Hand Gesture Recognition: A Review

Sundus Munir, Shiza Mushtaq, Afrozah Nadeem, SyedaBinish Zahra

Abstract : The objectiveof this paper is to introduce and identify the techniques and methods of hand gesturerecognition throughhuman computer interaction. Human-computer interaction is very essentialcomponent of most people's daily life. We have discussed some Human Computer Interaction (HCI) techniques and methods which will recognize the human hand gesture recognitionthrough different methodologies. The goal of gesture recognitionresearch is to establish a system which can classify specific human gestures and can make its use to convey information or for device control. These methods have different input types and different classifiers and techniques to identify hand gesture. This paper includes hand gesture recognition, human computer interaction systems, apps and comparative study of techniques and methods used in these systems. Applications for hand detection segmentation technique, RGB color scheme, web cam, real time tracking method q and The Markovhidden models, Depth Map methods and models are used in different researches.In this paper we have discussed maximum seven methods from the previous researches. We will analyze the best methodology of hand gesture recognition along with the pros and cons of each article.

Key words: q and hidden Markov models, Depth Map, RGB color scheme, Kinect camera, leap

1.0 INTRODUCTION:

Human interact with each other mostly occur through speech but some non-verbal means of communications are also used for interaction between humans as well [1]. The objective of creating hand gesture recognition system is to generate a natural interaction between human and computer where recognized gestures can be used for monitoring a robot or can conveymeaningful information [14].Hand gestures are the source of delivering information which is not easy to perceive. This research shows the different methodologies to detect and read the language of hand gesture for effective communication. Hand gesture recognition through robust marker less hand gesture recognition system, through segmentation method, Depth Map based recognition Captured by RGB-D Camera [13,15], Depth-Sensing Cameras based recognition and EMG Monitoring [21], using the convolutional neural network (CNN) to recognize gestures, based on Wireless Sensor, using Webcam, using a real-time tracking technique [6] & Markov hidden models, recognition through machine is an important and efficient topic in human interaction system [7]. If computer would be able to understand human's hand movements or gestures, we can reduce the gap between them and the tasks will become much easier. Human hand recognition is used in many areas such as image processing, cyber security and robotics etc. Hand gesture recognition is very active research topic now a days. As increasing interest and worth of gesture detection, experiments have been conducted to verify the results of application and system. In this article, we have comparatively discussed many techniques and methods in these systems and application. These systems introduced us with new techniques to recognize emotions. This article consists of five sections, section I consists of introduction of this article. Section II consists of categorization of hand gesture and its features. Section III contains comparative study (review) of previous studies. Section IV consists of conclusions and results of article.

2.0 RECOGNITION OF HAND GESTURE RECOGNITION ANALYSIS FROM PREVIOUS STUDY:

Hand gesture recognition can be recognized by the human through its movements. But recognition of gesture of human by a machine is a big challenge. Some of previous studies have been discussed in this article.

3.1 Hand Gesture Recognition using Webcam

In this article the writer has focused on creating a new way of communication or interaction between the computer and human. And described the system that is supposed to receive human gestures [38] as an input to control computer applications. Writer had introduced a method which make use of webcam through which gestures [39] provided by the user are captured, processed and the functions associated to that specific gesture is broughtoff [25]. This system has 4 phases

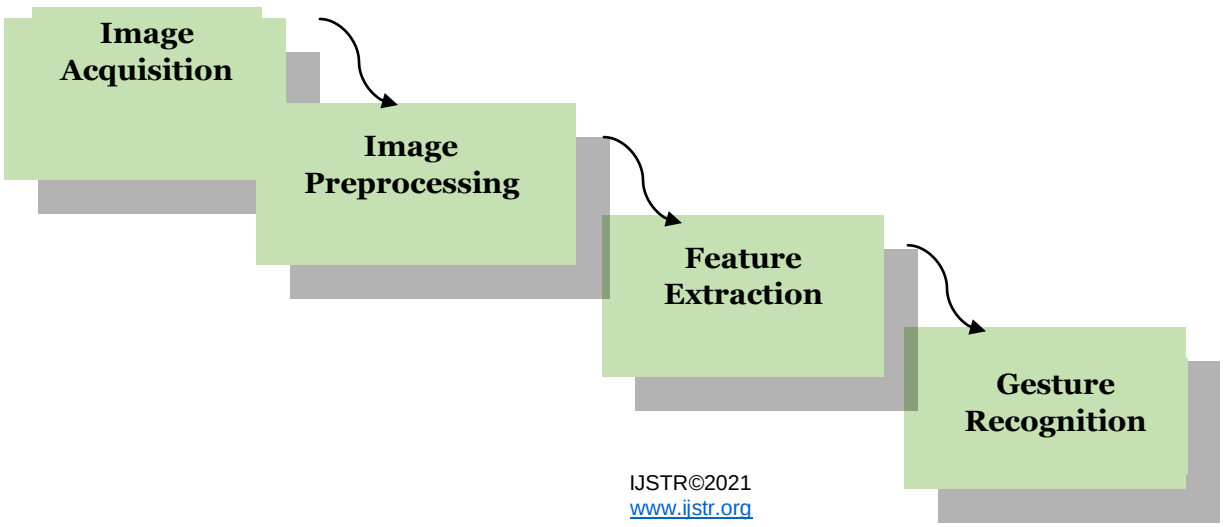


Figure 1:*Hand Gesture Recognition*

This system introduced uses python programming language for the movements of cursor by hand gesture are done using OpenCV [6,7] library, and the modules of python used are PyAutoGUI [8,9] & NumPy [10,11]. The video taken will be fragmented into nonstoppicturesedgeson the behalf of functions defined in OpenCV for the recognition of gestures done by the handler [26]. In this paper for detection process, they eliminate the mouse using webcam. In the future it will be the matter of attraction as it doesn't want any physical contact with the device [27].

Algorithm for the system

Start the webcam

Step#1: User's hand will be detected

Step #2:Image will be captured

Step #3:Specific hand gesture will be identified

Step #4: If the gesture for require movement is detected, go

Step #5:Coordinates of the mouse will be detected andcursor movement will be performed.

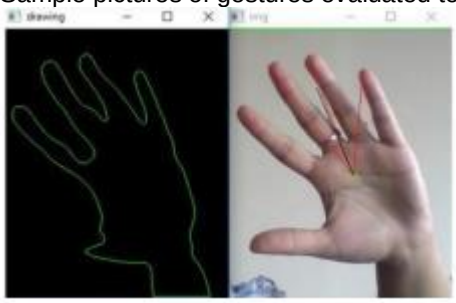
Step #6:Perform selection by using coordinates from the mouse, go to detect next gesture.

Step #7:Speed of cursor will be decreased

Step #8:Then speed of cursor will be increased

Step#9:End

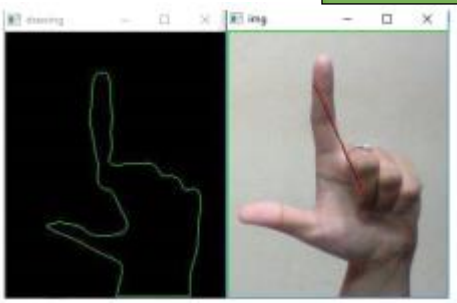
Sample pictures of gestures evaluated to detect either the system receive input through human hand gestures using webcam.



The gesture will decrease the speed of movement of cursor.

This gesture increases the speed of the cursor movement.

The gesture makes all cursor movements as drag.



The gesture performs double click operations.

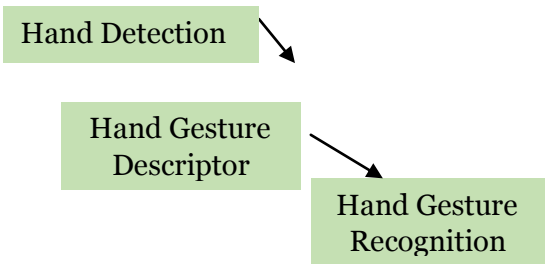
Figure 4

Figure 5

Figure 6:*Hand Detection*

3.2 A Simple and Effective Method for Hand Gesture Recognition

In this paperanefficient and simple scheme is presented. Usage of the skin color and labeling algorithm is introduced for hand recognition,it will do segmentation on the hand area from the background [28]. Then the center of mass& the palm pointisoriginatedused for the production of the baseline [29]. By which shapes of hand gesture the signature will constructed [28,30]. As this can be forecast thelabels of class &will be classify in last phase.



In this experiment original set of data [5] of 240 hand images are used for experimentwhich are captured by normal camera under the same condition [31]. The main focus is background, that background of the image should be very clean [29]. The skin color is calculatedby the HSV color model. Binary image is the output of the hand recognition. But the overall performance of the proposed method in this article depends on the proper detection of hand gesture[29].

Algorithm for the system

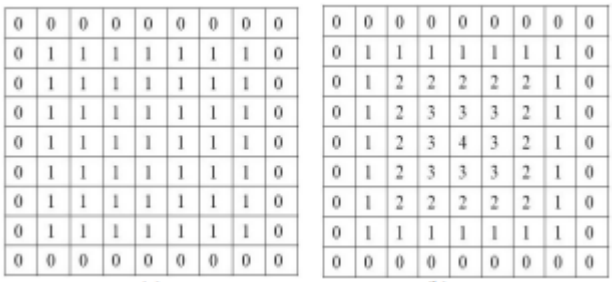
Step #1: Capture the image from random camera

Step #2: Detect hand in image from skin color, skin measured with HSV color model

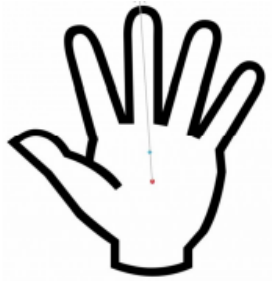
Step #3: Crop the image, remove the part under the wrist region using labeling algorithm.

Step #4:Define the center point of the palm, by the method of distance transform.

Step #5: Find the mass center of hand
Step #6: Characterize the shape of the hand gesture, by distance signature.
Step #7:Perform Hand Gesture Descriptor, train data sets for hand gestures (KNN Classifier).
Step #8: Perform evaluation on data sets.
Step #9: End



Matrixes of
1) Binary image
2) Distance Transform



The palm indicating palm point and mass center.

Fig

3.3 A New Approach for Hand Gestures Recognition Based on Depth Map Captured by RGB-D Camera

This paper isbased on depth map & RGB Kinect camera, which give two types of info “Depth Map” and “RGB Image” [13]. In this paper they had used Depth map info to examine & diagnose the hand gesture. The proposed method consist of edge detection is also helpful to remove the noise and segment the hand [32]. This methodology is applied to recognize the French language sign alphabets to demonstrate its effectiveness & evaluation the strength of the strategic descriptors [14] is used. Depth sensor [15] is used for better result, it consists of two methodologies :1) Static & 2) Dynamic. Used static gesture along with the individual movements and image as an input. 23-static letter of the French alphabet are recognized by them [33]. The main purpose is to attained fast and precise hand gesture recognition [49] on depth map which is conducted by Kinect camera [14].
The segmentation is an important module to is essential to detect the hands and their appearances in the image [14]. Hand segmentation is comprised into 3 stages Edge detection, Edge closing,filling the Hand region, and removing all the unwanted edge regions. For the color image & the depth mapthe Kinect sensor which is an input device [14] is used.The depth info is the main factor which gives each pixel depth for the sensor, firstly the depth info is converted into a grey scale image [14]. To get good result from camera people will be in 1.2 to 3.5-meter distance, at the above of this the accuracy of the sensor decreases rapidly [14,15].

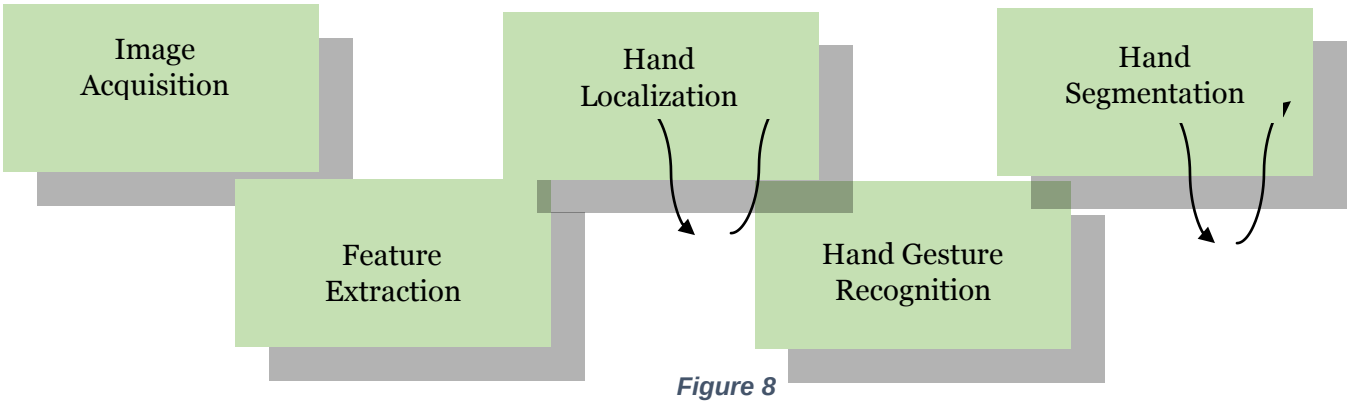


Figure 8

There are 20 point which are detected in human body [14]. So, only the 12-point matched to the center of the right-hand palm from the 20 key point coordinates matrix. In hand segmentation they remove all noise & useless info from the image by using the canny method [16]. It is most effective method because it uses different threshold like strong & weak edges, by applying a bilateral filter which would preserve the edge and reduce the noise & then it will deliver to the canny method for more efficient work. In this paper they had used two types of structures:first one consists of 2-D structure which denote the deformation of the hand in the 2-D strategy & demonstrate the geometry info & distinguish the shapes of the hand of the hand structure [14]. And the second feature signify the depth info 3-D mainly selected to signify the finger position and palm closure, they are based on proposed recognition system [14,33]. With the change of gesture, the hand position changed [32]. The point of view is related who established different hand gesture affectionate the alphabet of the American sign language [15].
Algorithm for the system:
Start#:Image is captured by RGB-D Kinect camera.
Step#1:Perform hand segmentation
Step#2:Hand Localization

Step#3:Apply bilateral filter on the image to remove noise.
Step#4:Apply canny method for edge detection.
Step#5:Close the edge region in the image.
Step#6:Close the hand edge region.
Step#7: Verification of edge closure.
Step#8:Find the circle region.
Step#9:Authenticate the hand region closure.
Step#10: Feature Extraction (2D and 3D).
Step#11:Identify hand orientation[37].
Step#12:Identify hand dimension and occupancy.
Step#13: Perform Euler number (describe the structure of the hand).
Step#14: Find variance depth value for 3D features.
Step#15: Find depth average to centroid depth information.
Step#16: Evaluate dataset (2300 gesture images of 23 static French language alphabets).
Step#17: Check the performance of the system.
Step#18: End

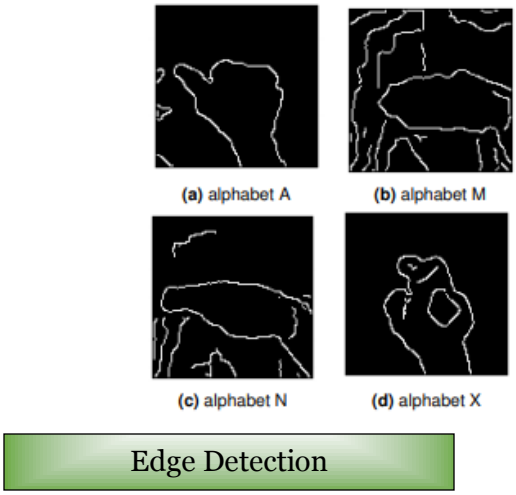


Figure 9: Edge Detection

3.4 Hand Gesture Recognition for Human Computer Interaction

In thispaper both the static and dynamic approach is used for detection of hand gestures. [14] As previous paper used only the static approach for their recognition. In this paper the gesture which are detected like opening website, launching application like and VLC, MS power point. Interface between user & computer is the main area of this paper [17]. To obtain hand gesture recognition the two terminologies are used: Non-vision & vision based. For some time, place and positioning of hand space does not change in static hand gesture, while, the waving of the hand is defined in dynamic hand gesture [14].

Generally, this paper contains two parts, backend & frontend. There are three components of backend are describedas the module of camera, module of detection&component of interface. [17] Connecting and taking contribution through various sorts of picture identifier and send picture to the discovery module for further process as edges this working is done in first segment [18,19]. The next component is responsible for image processing, it removes noise, color conversion which is done by contour extraction[34,35]. Thecomponent in the last is responsible for mapping of the hand gesture detected to t heir linked actions. Frontend contains three layouts. Initial one gathers the video input caught through camera with the relating name of the motion identified. Second design demonstrate the shapes found in the picture [19]. The last format demonstrates the smooth thresholder rendition of the picture. RGB color space image is taken from input image and then is cropped and it convert into a gray scale image [17]. At that point, thresholding strategy is actualized to get a twofold picture from dark scale picture [18,36]. Shapes are a significant apparatus for item identification and acknowledgment in picture preparing, in this paper the technique to identify and perceive the hand from the foundation is displayed [36]. Firstly, find white object from black background, besides to draw the forms which can be utilized to draw any shape gave the limit focuses [17,19]. Further they need to enhance and need more exactness do the augmentation of more motions to actualize more capacities [17].

Algorithm for this system:
Start: Input image with normal cheap camera
Step#1: Convert image into grey scale image
Step#2: Remove noise from the image and smooth the image
Step#3: Perform contour extraction
Step#4: Find convexity defects and convex hull
Step#5: Recognize gesture
Step#6: Use cascading classifier to expose gestures
Step#7: Map pair of gesture actions
Step#8: Dynamic gestures will be detected if any folder (PowerPoint or google) is open and webcam detects the palm region for 5 constant frames dynamic gestures.

By using gesture, user is operating computer system, "V" for VLC media player and "3" for google browser.

The method to convert RGB scale input image to grey scale and crop the hand image.

The result of static gestures used in experiment to represent the gesture recognition system.

Figure 10

3.5 Hand gesture recognition using a real-time tracking methodand hidden Markov models

In this paper the procedure used to perceive consistent motion before stationary foundation. This method recognizes the unknown input gesture by the use of HMMs.The writer has observed recent and used methods associated with hand gesture techniques [53], this technique is characterized into two methods glove based method [54,55] and vision-based method. This framework is having four modules which are: an ongoing hand following and extraction, include extraction, concealed Markov display (HMM) preparing, and motion acknowledgment.Initial step is to apply an ongoing hand following and extraction calculation to follow the moving hand and concentrate the hand locale, at that point we utilize the Fourier descriptor to depict spatial highlights and the movement examination to portray the worldly highlights. At that point we join the spatial and worldly highlights of the info picture arrange as our element vector. Subsequent to removing the component vectors, we apply HMMs to perceive the info signal of hand. The signal to be perceived is independently recorded against various HMMs.In this article the feature extraction method consists of different modules: Thresholding[56]to extract the moving area in the complex backgrounds. Skin color detection, will detect skin easily by using the color information. And will detect the hand region by detecting skin regions from the image.3rd module is edge detection; it is applied to the image to separate the arm area from the hand area.The model with the most elevated score demonstrates the proportional signal. This paper is not quite the same as other HMM based signal acknowledgment frameworks this framework does not utilize any instrumented glove, not any markers for acknowledgment but rather it utilizes 2D video contribution to the HMM based[51,52] motion acknowledgment framework in the examinations of this article we have tried our framework to perceive 20 distinct motions, and the perceiving rate is above 90%.

The framework of the proposed method of this article.

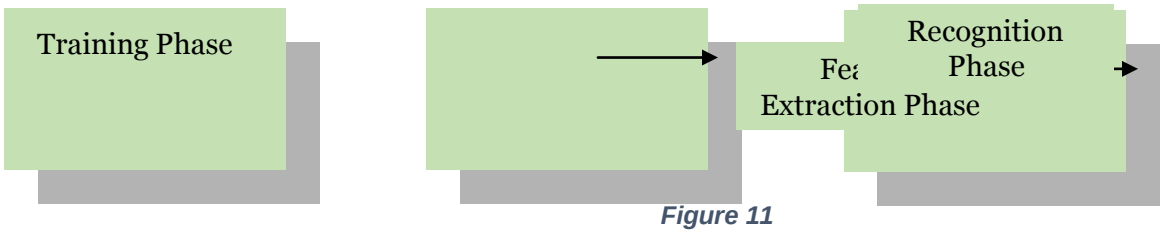


Figure 11

Algorithm for the system:
Start: Video Sequence
Step#1: Capture images from the video.
Step#2: Perform Motion detection, edge detection and skin color detection on the image.
Step#3: Collectively after detecting results of step 2 perform And Operation.
Step#4:Do labeling
Step#5: Find center of the hand
Step#6: Control the hand movement,through skin color sampling.
Step#7: Determine the hand gesture region.
Step#8: Clear the background, if required.
Step#9: Determine the location and bounding box.
Step#10: End

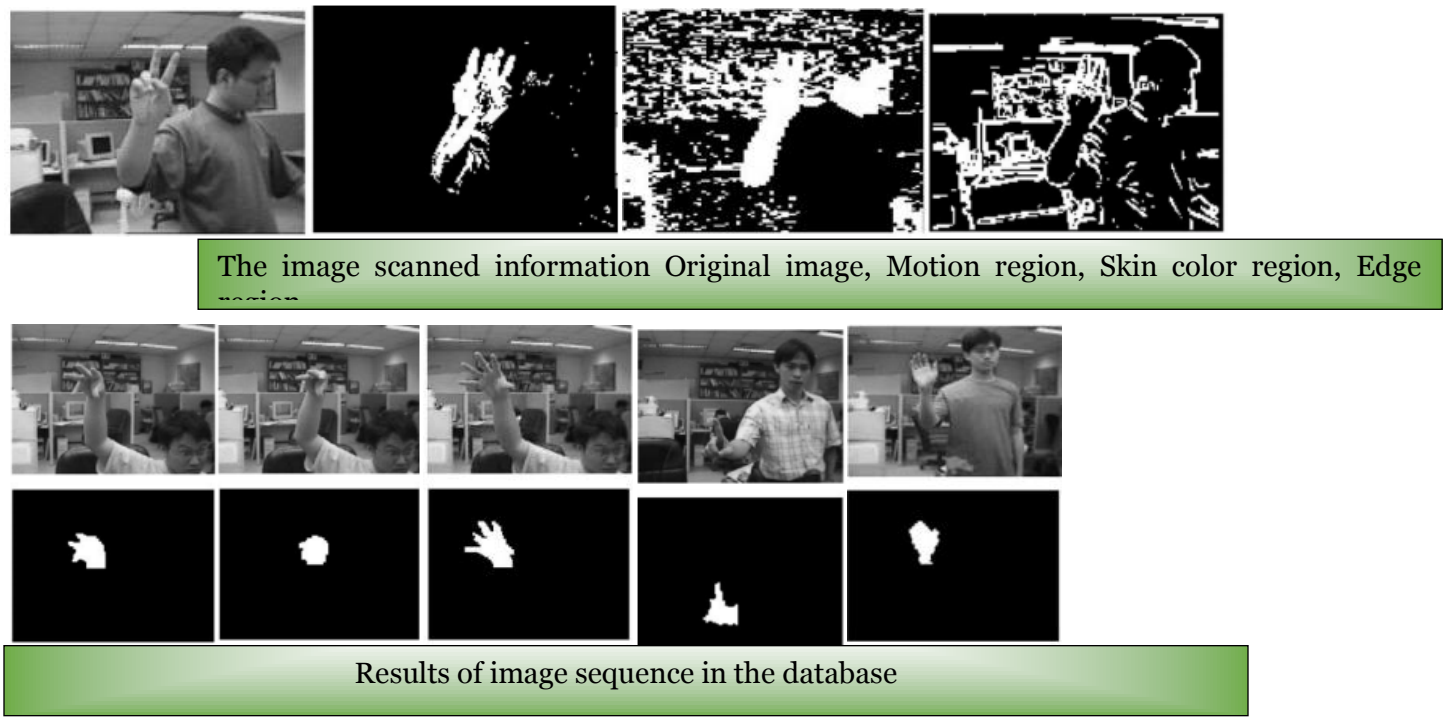


Figure 12

3.6 A Real-time Hand Gesture Recognition and Human-Computer Interaction System

In this article, gestures are variable and hands are agile [40]. This paper has three parts hand location, motion acknowledgment [3] and human-interaction point [40]. Used CNN modified from LeNet-5 [46] To recognized gesture, they use convolutional neural network and cheap monocular camera [45]. Monocular camera [5] doesn't provide in-depth information such as separation of background from hands. Serious of sequential and static 2D images can get by this cheap camera [43]. Natural communication network among people is hand gesture. So, HCI has application scenarios that are based on gestures [44]. Wearable electromagnetic devices and computer vision are two methods to perform gesture recognition [42]. First one performs good but the side-effect is it is costly and unusable. Features that are extracted by image processing are used for the performance of gesture recognition [44]. They have a set of gesture that can control mouse courser and it keeps a continuous trackable hand and to limit the mouse courser's movement they use Kalman filter that causes smoothness and stability [41]. Serious of transient, and intermediate gesture are caused by gestures that changes from one to another [44]. Hand gesture [45] variability can lead a significant change in hand's shape. So, we need special point on hand and we don't know where the center of hand exists. By the change of gestures, hand's center is also changing. Palm's center would be different form fist's center [41].

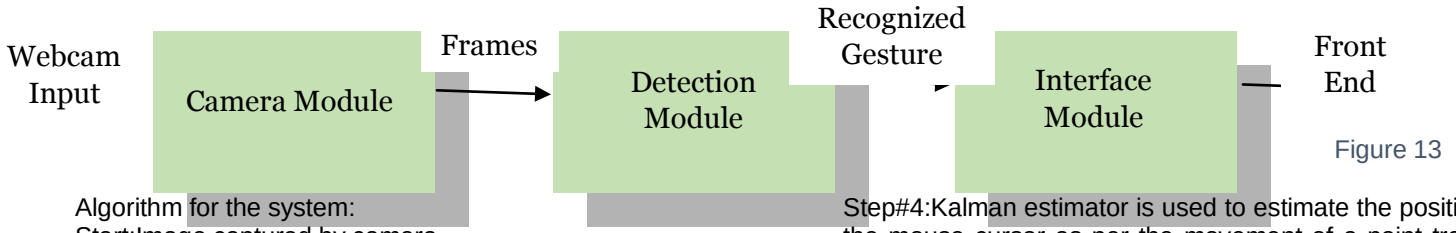
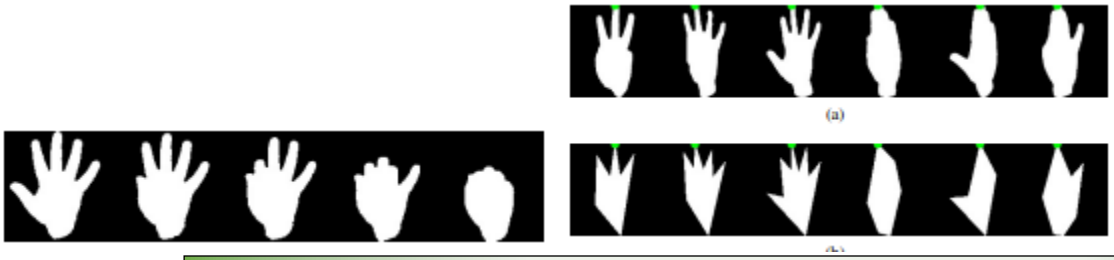


Figure 13

Algorithm for the system:
Start:Image captured by camera
Step#1:Hand detector filter out the hand image
Step#2: System terminates with hand is not detected
Step#3:CNN classifier is used to recognize gesture from image
Step#4:Kalman estimator is used to estimate the position of the mouse cursor as per the movement of a point tracked by hand detector.
Step#5:The recognition and estimation outcomes are submitted to a controller center
Step#6: A humble probabilistic model is used to resolve what response the system should make.
Step#7: End

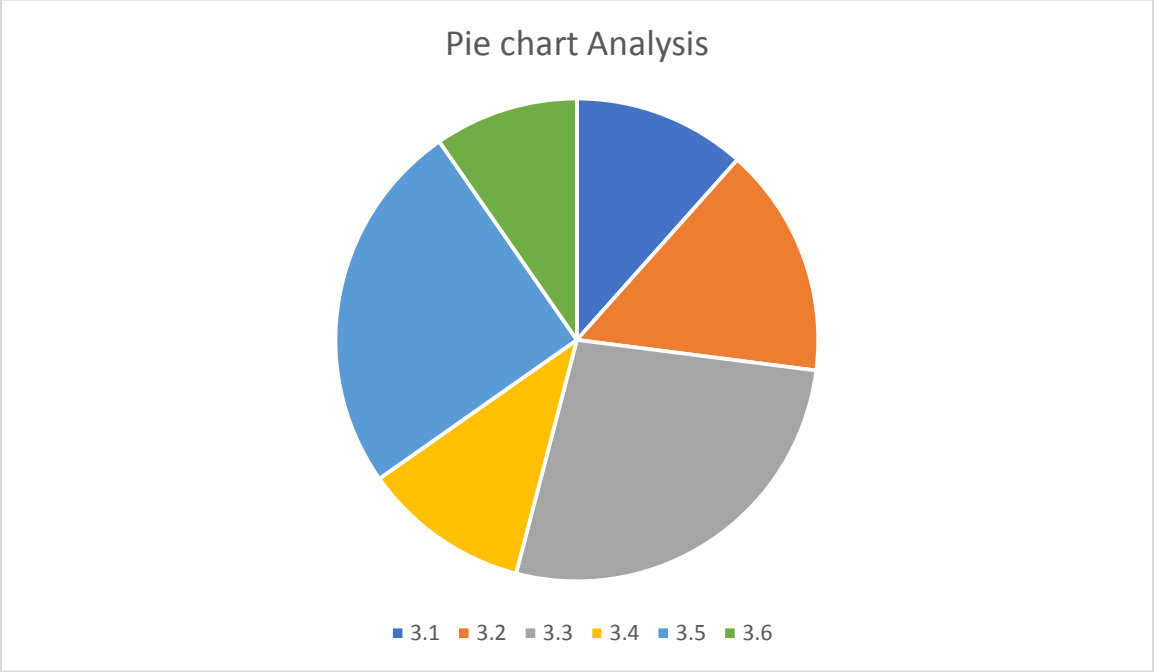


The results show that some false gestures are also detected during the experiment of the gesture changing from palm to fist.

Quick Analysis of previous study:

ARTICLES	TECHNIQUES	No of Pictures for Testing	No of features	PERFORMANCE OUTCOME %
Hand Gesture Recognition using Webcam	Webcam Method	10 gestures	1	70%
A Simple and Effective Method for Hand Gesture Recognition	Segmentation	10 images	1	95.5%
A New Approach for Hand Gestures Recognition Based on Depth Map Captured by RGB-D Camera	RGB-D camera & Depth Map	23static letters of the French alphabet	2	86%
Hand Gesture Recognition for Human Computer Interaction	Static &dynamic	7 gesture,6 static,1 dynamic	2	88%
Hand gesture recognition using a real-time tracking method and hidden Markov models	Hidden Markov Model (HMM)	20 gestures	5	90%
A Real-time Hand Gesture Recognition and Human-Computer Interaction System	Neural network and cheap monocular camera	3200 gesture images	1	85%

Graphical representation of Analytical study



3.0 CONCLUSION

Some techniques and methods discussed in this article. In which different methods of hand detection are discussed, Webcam, wireless technique, KNN, HMM, Markov Model. After analyzing nine articles of different authors regarding hand gesture recognition we had concluded that the article 3.5 titled as "Hand gesture recognition using a real-time tracking method and hidden Markov models "is best and most accurate one. In this article writer describes a hand gesture recognition system, technique used in this article is to recognize continuous gesture before stationary background. This method recognizes the unknown input gesture by the use of HMMs. convoyed by suitable confidence measures of the estimation accuracy. The experiments are performed on real data for detection which includes images of multiple users of different genders. Each hand motion is made multiple times by 20 distinct people. There are 60 changed picture successions caught for each hand signal in the trial. There are twenty unique motions, and 1200 picture successions are utilized for preparing. The span of each dim dimension picture outline is 256/256, the rate of casing is 30 outlines/sec, and signal creation of each picture takes around one moment. This method is much accurate and highly effective.

1. References

References

[1] Z. Zafrulla, H. Brashear, T. Starner, H. Hamilton, and P. Presti, "American sign language recognition with the kinect," in Proceedings of the 13th international conference on multimodal interfaces. ACM, 2011, pp. 279–286.

[2] J. Choi, H. Park, and J.-I. Park, "Hand shape recognition using distance transform and shape decomposition," in Image Processing (ICIP), 2011 18th IEEE International Conference on. IEEE, 2011, pp. 3605–3608

[3] Granit Luzhnica, Elizabeth Lex, Viktoria Pammer. A Sliding Window Approach to Natural Hand Gesture Recognition using a Custom Data Glove. In: 3D User Interfaces (3DUI); 2016IEEE Symposium on ; 2016 Mar 19 ; New York : IEEE; 2016 ; p.81-90.

[4] Ji-Hwan Kim,Nguyen Duc Thang,Tae-Seong Kim. 3-D hand Motion Tracking and Gesture Recognition Using a Data Glove. In; Industrial Electronics; 2009 IEEE International Symposium on ; 2009 July 5; New York : IEEE;2009 ; p.1013-1018.

[5] Dulayatrakul J, Prasertsakul P, Kondo T, Nilkhamhang I. Robust implementation of hand gesture recognition for remote human-machine interaction. In: Information Technology and Electrical Engineering (ICITEE); 2015 7th International Conference on ;2015 Oct 29;p. 247252.

[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, 2013.

[7] Itseez, Open Source Computer Vision Library - itseez2015opencv, 2015, accessed at https://github.com/itseez/opencv on 01/2/2017.

[8] Itseez, The OpenCV Reference Manual - itseez2014theopencv 2.4.9.0, April 2014, accessed at http://opencv.org/ on 01/2/107.

[9] Python Software Foundation (PSF), PyAutoGUI package, PyAutoGUI 0.9.36 accessed at https://pypi.python.org/pypi/PyAutoGUI on 21/4/2017.

[10] Al Sweigart, PyAutoGUI Documentation, Release 1.0.0, accessed at https://media.readthedocs.org/pdf/pyautogui/latest/pyautog ui.pdf on 21/4/2017.

[11] Stéfan van der Walt, S. Chris Colbert and GaëlVaroquaux. The NumPy Array: A Structure for Efficient Numerical Computation, Computing in Science & Engineering 13, 22-30 (2011) DOI:10.1109/MCSE.2011.37.

[12] NumPy Developers, numpy 1.13.0rc2, accessed at https://pypi.python.org/pypi/numpy on 01/2/107.
[13] Chen WL, Wu CH, Lin CH. Depth-based hand gesture recognition using hand movements and defects. In: Next-Generation Electronics (ISNE); 2015 International Symposium on; 2015 May 4 ; Taiwan, Taipei ;New York : IEEE;2015 ;p. 1-4.
[14] Ahmed Ben Jmaa, Walid Mahdi, Yousra Ben Jemaa, Abdelmajid Ben Hamadou. A New Approach For Hand Gestures Recognition Based on Depth Map Captured by RGB-D Camera.
[15] Ohn-Bar, E. & Manubhai Trivedi, M. (2014). Hand gesture recognition in real time for automotive interfaces: A multimodal vision-based approach and evaluations. IEEE Transactions on Intelligent Transportation Systems, Vol. 15, pp. 2368–2377.
[16] Berard, F., Coutaz, J., & Crowley, J. L. (1995). Finger tracking as input device for augmented reality. Proc. Intel Workshop on Automatic Face and Gesture-Recognition, Zurich, Switzerland.
[17] AashniHariaa, ArchanasriSubramaniana, NivedhithaAsokkumara, ShristiPoddara , Jyothi S Nayaka. Hand Gesture Recognition for Human Computer Interaction
[18] Granit Luzhnica, Elizabeth Lex, Viktoria Pammer. A Sliding Window Approach to Natural Hand Gesture Recognition using a Custom Data Glove. In: 3D User Interfaces (3DUI); 2016 IEEE Symposium on; 2016 Mar 19; New York: IEEE; 2016
[19] C. Wang, Z. Liu and S. C. Chan. Superpixel-Based Hand Gesture Recognition with Kinect Depth Camera. IEEE Transactions on Multimedia 2015
[20] Ishiyama H, Kurabayashi S. Monochrome glove: A robust real-time hand gesture recognition method by using a fabric glove with design of structured markers. In: Virtual Reality (VR); 2016 IEEE ;2016 Mar 19; Greenville, SC; New York: IEEE;2016
[21] OndrejKainz, FrantišekJakab. Approach to Hand Tracking and Gesture Recognition Based on Depth-Sensing Cameras and EMG Monitoring
[22] Hand Gesture Recognition Library Jonathan Fidelis Paul, Dibyabiva Seth, Cijo Paul, Jayati Ghosh Dastidar, St. Xavier's College, Kolkata, India, St. Xavier's College, Kolkata, India, St. Xavier's College, Kolkata, India, St. Xavier's College, Kolkata, India
[23] Bretzner. L, Laptev. I, Lindeberg. T, Hand gesture recognition using multi-scale colour features, hierarchical models and particle filtering, Proceedings of Fifth IEEE International Conference on Automatic Face Gesture Recognition
[24] D. Shridhar, A. Badreldin, High-Accuracy character recognition algorithm using fourier and topology descriptors, Pattern Recognition 17 (1984) 515–524.
[25] K. Madhuri, L. Praveen Kumar, "Cursor Movements Controlled By Real Time Hand Gestures", International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064.
[26] Mark Bayazit, Alex Couture-Beil, and Greg Mori, 'Real-time motion based gesture recognition using the gpu', in IAPR Conference on Machine Vision Applications (MVA), (2009).
[27] AthiyaMarium*, Deepthi Rao, Divina Riya Crasta, Kavya Acharya, Rio D'Souza,Hand Gesture Recognition using Webcam
[28] Chunying QUAN, Jianning LIANG,A Simple and Effective Method for Hand Gesture Recognition.
[29] Z. Zafrulla, H. Brashear, T. Starner, H. Hamilton, and P. Presti," American sign language recognition with the kinect," in Proceedings of the 13th international conference on multimodal interfaces. ACM, 2011, pp. 279–286.
[30] J. Choi, H. Park, and J.-I. Park, "Hand shape recognition using distance transform and shape decomposition," in Image Processing (ICIP), 2011 18th IEEE International Conference on. IEEE, 2011, pp. 3605–3608.
[31] Z. Mo and U. Neumann, "Real-time hand pose recognition using low resolution depth images." in CVPR (2), 2006, pp. 1499–1505.
[32] Canny, J. (1986). A computational approach to edge detection. IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 8, pp. 679–698.
[33] Ghosh, S. & Chaudhury, K. N. (2016). On fast bilateral filtering using fourier kernels. IEEE Signal Processing Letters, Vol. 23, pp. 570–573.
[34] Granit Luzhnica, Elizabeth Lex, Viktoria Pammer. A Sliding Window Approach to Natural Hand Gesture Recognition using a Custom Data Glove. In: 3D User Interfaces (3DUI); 2016 IEEE Symposium on ; 2016 Mar 19 ; New York : IEEE; 2016 ; p.81-90.
[35] Lee DH, Hong KS. A Hand gesture recognition system based on difference image entropy. In: Advanced Information Management and Service (IMS), 2010 6th International Conference on; 2010 Nov 30; Seoul; New York: IEEE; 2010 ; p. 410-413.
[36] Otsu, Nobuyuki. A threshold selection method from gray-level histograms. IEEE transactions on systems, man, and cybernetics 1979; 9(1): 62-66.
[37]Bretzner. L, Laptev. I, Lindeberg. T, Hand gesture recognition using multi-scale colour features, hierarchical models and particle filtering, Proceedings of Fifth IEEE International Conference on Automatic Face Gesture Recognition, Pages 423-428, 2002.
[38] Ann Abraham Babu, Satishkumar Varma, Rupali Nikhare, "Hand Gesture Recognition System for Human Computer Interaction Using Contour Analysis", International Journal of Research in Engineering and Technology, eISSN: 2319-1163, pISSN: 2321-7308
[39] Ming-Hsuan Yang, Ahuja, N. ; Tabb, Extraction of 2D motion trajectories and its application to hand gesture recognition, Pattern Analysis and Machine Intelligence, IEEE Transactions on (Volume:24 , Issue: 8), Page(s):1061 - 1074, 2002.
[40] Pei Xu∗ Department of Electrical and Computer Engineering, University of Minnesota, Twin Cities,A Real-time Hand Gesture Recognition and Human-Computer Interaction System
[41] S. Thakur, R. Mehra and B. Prakash, Vision based computer mouse control using hand gestures. Soft Computing Techniques and Implementations (ICSCTI), 2015 International Conference on. IEEE, 2015: 85-89.
[42] A. A. Argyros and M. I. A. Lourakis, Vision-based interpretation of hand gestures for remote control of a

computer mouse. European Conference on Computer Vision. Springer Berlin Heidelberg, 2006: 4051.
[43] D. Kuli and E. A. Croft, Safe planning for humanrobot interaction. Journal of Field Robotics, 2005, 22(7): 383-396.
[44] S. H. Grif and C. C. Farcas, Mouse Cursor Control System Based on Hand Gesture. Procedia Technology, 2016, 22: 657-661.
[45] ThittapornGanokratanaa,SureePumrin,Hand Gesture Recognition Algorithm for Smart Cities based on Wireless Sensor.
[46] Ankit Chaudhary and Jagdish L. Raheja, "A Health Monitoring System for Elder and Sick Persons," presented at the International Journal of Computer Theory and Engineering, Vol. 5, No. 3, June 2013, 2013.
[47]Ankit Chaudhary and Jagdish L. Raheja, "A Health Monitoring System for Elder and Sick
Persons," presented at the International Journal of Computer Theory and Engineering, Vol. 5,No. 3, June 2013, 2013.
[48] C.-C. Hsieh and D.-H. Liou, "NovelHaar features for real-time hand gesture recognition
using SVM," Journal of Real-Time Image Processing, vol. 10, pp. 357-370, 2015.
[49] C. Shan, T. Tan, and Y. Wei, "Real-time hand tracking using a mean shift embedded particle filter," Pattern recognition, vol. 40, pp. 1958-1970, 2007.
[50] C. Acharya, H. Thimbleby, and P. Oladimeji, "Human computer interaction and medical devices," in Proceedings of the 24th BCS Interaction Specialist Group Conference, 2010, pp. 168-176.
[51] L.W. Campbell, D.A. Becker, A. Azarbayejani, A.F. Bobick, A. Plentland, Invariant features for 3-D gesture recognition, Proceedings IEEE Second International Workshop on Automatic Face and Gesture Recognition, 1996
[52] J. Schlenzig, E. Hunter, R. Jain, Recursive identification of gesture inputers using hidden Markov models, Proceedings Second Annual Conference On Applications. Of Computer Vision (1994) 187–194.
[53] V.I. Pavlovic, R. Sharma, T.S. Huang, Visual interpretation of hand gestures for human-computer interaction, A Review, IEEE Transactions on Pattern Analysis and Machine Intelligence 19 (7) (1997) 677–695.
[54] T. Baudel, M. Baudouin-Lafon, Charade: remote control of objects using free-hand gestures, Comm. ACM 36 (7) (1993) 28–35
[55] D.J. Sturman, D. Zeltzer, A survey of glove-based input, IEEE Computer Graphics and Applications 14 (1994) 30–39.