Volume 5, No. 3, March 2014
Journal of Global Research in Computer Science
ISSN-2229-371X
RESEARCH PAPER
Available Online at www.jgrcs.info

Robust Hand Gesture Recognition for Human Machine Interaction System

[1]Vijay Kumari Thakur, [2]Priyadarshni
[1]Fellow, [2]Associate Professor
LCET, Katani kalan, Ludhiana, Punjab, India
[1]thakurvijaya0@gmail.com

Abstract: Hand gesture is the form of non verbal communication to convey particular message by using the visible movements and posture of hand. It is interpreted by using a recognition system that can be used for interfacing between humans and computer devices. The interfaces based on hand gesture recognition (HGR) can be used for a wide range of applications like sign language recognition, virtual gaming, automation and security. The present work represents a technique for human machine interface (HMI) using HGR system. This system is able to recognize five different hand gestures with remarkable accuracy. The proposed system is tested for five different environmental and physical conditions. Best techniques of image processing implemented to make system more and more robust. The segmentation scheme used in this system was based on grey level thresholding. The Y component reduced from test image and Cb, Cr components separately used to extract the particular hand area. This helped in making system more robust for light varying environment. Further binary image has been used to extract contour of hand area. For this canny edge detector was used. After successful edge detection contour scale space used to find out the raised finger count, hence hand gesture recognized according to the number of fingers raised. On MATLAB successful implementation of proposed system yielded overall average accuracy of 95.2% varying from 96% for good light and 92% for bad light conditions. The whole system took 0.8 sec to recognize a complete hand gesture in MATLAB 2012b.

Keywords: Hand Gesture Recognition (HGR), Human Computer Interface, Curvature Scale Space, MATLAB

1. INTRODUCTION

Computer is used by many people either at their work or in their spare-time. Special input and output devices have been designed over the years with the purpose of easing the communication between computers and humans. The two most commonly known interactive devices are the keyboard and mouse. Every new device can be seen as an attempt to make the computer more intelligent and making humans able to perform more complicated communication with the computer. This has been possible due to the result oriented efforts made by computer professionals for creating successful human computer interfaces. The computer programmers have been incredibly successful in easing the communication between computers and human [1]. To achieve natural and immersive human-computer interaction; the human hand could be used as an interface device. Hand gestures are a powerful machine-human communication channel, which forms a major part of information transfer in our everyday life. Hand gestures are an easy to use and natural way of interaction. For example, sign languages have been used extensively among speech-disabled people [2]. Compared with traditional Human Computer Interaction devices, hand gestures are less intrusive and more convenient for users to interact with computers and explore the 3D virtual worlds [3]. Human machine interaction using hand gestures requires a human gesture recognition system that should be capable to recognize and classify variety of hand gestures in real time. Initially hand gestures recognition were implemented using traditional electrical circuitry which takes a lot of time and space. Later on researchers started using computer vision based tools for HGR systems. Human gesture recognition can be contact based recognition or vision based recognition. Proposed system is using vision based recognition approach. This approach is more effective than the wearable devices in HGR because vision is one of the six physical media that computer must be instantiated perceptively when communicated to humans. Normally, most of the HGR system is divided into four stages. Namely, image acquisition followed by preprocessing and then feature extraction succeeded finally by the classification stage as shown in figure 1.

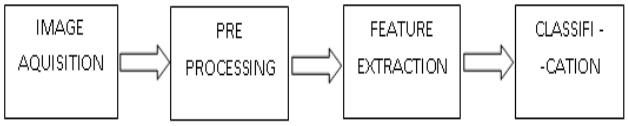

Figure 1: Block diagram of HGR System

The proposed system is a simple vision based hand gesture recognition system that acts like an interface between a user and computer under different light varying environment. Taking advantage of this, computer inbuilt windows media player is successfully operated using proposed technique. This paper is organized as follows. In section 2, some related researches are discussed. Section 3 gives the proposed scheme for hand gesture recognition system. Finally results are shown and conclusion is drawn in section 4.

2. RELATED WORKS

To improve the interaction in qualitative terms in real time environment it is desired that the means of interaction should be as ordinary and natural as possible. Gestures, especially expressed by hands have become a popular means of human

machine interface nowadays. Human hand gestures may be defined as a set of permutation generated by actions of the hand and arm. A lots of hand gesture recognition techniques have been developed by the researchers for different applications, these includes human computer application, virtual game control, robotics and others [17]. Quam D L [4] developed a hand gesture recognition system using gloves in 1990. These data gloves were fitted with some kind of movement sensing electrical circuitry, which converts hand movements into electrical signals and soon. But the system was not portable and user needed to carry huge cables wire and electrical circuitry. Then in 1996 Kjeldsen R and Kendrew J [5] presented a real time gesture system which was used in place of mouse to move and resize windows. A drawback of the system was that its hand tracking has to be specifically adapted to each user. Ishikawa [6] developed a hand gesture recognition system based on self organizing technique, but the user has to wear a data glove for hand segmentation. It limited the freedom of user to communicate with bare hands. Yu shi, Taib R. *et al.* [7] developed the first new different technique based on smart web camera. Here contour detection is used for hand region detection. Chen S, Chu Chih-Ming *et al*. [8] have introduced a hand gesture recognition system to recognize continuous gesture before stationary background using 2D video input. The system consists of four modules: a real time hand tracking and extraction, feature extraction, hidden Markov model (HMM) training, and gesture recognition. Mitra S and Acharya T [9] provided a survey on gesture recognition with particular emphasis on hand gestures and facial expressions. They explained that gesture recognition pertains to recognizing meaningful expressions of motion by a human involving hands, arms, face, head and/or body. Jinda-apiraksa, Pongstiensak W. *et al.* [10] presented a simple recognition algorithm that used three shape based features of hand to identify what gesture it is conveying. The overall algorithm has three main steps: Segmentation, Feature calculation and classification. The algorithm takes an input image of a hand gesture and calculates three features of image, two based on compactness and one based on radial distance. The system was designed to recognize and classify ten hand gestures based solely on their shapes. Overall 91% successful recognition rate was calculated. Chaudhary Ankit, Reheja J.I. *et al.* [11] has discussed the work done in the area of hand gesture recognition (HGR). They showed different methods used in pre processing of image for segmentation and hand image construction. Gupta Amit, Sehrawatt *et al.* [12] designed a gesture recognition system to recognize 10 different static hand gestures. The proposed system can recognize 10 different hand gestures at faster rate with reasonable accuracy. The illumination compensation technique is employed for robust recognition under varying background lightning condition. And skin color segmentation is used to minimize the chances of false detection. The gestures are classified on the basis of shape- based features. The accuracy of the system is computed as 94.40%. Panwer M. [13] developed a HGR system based on shape parameters. She presented a real time system for hand gesture recognition on the bases of detection of some meaningful shape based features like orientation, centre of mass (cetroid), status of fingers in terms of raised or folded fingers of hands and their respective location in image. She used a simple web cam which is working on 20 fps with 7 mega pixel intensity. This approach was able to identify around 45 different hand gestures on the bases of 5 bit binary string resulted as the output of this algorithm. Recognition rate calculated was 95%.

3. PROPOSED HGR SYSTEM

The system is designed to recognize 5 different hand gestures under different lightning conditions. The vision based approach has been used to recognize different hand gestures. The 2D shape based techniques are used to differentiate 5 hand gestures, shown in figure 3.1. This 2D based approach reduces computations, computational time and save resources. The hand gestures are differentiated using simple Contour scale space technique, instead of using different features. In order to make system real time in MATLAB, we need to recognize hand gesture by using only one or two features. The segmentation scheme used is based on the gray level thresholding instead of skin color detection. Now days, maximum work of hand gesture is done by using skin color segmentation. But for real time application and for convex hull techniques we need not to get completely segmented image. So, gray level thresholding is sufficient to segment hand region. The system is completed implemented on MATLAB2012b version.

Figure 3.1: Different types of counting gestures under experiment

The block diagram of the proposed technique is given below

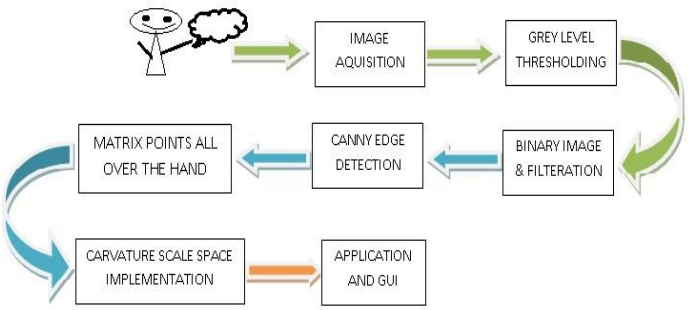

Figure 3.2: Block diagram of proposed HGR system

The block diagram of proposed system is illustrated by three different colors. These three parts are divided as follow: green color represents image acquisition part, blue color represents pre-processing part, orange color represents hand gesture recognition technique i.e. curvature scale space (CSS). The complete description of each section is discussed in preceding parts.

3.1 Image Acquisition

Image acquisition is the primary step in the image processing procedure. The image is acquired by the combination of an illumination source and the reflection or absorption of the energy from that source by the elements of the scene being imaged. Here our hand under experiment is the source. The

image of the test hand is acquired using CMOS image sensor web cam. The used web cam is clarion model from ZEBRONICS. It's a 25 megapixel interpolated web cam. It is almost similar to integrated web cam with only difference that It has a long stand which make it more flexible for use. It can produce output in many resolutions starting from **320*240 to 1024*768**. The distance between camera and hand may vary from 35cm to half meter. To initialize the system the user should first wave his or her hand in front of the USB camera, which is the only required hard ware in this system. The output from the camera is video and this video is then acquired by the system in the form of sequence of images; the video is converted in to images since MATLAB cannot process on videos. For this purpose two functions in MATLAB Image Acquisition Tool box are used:

frame = getsnapshot(obj)

Immediately returns one single image frame, from the video input object.

- **data = getdata(obj)**
- **vid.FrameGrabInterval = 5**

The FrameGrabInterval property specifies how often frames are stored from the video stream. For instance, if we set it to 5, then only 1 in 5 frames is kept and other 4 frames will be discarded**.**

3.2 Pre-Processing

Pre-processing is very much required task to be done in hand gesture recognition system. Pre-processing consist of many steps like Segmentation, Morphological filtering, de- noising, enhancement etc. The quality of the image acquired depends upon background lighting conditions and quality of imaging device. A low quality image affects the accuracy of the system. So, pre-processing of the image is mandatory to enhance the quality of the acquired image, which ultimately improves the accuracy of the proposed system. In proposed technique, we frequently require pre-processing as we are not taking stand image. The web cam generally produce noisy image. In order to make system robust we need to opt best hand segmentation techniques. So, in this regards RGB component image is converted to YCbCr format. After that, gray level thresholding is applied and Y component that contribute to the luminance is removed. So, in this way only hand portion is detected out of whole picture. Afterwards, image dilation is used followed by canny edge detection. Each of the above discussed operation is explained and results are also shown in detail in following section.

3.2.1 Hand Extraction

A very good segmentation is needed to select a adequate threshold of gray level for extract hand from background .*i.e.* there is no part of hand should have background and background also shouldn't have any part of hand. In general, the selection of an appropriate segmentation algorithm depends largely on the type of images and the application areas. The Otsu segmentation algorithm was tested and found to give good segmentation results for the hand gesture. Otsu algorithm is nonparametric and unsupervised method of automatic threshold selection.

Let the pixels of a given picture be represented in *L* gray levels *[1, 2, 3,.....,L]*

The number of pixels at level *i* is denoted by n_i and the total number of pixels by $N= n1+ n2+ n3+ n4+..... n_L$. Now the probability distribution of pixel is given by

$$p_i = n_i N,\ p_i \geq 0,\ \sum p_i = 1,\ L_i = 1 \qquad (3.1)$$

Let us suppose we have two classes of pixels one is Ω_0 which is background and Ω_1 is the hand. Ω_0 shows the pixels with level $[1....k]$, and $\Omega 1$ shows pixels with level $[k+1....L]$. The probability of class occurrence and the class mean levels, respectively are given by

$$\omega_0 = \Omega_0 = \sum p_i = (k)\ k_i = 1 \qquad (3.2)$$

$$\omega_1 = \Omega_1 = \sum p_i = 1\text{-}\omega(k),\ L_i = k+1 \qquad (3.3)$$

and

$$\mu_0 = \sum(1/\Omega_0) = \sum(ip_i/\omega_0) = \mu(k)/k_i = 1,\ \omega(k)(k_i) = 1 \qquad (3.4)$$

$$\mu_1 = \sum(1/\Omega_1) = \sum(ip_i/\omega_1) = \mu T\text{-}\mu(k) = 1\text{-}\omega(k),\ L_i = k+1 \qquad (3.5)$$

These two are *zero*th and the *first* order cumulative moments of the histogram up to *k*th level and respectively.

$$\mu_T = \Sigma\ i\ p_i\ k_i = 1 \qquad (3.6)$$

Here μ_T is total mean level of the original hand image. So we can check for relation for any value of *k*,

$$\omega_0\mu_0 + \omega_1\mu_1 = \mu_T,$$

$$\omega_0 + \omega_1 = 1$$

The class variance for both class is given by

$$\sigma 0^2 = \Sigma(i-\mu_0)^2\ p_i(i/\Omega_0)\ k_i = 1 = \Sigma(1-\mu_0)^2 k_i = ip_i/\omega_0 \qquad (3.7)$$

$$\sigma 1^2 = \Sigma(i-\mu_1)^2\ p_i(i/\Omega_1) L_i = k+1 = \Sigma(1-\mu_1)^2 L_i = k+1(p_i/\omega_0) \qquad (3.8)$$

and between classes variance is given by

$$\sigma B^2 = \omega_0(\mu_0-\mu_T)^2 + \omega_0(\mu_1-\mu_T)^2 \qquad (3.9)$$

and total class variance is given by

$$\sigma T^2 = \sum(i-\mu_T)^2\ L_i = 1 p_i \qquad (3.10)$$

Now the ratio between class variance to the total class variance is calculated with all value for (*i=1,2,3, ...k,k+1....L).* The optimum threshold *k** is determined the value of pixel for which we get the maximum value of $\sigma B^2/\sigma T$.

$$k^* = max(\sigma B^2/\sigma T^2),\ 1 \leq k \leq L \qquad (3.11)$$

Now the value of threshold *k** is set and hand pixel is assigned *'1'* and background pixels are assigned *'0'* and thus an binary image is formed.

Initially the RGB image should be converted into the YCbCr color space. Y (luminance) is not required, only the chrominance information i.e. Cb is taken and these two matrices are converted into binary images with a binary threshold values. Then perform a binary and operation with Cr binary matrix and complemented Cb binary. The resultant image will be a black and white image such that the skin colored portion as white and rest will be in black. After converting RGB to binary image, now it's time to make image more readable and understandable by using some image enhancement techniques.

3.2.2 Image filtering

Morphological image filtering is used to filter out the noisy pixels. In binary image we may have some 1s in hand area and have 0s in background area. This may lead to incorrect detection of the connected components. Hence, accuracy will decrease. The morphological filtering works on the sequence operation of dilation and erosion. In dilation and erosion we apply a matrix on a test image. The images and results of above discussion are shown in figure 3.5.

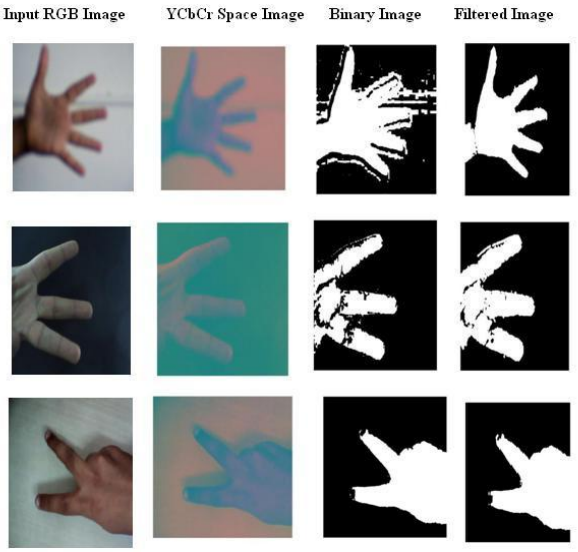

Figure 3.5: Column 1 shows the RGB input image, Column 2 shows the YCbCr space image, Column 3 shows binary image, Column 4 shows filtered image.

3.2.3 Contour Detection

In image processing, detecting edge is most complex problem as edge defines the boundaries of different objects. Edge can be defined as sudden change in the intensity. We can say sudden jump in intensity from one pixel to another pixel. Although in edge detection we are losing information but on same side we are highlighting the edges. There are many edge detectors like Sobel, Prewittive but canny edge detector is best among all. Canny edge detection algorithm is also known as the optimal edge detector [14]. The robustness of canny edge detector is due to three important parameters. The first is low error rate. It only picks edge points and neglect all no edge points. The second criterion is that the edge points be well localized. In other words, the distance between the edge pixels as found by the detector and the actual edge is to be at a minimum. A third criterion is to have only one response to a single edge. This was implemented because the first two were not substantial enough to completely eliminate the possibility of multiple responses to an edge. Based on these criteria, the canny edge detector first smoothes the image to eliminate and noise. It then finds the image gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (non maximum suppression). The gradient array is now further reduced by hysteresis. Hysteresis is used to track along the remaining pixels that have not been suppressed. Hysteresis uses two thresholds and if the magnitude is below the first threshold, it is set to zero (made a non edge). If the magnitude is above the high threshold, it is made an edge. And if the magnitude is between the two thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a gradient above. The obtained results are shown in following figure 3.6.

Figure 3.6: 1 shows YCbCr space image, 2 shows binary image, 3 shows canny edge detector image

3.3 Hand Gesture Recognition

Human hand represents different types of hand gestures. The hand gestures are formed by the different shape pattern opted by the hand. The shape based gesture recognition is primarily used, as it provides better results for real time applications. In order to recognize hand shape, we can opt different feature parameter like perimeter, area, radial profile etc. the major trade –off lies here, more feature parameters, more accuracy at the cost of increased computational time. The novelty of the proposed techniques is that we need not to go for such feature parameters in order to enhance the accuracy. Although proposed techniques is based upon the shape based detection, but we are dealing with only one parameter i.e. peak and valley points of the fingers. It will decrease the computational time by simultaneously maintaining the accuracy of the system. Here in below section, detailed study of technique is given.

3.3.1 Curvature Scale Space

The curvature scale space method is used to find the static hand gesture that is the count of hand fingers. Basically, curvature scale space technique is mother technique of pattern recognition operations. It is best suitable techniques of recovering the invariant geometric features i.e. curvature zero crossing points of a planer curve[15]. This technique is also considered as the best technique for corner detection. The curvature scale space method will help to identify the peaks and valleys of the binary image. Using the number of peaks and valleys we can identify the gesture. Below steps represents the algorithm flow for the proposed method.

- Let X*i* represent the contour for the hand. In the proposed system canny edge is used for the contour extraction. Now, matrix of connected components is created, out of the real contour matrix. This is achieved by assigning one particular label to pixels of same values. The returned matrix will be of same size as the input matrix.
- For each hand, a n attempt is made to find pixels that represent peaks along the contour perimeters. This is done by obtaining a matrix containing (x,y) coordinate values of the complete hand perimeter. For initiating the process any three consecutive coordinate points are considered i.e. X_{i-1}, X_i, X_{i+1}.
- The desired requirement is to find the angle between these three points. For that slopes formed by these three points are calculated. Here the threshold angle is set between 60 degree to 90 degree.
- At each pixel j in a hand contour *i*, the *k*-curvature is computed which is the angle between the two vectors $[X_i(j), X_i(j-k)]$ and $[X_i(j), X_i(j+k)]$, where *k* is a constant (currently set to 30). The k-curvature can be computed with the help of vector algebra.

The equation that we have use for the angle calculation is

$$\theta = \tan^{-1}\left(\frac{m2 - m1}{1 + m1.m2}\right) \quad (3.12)$$

Where

m1 = the slop of the line joining vector $[X_i(j), X_i(j - k)]$
m2 = the slop of the line joining vector $[X_i(j), X_i(j + k)]$

Now all those points which satisfy above threshold conditions will be labeled and all other are neglected. Basically these labeled points represent the peak and valley points of the hand shown in figure 3.7. At last, the centroid of each labeled points is calculated and a red dot is placed there to represent the peak valley point

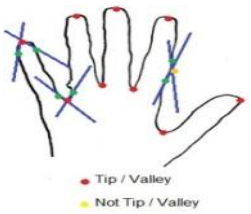

Figure 3.7: Representation of Detection of Peak and Valley Points.

3.4 Static hand gesture recognition system

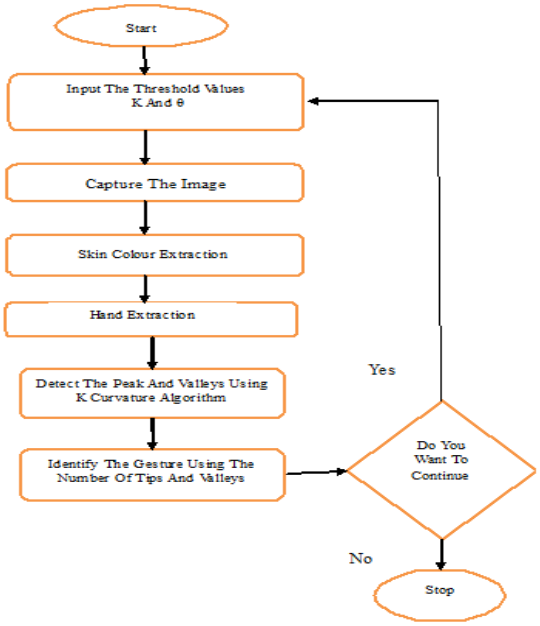

Figure 3.8: Flow chart of static hand gesture recognition system

3.4.1 Explanation of flow chart:

- Initially the threshold value k and θ is set, since these values changes with the light conditions, but this threshold have assigned with default values.
- Then the image should be capture from the video object. Matlab image acquisition function "getsnapshot (vid)" is used for this purpose.
- Then extracted the skin color from the image. The result of the skin color extraction will be a binary image. The skin colored part in the image is in white and background is in black.
- In order to extract the hand from the binary image we assume that hand is the biggest white area. Using the bwlabel function and area calculation we can extract the biggest area from the binary image.
- The peaks and valleys are extracted using the curvature skin space (CSS) i.e. k curvature algorithm (as explained above). Using the co-ordinate values of tips and valleys the captured image is plotted.
- From the number of peaks and valleys, the number of fingers in the current hand gesture is identified.
- These six steps include on cycle. After that the user can decide whether he or she want to continue. If yes, this step will iterate otherwise it will terminate.

4. RESULTS AND CONCLUSION

4.1 Results

The implemented system is capable of recognizing 5 hand gestures with remarkable accuracy. The proposed system is tested over 5 different environmental and physical conditions. First set comprised of total twenty five images of single raised finger with five replications under each environmental conditions. Likewise, set 2, 3, 4 and 5 were tried adding extra finger with each advancing set number, e.g. set 3 comprised of three fingers whereas set 5 with five fingers. Each set was tested for five different environmental conditions viz. Bad light condition (I), Constant background condition (II), Background with unwanted pictures (III), Fingers with ring or bandage (IV), Different skin shades (V).

The hand image data and accuracy is illustrated in table no. (4.1). It is evident from the perusal of data that accuracy of the system varied from 92% under bad light condition and 96% under good light condition. Irrespective of different environmental/physical conditions, the set 1 and set 2 gave (100%) accurate images whereas set 4 produced lowest (92%) accurate images. The background with unwanted pictures (III) produced lowest (88%) accurate images which may be due to false images because of absence of constant and clear background. The overall accuracy of the proposed system was recorded 95.2%.

Table 4.1: Accuracy of the proposed system

Hand	Total	Correctly Recognized Images	Average

Gesture	Images	Environmental/ Physical conditions					Accuracy (%)
		I	II	III	IV	V	
Set 1	25	5	5	5	5	5	100
Set 2	25	5	5	5	5	5	100
Set 3	25	4	5	4	5	4	88
Set 4	25	4	5	4	5	5	92
Set 5	25	5	5	4	5	5	96
Accuracy (%)	_	92	100	88	100	96	95.2

Whereas:

I: Bad light condition Set 1: Single finger

II: Constant background condition Set 2: Two fingers

III: Background with unwanted pictures Set 3: Three fingers

IV: Fingers with ring or bandage Set 4: Four fingers

V: Different skin shades Set 5: Five fingers

4.2 Conclusion

With the increasing needs of natural human machine interfaces, hand gesture technologies are getting more and more popularity. The major parameters in this field are accuracy and time of execution. In proposed system only five gestures are taken in order to make system more and more accurate. The most optimized techniques of MATLAB have been used to get required time of execution. Proposed system is robust in context of background variability and is tolerable to bad light conditions. The gray level thresholding and canny edge detector has been used to make system more and more accurate and real time. The overall accuracy of the system varied from 100% to 88% for different set of data.

REFERENCES

[1] Pavlovic V.I., Sharma R., Hauang T.S., "Visual interpretation of hand gestures for human – computer interaction: A Review", *Pattern Analysis and Machine Intelligence, IEEE Transaction On*, Vol.19, pp. 677-695, 1997.

[2] Maebatake M.T., Suzuki T, Nishida M., Horiuchi Y., Kuroiwa S., "Sign language recognition based on position and movement using multi-stream HMM," *Universal communication, 2008.isuc'08.second international symposium* On, pp.478-481, 2008

[3] Rautaray Siddharth S., Agrawal Anupam, "Real Time Hand Gesture Recognition System For Dynamic Applications", *International Journal of UbiComp (IJU)*, Vol.3, No.1, pp. 21-31, 2012.

[4] Quam, D.L., "Gesture Recognition with a Data Glove," *in Proceeding of the IEEE National conference on Aerospace and Electronics NAECON 1990*, pp.755-760 Vol.2, 1990.

[5] Kjeldsen R., and Kender J.,"Toward the use of gesture in traditional user interfaces," *in Proceedings of International Conference on Automatic Face and Gesture Recognition, (Killington, Vt.)*, pp. 151–156, 1996.

[6] Ishikawa Massimi, Matsumura Hiroko, "Hand Gesture Recognition Based On Self Organizing Technique," *in Proceeding ICONIP'99 of 6th International Conference On Neural Information Processing*, vol 2, pp.739-745, 1999.

[7] Yu Shi, Taib R., Lichman S., "GestureCam: A Smart Camera for Gesture Recognition and Gesture–Controlled Web Navigation," *ICARCV '06. 9th International Conference On Control, Automation, Robotic and Vision*, pp.1-6, 2006.

[8] Sheng Chen, Chih-Ming Chu, Chung-Lin Huang, "Hand Gesture Recognition using Real Time Tracking Method and Hidden Markov models," *Institute of Electrical Engineering, National Tsing Hua University*, Hsin Chu 300, Taiwan, ROC.

[9] Mitra, S., Acharya T., "Gesture Recognition: A Survey, "System, Man and Cybernetics, Part C," *IEEE Transactions On*, Vol.37, pp. 311 -324, 2007.

[10] Jinda-Apiraksa Amornched, Pongstiensak Warong, Konda Toshiaki, "A Simple Shape Based Approach To Hand Gesture Recognition," *Electrical Engineering/Electronics Computer Telecommunications and Information Technology (ECTI-CON), International Conference On* , pp.851-855, 2010.

[11] Chaudhary Ankit, Raheja J.I, "Intelligent approaches to interact with machines using Hand Gesture Recognition in natural way: A Survey," *International Journal of Computer Science & Engineering Survey (IJCSES)*, Vol.2, No.1, 2011.

[12] Gupta Amit, Sehrawatt Kumar Vijay, Khosla Mamta, "FPGA *Based Real Time Human Hand Gesture Recognition System," Procedia Technology* 6, pp. 98-107, 2012.

[13] Panwer Meenakshi, "Hand Gesture Recognition based On Shape Parameters," *IEEE International Conference on Computing, Communication and Applications (ICCCA)*, pp.1-6, 2012.

[14] Bretzner L., Laptev I., Lindeberg T., "Hand gesture recognition using multi scale colour features, hierarchical models and particle filtering," *in Proceedings of Fifth IEEE International Conference On Automatic Face and Gesture Recognition*, pp. 405-410, 2002.

[15] Chang C.C., Chen Y.I., Huang Y., " Hand Pose Recognition Using Curvature Scale Space," *in Proceedings of 16th International IEEE Conference on Pattern Recognition*, Vol-2, pp. 386-389, 2002.

[16] Rautaray S.S., Agrawal A, " Interaction with virtual game through hand gesture recognition," *International Conference on Multimedia, Signal Processing and Communication Technologies (IMPACT), 2011*, pp. 244-247, 17-19 Dec. 2011.

