Hand Gesture Recognition System

Aashni P Haria[#1], Archanasri Subramanian[#2], Nivedhitha Asokkumar[#3], Shristi Poddar[#4], Jyothi S Nayak[#5]

[#1#2#3#4]*Student,* [#5]*Associate Professor,*

Department of Computer Science & Engineering, BMS College of Engineering, Bangalore 560019, India

Abstract *— Most of the human computer interaction interfaces that are designed today require explicit instructions from the user in the form of keyboard taps or mouse clicks. As the complexity of these devices increase, the sheer amount of such instructions can easily disrupt, distract and overwhelm users. A novel method to recognize hand gestures for human computer interaction, using computer vision and image processing techniques, is proposed in this paper. The proposed method can successfully replace such devices (e.g. keyboard or mouse) needed for interacting with a personal computer. In this we use a depth camera along with markers to recognize hand gestures for various mouse functions like scroll, swipe, zoom etc. and different gestures which represent words that would facilitate searching for common subjects on the internet without typing the entire word. This results in real time performance and a more intuitive and natural interaction between the user and the computer.*

Keywords *— HCI, Haar Cascade, Convex Hull, Convexity Defects*

I. Introduction

Human Computer Interaction (HCI) is a discipline associated with the design, evaluation and implementation of computing systems which are interactive for human use. The basic goal of HCI is to improve the interaction between users and computers by making the computer more receptive to user needs. HCI with a personal computer today is not just limited to keyboard and mouse interaction. Interaction between humans comes from different sensory modes like gesture, speech, facial and body expressions. Being able to interact with the system naturally is becoming ever more important in many fields of HCI.

Both non-vision and vision based approaches have been used to achieve hand gesture recognition. An example of a non-vision based approach is the detection of finger bending with a pair of wired gloves. In general vision based approaches are more natural as they require no hand fitting devices.

Theoretically the literature classifies hand gestures into two types: static and dynamic gestures. Static hand gestures are defined as orientation and position of hand in the space during an amount of time without any movement. If during the aforementioned time duration, there is a movement then it is called dynamic gesture. Dynamic hand gestures are those gestures which involve movement of body parts like waving of hand while static hand gestures include single formation without movement. Static pose includes the "Ok" symbol. It is done by jamming the thumb and forefinger.

II. Literature Survey

After research, the various steps involved in gesture recognition involve image acquisition, pre-processing, segmentation, feature points extraction and classification followed by the result.

A. Camera Module

The commonly used methods of capturing input from the user that has been observed are data gloves, hand belts and cameras. Input extraction through data gloves has been used by [10] where two bend sensors along with motion sensor were deployed to detect dynamic hand gestures. In the paper [19], KHU-1 data glove was developed which was composed of triaxis accelerometers, controller and a bluetooth. A hand belt with gyroscope, accelerometer and a bluetooth was deployed to read hand movements in papers [1] [31]. Paper [2] used a creative Senz3D Camera to capture both color and depth information and [5] used a Bumblebee2 stereo camera. While monocular cameras do not give depth information, they require less computing costs and so was used by [32]. Cost efficient models like [3][29][25] have implemented their systems using simple web cameras. Papers [18][30] make use of a kinect depth RGB camera which was used to capture colour stream. As depth cameras provide additional depth information for each pixel (depth images) at frame rate along with the traditional images, it was used in [33][27]. Most technologies allow a hand region to be extracted robustly by utilizing the colour space. These do not fully solve the background problem. This background problem was resolved in [6] by using a black and white pattern of augmented reality markers (monochrome glove). This technique shows how the usage of markers for hand detection facilitates both efficiency and accuracy. Hence we expect to use a similar method along with a suitable depth camera for capturing input in our proposed model.

B. Detection Module

Our main intention is to recognize static and dynamic hand gestures with the support of a depth camera. A large number of methods have been utilized for pre-

processing the image which includes algorithms and techniques for noise removal, edge detection, smoothening followed by different segmentation techniques for boundary extraction i.e separating the foreground from the background.

Digital images can have different types of noise. Noise is a result of errors in the image learning process that results in pixel values different from the true intensities of the real scene. In paper [34][29] a morphology algorithm was used that performs image erosion and image dilation to eliminate noise. Erosion helps in trimming the image area where the hand is not present and dilation helps in expanding the area of the image pixels which are not eroded. Gaussian filter was used to smoothen the contours after binarization [17][25]. In the cases where larger noises cannot be removed using opening operation, component labelling and concept of scanline was implemented [26]. Canny edge detector can also be used to obtain the object boundaries with the image. It uses a multistage algorithm.

1) ***Segmentation:*** In [7] they consider the difference in colour of the palm region due to the presence of a red colour decoration on the fingertips and on the middle of the palm of the Bharatanatyam dancer. In order to deal with is, they used texture based segmentation as a basic segmentation technique to differentiate the hand from the background instead of using skin colour segmentation which would not detect the red colour areas as a part of the hand. In [5] a depth map was calculated by matching the left and right images with the SAD (Sum of Absolute Differences) algorithm. The SAD algorithm calculates the similarity between the image blocks. Based of this calculated depth map, the background is removed. The detection error of lighting was removed by applying histogram equalization. A similar approach that used histogram was [17] in which to detect the skin region of a person's face, the eyes, nostrils etc. were eliminated by using a grey level histogram analysis to obtain the skin colour range of the person. This skin colour was then used to detect the hand region.

In paper [33], an assumption was made that the user is located closest to the camera so the user was occupying a large area in the depth map. They used a bayesian object localization for hand detection. In [9], the signatures were extracted after which the image was clustered into the foreground and background using Gaussian Mixture Model. [6] used an augmented reality sdk. The hand posture was calculated with the help of the augmented reality markers of the monochrome gloves. SubSENSE is one of the best background subtraction algorithm at the CDnet website [35].

We have also come across the use of the skin detection algorithm to detect and separate hand from background using which a range for skin colour was defined (YUV[3][20] scale or HSV scale[32]). For the YUV scale, this range was then used as a threshold to determine whether the value belongs to a white pixel (hand image) or black (background). For the [32], HSV colour space was used as the skin threshold for the detection for the foreground image (hand). Background subtraction was then performed using UGV (Unit Gradient Vector). UGV background subtraction begins with intensity based grayscale images of both the background and current frame. This resulted in a binary image representing foreground objects

2) ***Feature Point Extraction:*** After the hand region is obtained, the next step is to extract the contour of the hand. In [29], the Theo Pavildis Algorithm which visits only the boundary pixels was used to find the contours. This method brings down the computational costs. In [33][34][29], the biggest contour was chosen as the contour of the hand palm after which the contour was simplified using polygonal approximation. The hand contour was obtained using the graham scan algorithm and to compute the convex hull of the hand. In paper [3], the Jarvis March algorithm was used to detect convex hull points. In [32], finger detection was achieved through top-hat transformation. Fingertip finding in [27] used distance transform on the hand region to find the palm center and the finger tips. The fingers were extracted as P(finger)=P-P(palm)-P(Arm).

After extracting the region of interest, the data is matched to the training data (using classifiers) to recognize and characterize the different hand gestures and give them as functional inputs to produce the system results.

3) ***Classification:*** Classification is a process in which individual items (objects/patterns/image regions/pixels) are grouped based on the similarity between the item and the description of the group. Various classifier algorithms have been used in the papers to derive the results after comparing the input data to the training set. Paper [10] uses Euclidean distance based classifier to recognise 25 hand postures whereas paper [25] uses Mahalanobis distance. Another commonly used technique was the SVM classifier. Here the goal is to find the optimal separation hyperplane between two classes. The classification algorithm calculates the distance of the input data from this decision boundary. This hyperplane is defined during the training stage where the SVM algorithm selects a subset of the input data, the support vectors to define the SVM model. If the decision boundary is highly non-linear, SVM algorithm can map the predictor on a higher dimension space where it is possible to separate data. Such space is called feature space. This approach is called Kernel technique. This technique along with Hidden Markov Model (HMM) was used in [15] to show combine accuracy (along with SVM) increase of 12% while classification. The same SVM classifier was used in [16][18]. Convolutional Neural Networks (CNN) were used to extract the features of view images which were then combined to form the

features of gestures and these gestures were recognized using the SVM classifier as in [21]. In [16], a Polynomial Kernel Function was chosen because the extracted feature vectors after zero-padding are quite long.

Hidden Markov Model (HMM) has also been widely used for the analysis of sequential data and is known for their application in gesture recognition, handwriting recognition etc. Paper [34] develops their simple virtual mouse based on this Hidden Markov Model. The advantage of DTW to HMM is that it can automatically align the sequences that have different lengths and thus give the proper distances. The DTW distance can be combined with k-NN to give robust results as seen in [19]. Polar hand image is a popular method of recognizing hand gestures due to its scale, translation and rotation invariance as demonstrated in [26].

After classification, the hand gestures that are recognized are now used to perform the related actions to give the desired results. In paper [20], Recognition Rate (RR) is used as parameter to measure the performance of gesture recognition. It is defined as the ratio of the number of video frames in which the gesture was correctly recognized to the total no of video frames in which the gesture was tested.

III. CONCLUSIONS

In this paper, we attempt to gather brief knowledge about the various methods and algorithms that have been used to detect hand gestures. We intend to make decisions on the methods and algorithms that we have considered to use during the implementation phase of our proposed system.

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