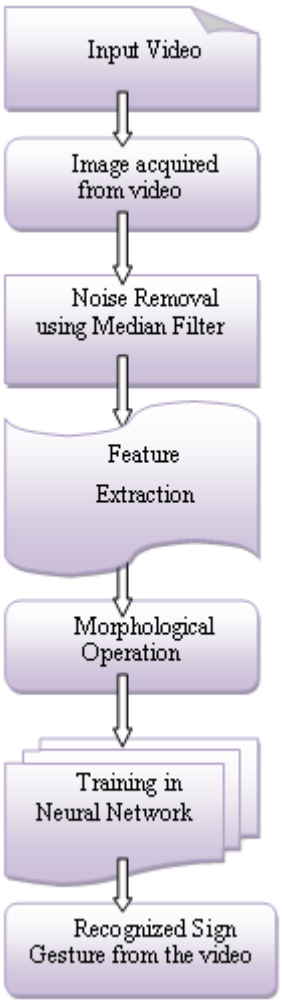


Fig. 1. Flow diagram for Proposed Sign Gesture Recognition

Noise removal Using Median Filter

Anything apart from the hand forming the gesture was considered as noise. Sometimes when only one hand was being used to form the gesture the second hand would come in the picture creating noise. Basically the noise removal can be performed with the help of filters. Various types of filters are available for the noise removal process like mean filter, Gaussian filter, median filter etc. To produce high quality images, for high level processing purposes such as edge detection, noise reduction is very helpful and often required. The median filter is mainly utilized method for such purposes. The median filter is concerned with each pixel and assures it fits with the pixels around it. Hence it helps in filtering out missing or damaged pixels. It is especially effective for pictures with salt and pepper noises, which are often results of electronic noise during transmission.

In our proposed method we utilize median filter for the noise removal. Noise suppression or noise removal is an important task in image processing. The median filter is often applied to gray value images due to its property of edge preserving smoothing. In the median filtering operation, the pixel values in the neighborhood window are ranked according to intensity, and the median becomes the output value for the pixel under evaluation. Thus following steps were used to remove the noise from images,

In median filtering, the neighboring pixels are ranked according to brightness and the median value becomes the new value for the central pixel. Median filters can do an excellent job of rejecting certain types of noise, in particular, "shot" or impulse noise in which some individual pixels have extreme values. The general expression for the median filter is given as per the below eqn,

$$F_m(a_1, a_2 \ldots\ldots a_N) = MIN(\sum_{j=1}^{N} \|a_1 - a_j\|, \ldots\ldots \sum_{j=1}^{N} \|a_N - a_j\| \quad (2)$$

Using Eqn 2, the median filtering is performed to remove the noise from the acquired image. Once the image is made free from the noise it is used for further process like feature extraction.

Hand detection and gesture recognition is used in many helpful applications. As the skin color can be much efficiently differentiated in the YCrCb Color Model so this model is preferable than RGB and HSV. For a more efficient detection, implementation of a background subtraction algorithm is used to differentiate between skin like objects and real skin colors. Initially, a frame is captured with only the background in the scene, after that, for every captured frame, each pixel in the new frame is compared to its corresponding one in the initial frame, if they pass a certain threshold according to specific algorithm computations, then this pixel is considered from the human body and it will be drawn in a new frame with its original color. If this pixel is below the threshold, then those two pixels are considered the same and they are considered as background so the corresponding pixel will take a zero color in the

Feature extraction

When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant then the input data will be transformed into a reduced representation set of features. Transforming the input data into the set of features is called feature extraction .Feature extraction is the process by which image features are extracted and used to represent concisely the image visual content [21]. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. Various features are present in the images which can be extracted for proper differentiation of any objects from its background such as the texture, color, edges etc. As per the proposed technique, we extract the feature like shape feature and then the aspect ratio is calculated.

Shape feature Extraction

Shape is an important visual feature and also it is one of the primitive features for image content explanation. The shape of an object is an important and basic visual feature for describing image content. Shapes are often the arch types of objects belonging to the same pattern class and can be used in a wide range of practical problems, such as document analysis, object detection etc.

Let X be the image database, which contains images of dimension $P \times Q$. For the filterization process, the image X is converted to gray scale X_g from RGB color space. Let, X_R X_G, X_B be the R, G, B weights of the image X then,

$$X_g = 0.2989 * X_R + 0.5870 * X_G + 0.1140 * X_B \quad (3)$$

The equation (3) which is known as the Craig's formula is applied for the conversion of RGB to gray scale image and then the mean filter is applied on the converted gray scale image X_g for the removal of noises. The mean filter smoothens the image data, thus the noise has been eliminated. Using the grey level values, this filter performs spatial filtering on each individual pixel in an image in a square or rectangular window surrounding each pixel. And then the filtered image is clustered to identify the various regions in the image.

This can be discovered by identifying groups of pixels that have similar gray levels, colors or local textures utilizing clustering in the image analysis. Clustering is a method of grouping data objects into different groups, such that similar data objects belongs to the same group and dissimilar data objects belongs to different clusters. For clustering process, numerous techniques exist and among them a vital role is played by the k means clustering method. For many practical applications, the k-means method has been shown to be effective in producing good clustering results. In this work, we use k means clustering to identify the various regions in the image. The denoised image X_g is then clustered by means of k means clustering. The input of k means clustering involves Denoised image X_g with $P \times Q$ pixels. The steps involved in the k means clustering process is as follows,

At first step arbitrarily select the K data items from the input as initial centroids and repeat the steps. Assign the remaining data items apart from the selected initial centroids to the cluster K, which has the closest centroids. Calculate the new centroids for each cluster until convergence occurs. After applying the k means clustering algorithm, the clustered regions of the denoised image X_g is identified. Then, utilizing level set method algorithm the diverse the shape present in the clustered regions of the image X_g are identified. The steps performed by the level set method are shown below,

1. Smoothing: The k clustered regions of the image X_g are blurred in order to remove the noises
2. Finding gradients: Then the edges of the clustered regions are marked wherever the gradients of the image possesses large magnitudes.
3. Non-maximum suppression: Only the local maxima of the clustered regions in the denoised image X_g should be marked as edges.
4. Double thresholding: Potential edges of the clustered regions of the image X_g are determined by a thresholding process.
5. Finally, the edges of the diverse clustered regions have been determined by suppressing all the edges which are not connected to a very certain edge.

Hence the edges of the clustered k regions are tracked and then the edges are smoothed for sharpening, in order to remove the number of the connected components that occur unnecessarily in the clustered regions. Therefore the diverse shapes which exist in the image X_g are extracted and the shape feature is retrieved from the image X_g. Subsequently, the shape feature of the diverse images existing in the database are also extracted and stored as a shape feature vector set S_f. Ratio of height to width of the window which is being selected for processing. This feature helps in extracting tall and wide gestures. The aspect ratio helps in extracting those alphabets which has wide gestures. The holes are the black regions that are enclosed by the gray region. The holes are normally used while extracting the alphabets like P, Q, and R.

The above method of the shape feature extraction provides accurate feature extraction for the sign gesture recognition. These features help in recognizing the sign gesture that is shown by the person. The feature extracted output is then processed with morphological operation which helps to provide better image output with less distortion regarding the appearance of the particular image being processed.

Morphological operation

Once the feature extraction is done morphological operation is performed. Morphological operations are affecting the form, structure or shape of an object. They are used in pre or post processing or for getting a representation or description of the shape of objects/regions. A set of functions that are valuable for processing and decomposition of shapes in arbitrary dimensions is provided by the mathematical morphology. Set-theoretic operations like union and intersection are used to define morphological operations. The two inputs given to morphological operation are binary image and structuring element. In our proposed method we use two functions of morphological operations like erosion and dilation. After adjusting the contrast and intensity of the image I, the image is converted to the binary form I_b. Then, by applying eqn (4) an enhanced image is obtained through the morphological operation 'imerod' that utilizes the structuring element S.

$$I_b \Theta S = \bigcap_{j \in S} A_{-j} \quad (4)$$

The above expression is used for calculating the erode function. Also by applying eqn (5) an enhanced image is obtained through the morphological operation 'imdilate' that utilizes the structuring element S.

$$I_b \oplus S = \bigcup_{j \in s} A_{-j} \quad (5)$$

The above expression is used for calculating the dilate function. By using these morphological operation maximum intensity pixels of the image alone is selected. Thus, the operation employed contrast and intensity adjusted image is further enhanced by utilizing the morphological operation. The output image obtained from the morphological operation is then compared with the black and white image of the input. By using these morphological operation maximum intensity pixels of the image alone is selected. Thus, the operation employed contrast and intensity adjusted image is further enhanced by utilizing the morphological operation.

Recognition

Once the features extraction is done the feature are recognized by comparing the feature vector of the input image with the base image. The extracted feature value i.e.) aspect ratios along with the values obtained from the morphological operations are applied to the neural network. Generally the neural networks are trained such that the input has to deliver a specified output. The neural network has greater compatibility with the human visual system. The Feed Forward Neural Network is employed in the proposed method for training. In a

neural network there are three layers namely input layer, hidden layer and output layer. The fig 2 given below shows the basic diagram for feed forward neural network.

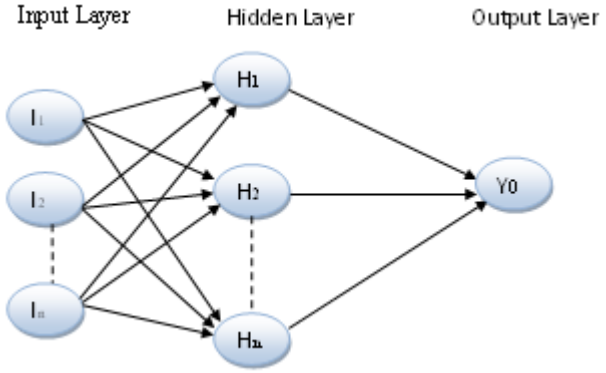


Fig. 2.Basic Diagram for Feed Forward Neural Network

The neural network is fed with the output which is obtained from the morphological operation. These values are compared with the data provided to the neural network while training and based on these the words are being classified and the sign gestures are recognized efficiently. Our proposed system aims at bridging communication gaps between the deaf community and other people. The fig 3 given below shows the process flow of sign Recognition step.

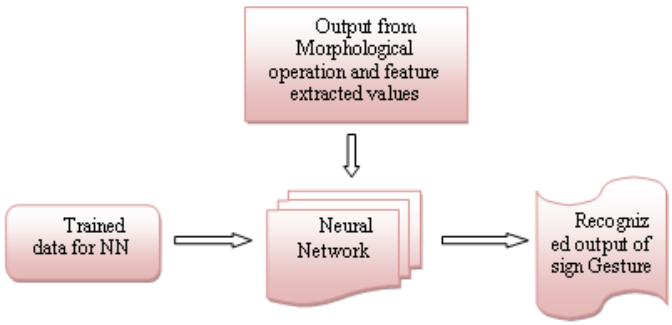


Fig. 3. Sign Gesture Recognition Process

Results and Discussion

The proposed Sign- Gestures Language Data Acquisition and Recognition is implemented in the working platform of MATLAB (version 7.12.0). The recognition process is tested with frames of different videos and the obtained result of the proposed work has been shown below. Initially, the video are segmented to different shots or frames and then features are extracted followed by the recognition process.

As mentioned in the section 3, the input video clip is shot segmented into number of frames. Then for each frame the various feature are extracted using the algorithms mentioned in the proposed methodology. These features help in identifying the words in each frame. Once the features are extracted, the exact words are recognized. Fig 4 shows the results obtained by the proposed method.

Fig (a): Input Frames For the video 'Ice cream'

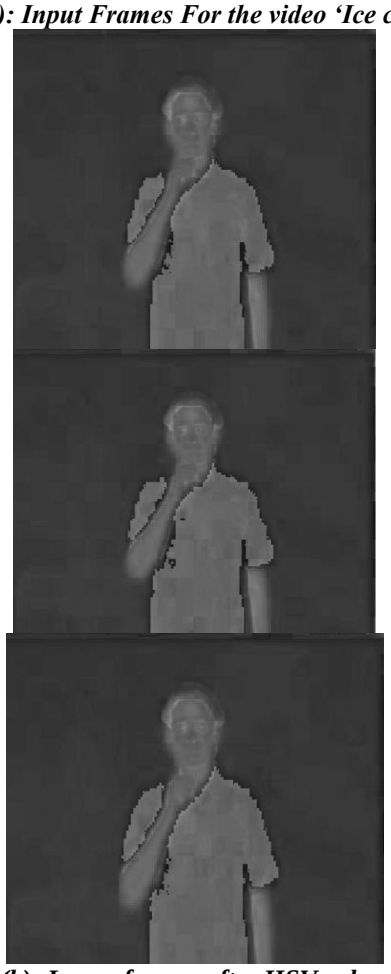


Fig (b): Image frames after HSV color map

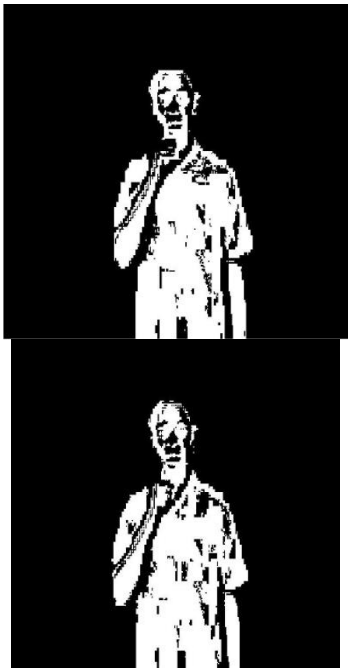


Fig (c): Image frames after black and white conversion

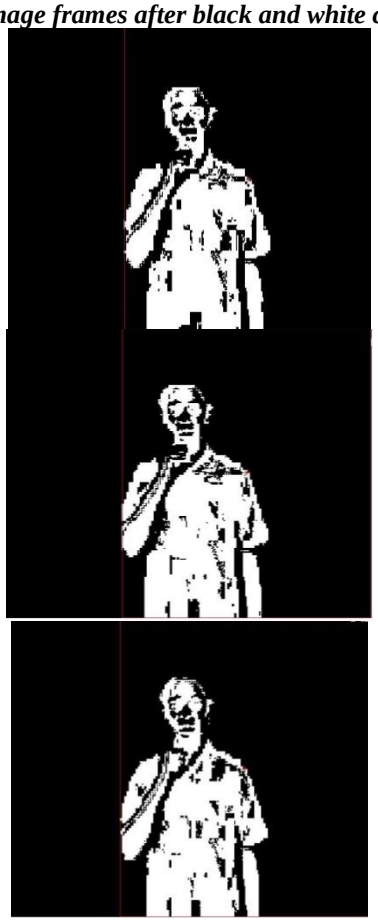


Fig (d): Image frames after Shape Feature Extraction using Aspect ratio.

Fig (e): Image frames after Morphological operation

Sign Gesture Recognition for Input Video 'Ice Cream'

The fig 4 shows the sign gesture recognition for the video 'Ice Cream'. Fig 4 (a) is the various input frames of the video which is to be processed. At first this images are converted to the HSV color map for further processing. Fig 4 (b) shows the corresponding HSV color map for the input frames. Fig 4 (c) is the black and white converted image of the respective frames.

Once the images are converted to black and white image the feature extraction process is performed. In feature extraction the shape features with the aid of aspect ratio are extracted. The Fig 4 (d) shows the Image frames after Shape Feature Extraction using Aspect ratio. After the feature is being extracted, the morphological operation is carried out. Fig 4 (e) shows the image after the morphological operations. This is preceded by training the acquired values in the neural network and finally the sign gesture is recognized. The above process is repeated for different videos and there results are shown below,

Fig (a): Input Frames For the video 'Sandwich'

Fig (b): Image frames after HSV color map

Fig (c): Image frames after black and white conversion

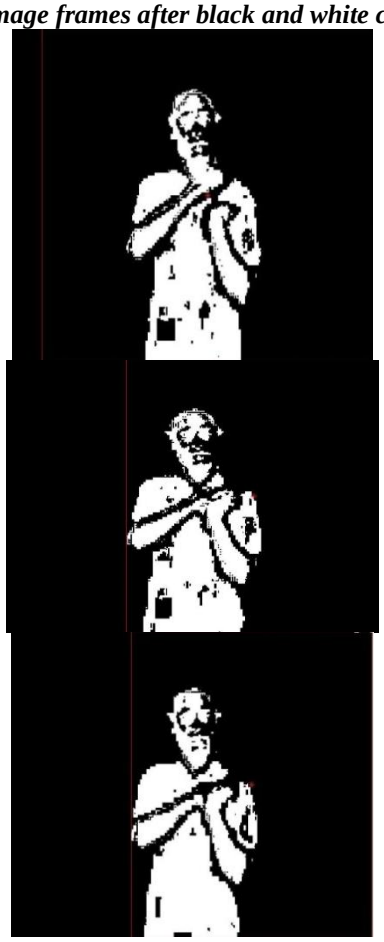


Fig (d): Image frames after Shape Feature Extraction using Aspect ratio.

Fig (e): Image frames after Morphological operation

Sign Gesture Recognition for Input Video 'Sandwich'

The fig 4 shows the sign gesture recognition for the video 'Sandwich'. Fig 5 (a) is the various input frames of the video which is to be processed. At first this images are converted to the HSV color map for further processing. Fig 5 (b) shows the corresponding HSV color map for the input frames. Fig. 5 (c) is the black and white converted image of the respective frames. Once the images are converted to black and white image the feature extraction process is performed. In feature extraction the shape features with the aid of aspect ratio are extracted. The Fig 5 (d) shows the Image frames after Shape Feature Extraction using Aspect ratio. After the feature is being extracted, the morphological operation is carried out. Fig 5 (e) shows the image after the morphological operations. This is preceded by training the acquired values in the neural network and finally the sign gesture is recognized.

Each video delivers different words as sign gesture and these video after processing through the different steps in our proposed method the gesture are finally recognized. Fig 6 given below shows the recognized words from different video inputs. The obtained results shows that the proposed method delivers better recognition of sign gesture than other existing methods.

Acquired Image	Sign Gesture Recognition
	**Ice Cream**
	**Sandwich**
	**Cone**

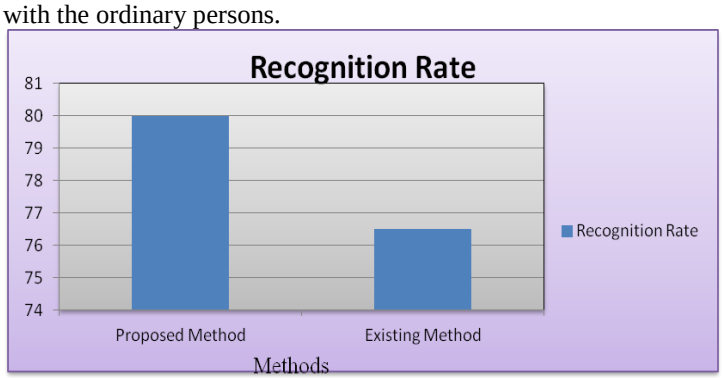
Gesture Recognition

The performance evaluation of our proposed methodology is calculated by measuring the accuracy of the method. The accuracy of our proposed method proved to be more efficient than the existing works. The recognition rate proved to be more improved than the previous work used in Gesture Recognition Using a Path Searching Method [22]. The average recognition rate obtained in our proposed method has better exceeded when compared with these existing method. The table given below shows the recognition rate obtained from our proposed method and the existing method.

Recognition rate for proposed and existing work.

Method	Average Recognition Rate (%)
Proposed method	80
Existing method	76.5

From the table 1, it is clear that our proposed method delivers better recognition rate than the existing method. The corresponding graphical representation of the recognition rate is shown in the fig 6.The results proves that our proposed method of sign gesture recognition is efficient in recognizing the exact words from the sign gesture videos and can effectively help in bridging the communication gap between the deaf community with the ordinary persons.



Graphical representation of Recognition rate for proposed and existing work.

Conclusion

In this paper we have proposed an efficient method for Sign gesture acquisition and recognition from the video. The sign gesture forms a basic mode of communication with the deaf community and its acquisition and recognition plays a vital role for the communication with those who are unfamiliar with sign gestures. Our proposed method helps in recognizing each and every gesture with higher accuracy and effortlessly. We employed feature extraction stage along with the morphological operations which forms a efficient process in extracting the required measures for recognition. This is followed by neural network training which delivers the exact recognized output from the sign gesture. The results of our method shows that it is more efficient when we compare with other existing works related to sign gesture recognition.

Acknowledgment

I would like to thank my institute Sinhgad College of Engineering, Pune for providing the necessary resources to carry my research work. Also like to extend my gratitude to both supervisors for guiding me throughout my work and to my family for being my support system always.

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