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A Survey of Hand Gesture Recognition

Mandeep Kaur Ahuja[1]
CE Department
Punjabi University Main Campus
Patiala – India

Dr. Amardeep Singh[2]
Professor, CE Department
Punjabi University Main Campus
Patiala – India

Abstract: ***Gesture recognition turns up to be important field in the recent years. Communication through gestures has been used since early ages not only by physically challenged persons but nowadays for many other applications. Hand gestures have been widely accepted for numerous applications such as human computer interactions, robotics, sign language recognition, etc. Hand gestures provides an inventive way to do interaction with the computer by replacing peripheral devices like keyboard, mouse with hand gestures for human-computer interaction(HCI). Hand gesture recognition basically involves four steps –image acquisition, hand segmentation, feature extraction and classification. Considerable efforts have been put forward by many researchers to develop efficient techniques for each step of hand gesture recognition. Mostly hand gesture techniques have been divided into two categories- sensor based and vision based techniques. This paper reviews different techniques designed by researchers at each step and finally we will compare their work in the tabular form on the basis of image acquisition method, segmentation technique, feature extracted, classifier, accuracy, etc.***

Keywords: hand; gesture; recognition; segmentation.

I. INTRODUCTION

Gestures are the movement of any body part used to convey the meaningful information. Communication through gestures has been widely used by humans to express their thoughts and feelings. Gestures recognition refers to the process of identifying gestures performed by human so that machine can perform the corresponding action .Gestures have been classified in two categories static and dynamic. Static gestures refer to still body posture and dynamic refers to movement of body part. Gestures can be performed with any body part like head , face, arms, hands, etc. but most predominately we use hand to perform gesture like we wave hand to say 'good bye'. Hand gestures have been widely used for many applications like human – computer interaction (HCI), robotics, sign language, human machine interaction, etc. With the advancement in the computer technology HCI has become an emerging field in recent years. From many years Gesture Recognition field has tried to replace the use of peripheral devices like joystick, mouse and keyboard with hand gestures.

Hand Gestures Recognition techniques have been divided into two categories- Sensor based and Vision Based recognition.

Sensor based recognition collects the gesture data by using one or more different types of sensors. These sensors are attached to hand which record to get the position of the hand and then collected data is analyzed for gesture recognition. Data glove [1][2] is an example of sensor based gesture recognition shown in figure1. Other sensors used were Wii controller, EMG sensors, accelerometer sensors, etc.

Fig1. The cyborg glove [1]

Sensor based recognition has certain limitations. First of all it requires a proper hardware setup which is very expensive. Secondly, it hinders the natural movement of the hand. So to overcome the limitation of sensor based recognition vision based techniques came into existence.

Vision based techniques [1] make use of camera to capture the image for hand gesture. Vision based recognition make use of many image processing algorithms to get hand posture information and movement of hand. This approach recognizes gesture from shapes, orientations, contours, and color or motions features of a hand. Colored markers are an example of vision based recognition. But the vision based recognition also has some limitations that it is affected by illumination changes and cluttered backgrounds [9].

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Recently, development of depth camera sensors like Kinect sensor[6], RGB sensor[7] has removed limitations of above techniques. These sensors are able to capture even a small object and also these depth cameras offer a very effective way to isolate hand from the background using depth thresholding. Kinect Sensor is shown figure 2.

Fig 2: Kinect Sensor[4]

The rest of the paper is organized into following ways. Section 2 will present a literature survey of hand geometry. Section 3 will present basic steps of hand geometry recognition. Section 4 will present work done by various researchers in tabular form and finally in section 5 conclusion and future scope will be discussed.

II. Literature Review

The use of hand images for the gesture recognition has been gaining popularity. Various works have been done by different researchers. In this section we will review the work done by various researchers on hand gesture recognition

Chang-Yi Kao. et. al.[3] presented a hand gesture recognition technique based on path of hand motion by using HMM as a classifier. In their approach eight different kinds of gestures have been developed using either single hand or both hands. In the proposed methodology first of all face localization is done and then maximum circle plate mapping is used to locate palm of the hand from skin region and in feature extraction procedure orientation is used as a main feature and the experiment shows 96% accuracy with HMM recognition model.

Amit Gupta, et. al. [4] introduced hand gesture recognition technique which utilize an FPGA based smart camera for gesture analysis. The experiment is performed using shape based features as the system is modeled on FGPA board and shape based features consume less FGPA area and requires less effort for computation. The features for used for experiment are - area of hand, perimeter of hand, thumb detection and radial profile and angular position. For image processing and hand segmentation, illumination compensation technique and skin color segmentation model is utilized keeping in view the changing background. For performing the experiment images of 25 different persons is captured and is found that system is able to recognize 10 different gestures with accuracy 94.40%.

Jing Lin, et. al. [5] proposed a technique based on histrograms of oriented gradients (HOG) in order to remove the hindrance caused by cluttered background during hand localization and modeling. Histrograms of oriented gradients and SVM are applied to localize the hand and then motion trajectory features of temporal gestures are extracted and standard database is created. For recognition Mahalanobis distance is used. The technique is tested on 6 standard gestures and average accuracy of 91.7% is obtained but this system is able to work for complicated gestures.

Zhou Ren, et. al. [6] developed a robust part based technique using kinect sensor keeping in view the limitations of glove based and vision based techniques. In their approach, first of all kinect sensor is used to capture the both color images and depth maps corresponding to that image. Using depth maps, hand can be easily detected even in cluttered background also by using depth thresholding. After detecting the hand it is represented by its finger parts using time series curve. Then for gesture recognition a dissimilarity measure called Finger-Earth Mover's Distance (FEMD) is proposed which can recognize noisy hand contours as compared to other recognition methods and is robust to change in scale, orientation, local distortions and background conditions. For experiments dataset consisting of 10 person, 10 gestures and 10 cases/gestures id used and achieves accuracy of 93.2% and system is tested on two real time applications.

Jos´e Manuel Palacios [7] developed hand gesture recognition technique using RGB-D sensors taking the advantage of depth information to remove the problems caused by lightning conditions and cluttered background. The proposed methodology includes four basic steps - Hand segmentation, Feature extraction, Static gesture classification and Dynamic gesture classification. For hand segmentation skin color segmentation and background subtraction is used. First of all face is detected from the image and is removed and then wrist is detected and hand is extracted. For gesture recognition various features extracted from the hand are utilized. For static gesture recognition fingertip detection is used and fingertip is detected using maximum curvature and convexity defects. For dynamic, Euclidean distance and direction is used. The experiment is performed on dataset consisting of 90 images of 9 different persons with 10 dynamic and 6 static gestures and achieves Precision- 92.1% and Recall-83.3%.

Paulo Trigueiros, et. al [8] proposed a general human computer interaction system based on hand gestures. The sysyem uses vision based and approach as they have advantage compared to traditional data glove approaches. Basically, the experiments consists of three steps- acquisition and preprocessing, feature extraction and recognition. For recognition machine learning classifier are used though they are not the only option but hereare used keeping in the view the extracted feature – centroid distance. For static geture recognition SVM is used and for dynamic HMM is used. The experiments obtains the 99.7% accuracy with SVM and 93.7 % with HMM with 11 predefined gestures.

Chetan Dhule, et. al. [9] proposed a vision based hand gesture recognition technique for human computer interaction. They proposed the method keeping in view that most the earlier methods are based on gesture recognition algorithms that require ANN training which is very time consuming and is not much accurate. So by using color detection techniques they develop real time application to restrict the mouse's motion in windows by detecting change in pixel value of RGB colors and which is possible without ANN training.

Stergios Poularakis and Ioannis Katsavounidis [10] presented a technique based on depth information for recognizing finger and hand posture. To deal with the problem of merged fingers they proposed a method which represents the apex-shaped structure of hand contour. For hand detection depth thresholding is used and for finger detection palm radius is estimated using Maximum inscribed circle and the morphological operators are applied. For recognition,Fourier descriptors are used and to reduce the search space size global information based on fingers knowledge is utilized. The experiment is performed on dataset consisting of 1000 postures having 10 gestures and achieves recognition rate of 99.1% using FD and 96.3% using global finger information.

Dong-Luong Dinha, et. al. [11] developed a hand gesture recognition technique for home appliances using depth imaging sensor. The experiment works in two stages, in the first stage a database is created which consist of hand depth silhouettes obtained by removing background and labeled hand parts of silhouettes obtained using trained Random forests. In the next stage, from the labeled hand parts various features are extracted which are used to give command to appliance. The experiment is performed on 500 hand silhouettes with 6 gestures – Ready, Hand mouse, Selection/Enter, Move right/left, Volume up/ down and Exit and achieves recognition rate of 98.5%.

Chong Wang ,et.al [12] proposed a new approach of hand gesture recognition based on superpixels using kinect sensor. First of all images are captured using Kinect sensor and then using Skelton and depth information hand is segmented from the whole image. Keeping in view the advantage of superpixel that it retain color, depth and shape information the hand is represented by superpixels. Based on the superpixel representation a new recognition distance measure called superpixel earth mover's distance (SP-EMD) is proposed which is robust to scaling, translation as well as local distortions. The experiment is performed on dataset consisting of 10 gestures and 20 different postures from 5 different persons and achieves recognition rate of 99.6 %. The experiment is performed on two public datasets also and is tested with two real time HCI applications.

III. Basic Module of Hand Gesture Recognition

The basic module of hand gesture recognition has four steps discussed below and shown in figure 3.

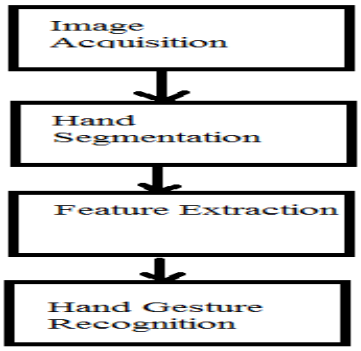

Figure 3. Basic Hand Gesture Module

A. Image Acquisition:

Image acquisition is the first step of hand gesture recognition and is should be as efficient as possible because rest of the work is dependent of this step. There are many devices for capturing the image. Some of them are data gloves [2], webcam [6],CCD cameras[5], RGB cameras[7], kinect sensor[9], etc. Now a days kinect sensor is mostly preferred keeping in view the limitations of vision based and data glove approaches and another reason is that it is able to capture both depth and color information.

B. Hand Segmentation:

Next step in the gesture recognition is hand segmentation which refers to isolate the hand from the rest of the image i.e. to get only the required part and remove the rest of the part. There are many techniques for hand segmentation. The basic techniques are: Thresholding based on depth information or color information [6][10][12] , Skin color segmentation [7][9], Background subtraction[9][11], etc.

C. Feature Extraction:

After the hand is segmented from the image various features are extracted from the hand which are utilized for gesture recognition. Features are very important part of hand gesture recognition. Various features that cane be extracted from the hand cane be orientation [3], velocity[5], angle[5], direction[7], centroid[8], color, superpixels[12], Fourier Descriptors[10], shape based features- area, perimeter, length[4] , Euclidean distance[7] ,etc.

D. Gesture Recognition:

After the features have been successfully extracted the last step is gesture recognition. Some researchers uses the above extracted features for gesture recognition [6][7][12] and some uses the machine learning classifiers – HMM[3][8], SVM[8],Nearest Neighbour classifer[10], etc. for classification.

IV. COMPARISON OF WORK DONE BY VARIOUS RESEARCHES

In this section work done by various researchers on hand gesture recognition based on image acquisition, no. of gestures, segmentation technique, features extracted, recognition method and accuracy.

TABLE 1: COMPARISON OF VARIOUS TECHNIQUES

Year	Image acquisition Method	No. of Gestures	Segmentation Technique	Features Extracted	Recognition Method	Accuracy
2011 [3]	Webcam	8	Bressenham's midpoint circle scan-conversion algorithm	Hand Orientation	HMM	96%
2012 [4]	CMOS image sensor	10	Illumination compensation of RGB color, Skin color segmentation	Shape based features- Area of hand , perimeter of hand, thumb detection, Radial profile	-	94.4%
2013 [5]	CCD cameras	6	Histogram oriented gradient	Velocity and angle	Mahalanobis distance	91.7%
2013 [6]	Kinect sensor	14	Depth thresholding	Finger's Earth mover's Distance	Template Matching	93.2%
2013 [7]	RGB Sensor	10- static 6- Dynamic	Skin color segmentation ,depth thresholding	Fingertips using curvature and convexity defects, Euclidean distance, direction	Feature based classifier	Precision- 92.1% Recall- 83.3%
2014 [8]	Kinect Camera	11	_	Centroid distance	SVM	99.7%
					HMM for dynamic	93.7%
2014 [9]	Webcam	-	Skin color detection, Background detection	Pixel extraction , position of RGB color	-	-
2014 [10]	Kinect device	10	Depth Thresholding	Fourier Descriptors,	Nearest Neighbor classifier	99.5
				Apex structure of hand contour(Finger Information)		96.3
2014 [11]	Depth Imaging sensor	4	Background subtraction	Hand silhouette, state of fingers.	Random forests	98.5%
2014 [12]	Kinect depth camera	9	Depth thresholding	Superpixel earth movers distance	Template Matching	99.2%

V. CONCLUSION

Hand Gesture Recognition has been used in wide number of applications- human computer interactions, robotics, sign language recognition, etc. Lot of work has been done by many researchers in the field of hand gesture recognition. In this paper we have discussed the basic methodology of hand gesture recognition have discussed the various techniques of hand gesture recognition and we have found that that nowadays depth sensor has been preferred over vision based approach and glove based approach as they provide color as well as depth information and are not affected by variation in illumination, cluttered background. In the future, hand gesture can be combined with other gestures like body posture, face recognition, etc. for better results.

References

1. Haitham Hasan , Sameem Abdul-Kareem, "Human–computer interaction using vision-based hand gesture recognition systems: a survey", Neural Comput & Applic,2013.
2. Fahn, C.S,Sun, H, "Development of a fingertip glove equipped with magnetic tracking sensors", Sensors 2010,vol. 10 ,pp. 1119–1140.,2010
3. Chang-Yi Kao,Chin-Shyurng Fahn, "A Human-Machine Interaction Technique: Hand Gesture Recognition Based on Hidden Markov Models with Trajectory of Hand Motion", Procedia Engineering 15, pp. 3739 – 3743,2011.
4. Amit Gupta, Vijay Kumar Sehrawat, Mamta Khosla, "FPGA Based Real Time Human Hand Gesture Recognition System", Procedia Technology 6 ,pp. 98 – 107, 2012.
5. Jing Lin, Yingchun Ding, "A temporal hand gesture recognition system based on hog and motion trajectory", Optik 124 pp.6795– 6798, 2013.
6. Z. Ren, J. Yuan, J. Meng, and Z. Zhang, "Robust part-based hand gesture recognition using Kinect sensor," IEEE Trans. Multimedia, vol. 15, no. 5, pp. 1110–1120, Aug. 2013.
7. Jos´e Manuel Palacios, Carlos Sagues , Eduardo Montijano and Sergio Llorente , "Human-Computer Interaction Based on Hand Gestures Using RGB-D Sensors" , Sensors 2013, vol.13, pp. 11842-11860, 2013.
8. Paulo Trigueiros,Fernando Ribeiro, Luis Paulo Reis "Generic System for Human-Computer Gesture Interaction" ,IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), Espinho, Portugal ,pp. 175-180, May 2015.
9. Chetan Dhule ,Trupti Nagrare , "Computer Vision Based Human-Computer Interaction Using Color Detection Techniques" , Fourth International Conference on Communication Systems and Network Technologies, pp.934-938, 2014.
10. Stergios Poularakis and Ioannis Katsavounidis, "Finger Detection And Hand Posture Recognition Based On Depth Information", IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP), pp. 4329-4333, 2014.
11. Dong-Luong Dinha, Jeong Tai Kimb, and Tae-Seong Kimc, "Hand Gesture Recognition and Interface via a Depth Imaging Sensor for Smart Home Appliances", 6th International Conference on Sustainability in Energy and Buildings, SEB-14, pp. 576 – 582 ,2014.
12. Chong Wang,Zhong Liu, and Shing-Chow Chan, "Superpixel-Based Hand Gesture Recognition With Kinect Depth Camera", IEEE Transactions On multimedia, vol. 17, no. 1, pp. 29-39, January 2015.

