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A Review Paper on Gesture Recognition

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Abstract:
Hand gesture recognition systems are becoming popular day-by-day due to their variety of applications and capability of interacting with machines efficiently. Interaction of human–beings with computers or machines with the help of gestures is gaining importance because it does not require any other device in between such as keyboard, mouse, laser-pens etc. The paper gives detailed summary of research carried out in this field in past as well as recent few years. There are total 30 papers in which various methods of gesture image preprocessing and technique by which gestures are recognized are discussed in brief. Different methods of feature extraction of the object of interest are discussed in detail. Some of the papers have used vision based recognition of gestures; some of them have used sensor based recognition of gestures. Different methods and techniques explained in this paper required for pre-processing of an image, feature-extraction, and classification gives a brief idea about how the gestures can be recognized in the field of human-computer interaction and how the communication between man and machine becomes easy for various applications.

Keywords: Classification, Feature Extraction, Hand Gesture Recognition, Human-Computer Interaction.

I. INTRODUCTION

In today's world, gesture recognition plays a vital role for interaction between Humans and Computers. Gesture recognition facilitates user-friendly communication between humans and computers and enables the human beings to interact without any mechanical devices such as keyboards, laser pens and many more other devices. In one of the system, users can use any suitable gestures in order to control the machine without physically touching the PC. The image gesture thus acquired consists of different background elements with varying surrounding lights. So, the acquired image is subjected to segmentation. The segmented image is processed further in order to make it fit for comparison with the gesture images stored in database [1]. One of the methods of hand gesture detection is by calculating the centroid of the object region with the help of Distance transform method and then determines the finger count [2]. Some also make use of Circular Profiling for determining the finger count [1]. Some systems use directional search algorithm for the identification of the entire hand contour. The finger tips over the contour are then located using k-curvature algorithm for recognizing the gestures and then the particular gesture belongs to which candidate is determined using Dynamic Time Warping[3]. Some systems have used the technique of camshaft for tracking hands and its gestures and classifier is implemented with the help of HAAR Technique [4]. One of the systems has used Gabor wavelet transformation and Support Vector Machines (SVM's) for gesture feature extraction and gesture recognition [5]. Some systems apply minimum distance classifier to the Zernike, Tchebichef and Krawtchouk moments [6]. DSP processor and monochrome glove have also been used in some systems for classification of hand gestures [7][12]. Digital Pen consisting of microcontroller etc. has also been used in Hand gesture recognition [8]. One of the methods makes use of visual attention model consisting of the Human Eye. The visual attention fixation points in the Human Eye help in the classification of gestures [9]. Similar to this paper some systems have used HOG Feature extraction of the captured image for the hand gesture recognition [10]. Some systems have used depth camera and depth information for capturing the images of hand gestures and recognizing the same. After the hand gesture recognition, gestures are classified using Fuzzy Logic Pattern [11]. One of the systems has used specialized gloves having 10 sensors for hand body language recognition and then with the help of following classifiers: support vector machine, probabilistic neural network, and k-nearest neighbor algorithm various machine learning algorithms were developed [13]. Some of the systems have also started working on emotion recognition. One of them uses three peak frame selection approaches; they are Dend, Maxdist, Eifs, and Cluster [14]. One of the systems has used selective temporal filtering for gesture recognition. Unlike temporal data analysis, selective temporal filtering helps to build a noise free model for classification [15].

II. IMAGE PREPROCESSING

For any type of the Gesture Recognition system, the initial step is to acquire the Gesture Image i.e. image acquisition. It can be done with the help of various methods. Then the foreground part of it is needed to be separated from the background. Statistical background modeling is one of the techniques to achieve background subtraction [16]. Some systems carry real time hand gesture recognition with the help of depth data collected by Kinect sensor. Considering that the hand region of user is the closest object in the view of camera, interest space is separated i.e. hand region. Kinect sensor collects the raw data and these raw data are used to regain depth information on all the pixels of an image. A novel faster algorithm is then proposed to identify each point of a closed contour identified within a given depth interval. Kinect Sensor collects the `16-bit raw data out of which last 13 bits represent the depth information. Next 3-bits are used to retain this information with the help of shift-operation [3]. Some techniques use skin colour information to separate the foreground part from the background i.e. for hand segmentation. Image segmentation with the help of skin colour information is quite simple

provided it is more sensitive to background light conditions. Also the image should not contain any object in the background which is same as skin colour such as wood. In such a case, stereo image consisting of depth information is used as a substitute to 2Dimensional pixel image. The depth information does not get affected due to any type of background light conditions and is robust even if the background of the image is complicated. Fig.1. Shows intermediate results of Image segmentation [17]. In some systems, Leap Motion and Kinect Devices are used to obtain the detailed description of hand gestures which further help in accurate classification of gestures. Relevant hand points set and few features of gesture are returned by the Leap Motion devices unlike Kinect devices that return a complete

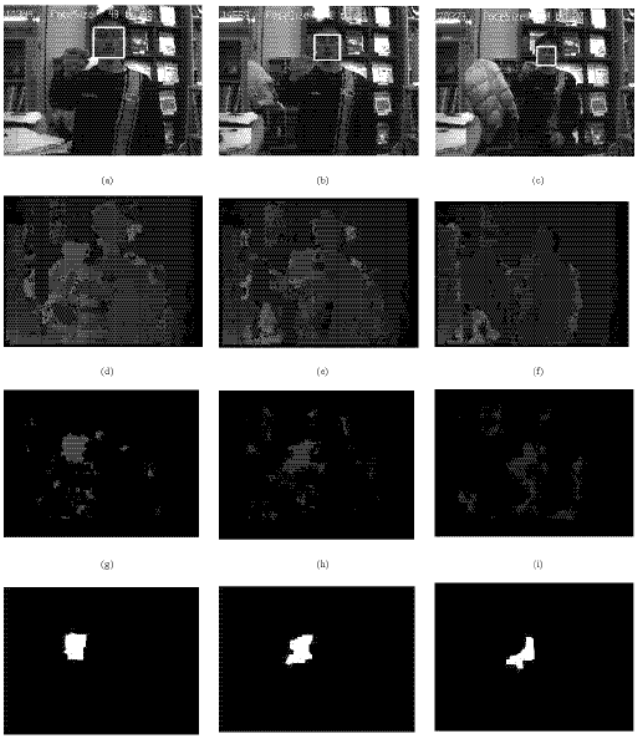

Figure.1. Intermediate results of hand segmentation-images are shown by the first row (a), (b), (c) ; depth maps are shown by second row (d), (e), (f); noise removal and segmentation are shown by the third row (g), (h), (i) ; the result after connected component analysis and morphological operation are shown by the fourth row (j), (k),(l).

Depth map of hand gesture image [18]. In most of the Emotion or Facial Expression recognition systems, detection of the face is the initial step. Appearance of the Face, Shape of the head, and colour of the skin are the various keys with the help of which Face detection can be done. The main distinguishing factor for detecting the face is Skin-Colour. It acts as a pre-processing filter for separating facial portion from the colourful image. An image is converted into RGB i.e. red, green, blue colour model. The given pixel then gets converted into an appropriate colour space model by the skin detector. Depending on database of skin colour, a decision boundary is defined by the skin filter in the colour space model [19]. Some systems use morphological techniques with two levels of skin colour detection techniques [20].

III. FEATURE EXTRACTION

The next step after image preprocessing is feature extraction of the processed image of gesture. Some systems implement this step for gesture recognition while some systems skip this step and directly do gesture recognition based on some advanced techniques such as user state recognition. After that the system will switch on the camera-based recognition module to control the required device [21]. The main factor which decides the efficiency and accuracy of recognized gesture is the quality of extracted features. In some systems, the first pixel on the hand contour is first identified within the segmented space. Initiating with this pixel, a directional search algorithm is used to identify the contour of the entire hand. The fingertips over the contour are located using *k*-curvature algorithm and gesture candidates are selected using dynamic time warping. These features are further useful for classification of gesture [3]. In some cases, when the image is captured from the Kinect devices, the skeleton as well as depth data are used for hand feature extraction. The features of shape of hand, their respective textures are stored in the form of Superpixels form. These Superpixels store whole shape and colour of the hand poses that are to be recognised very effectively [22]. In one of the systems, binary image of the shape of the hand is given as an input to the feature extractor. The features related to the shape of the hand are extracted by using the following given by (1).

$$d = \frac{1}{2}\left(1 + \frac{1}{hw^2}\sum_{j=1}^{h} n_j^{\,2} - \frac{1}{h^2 w}\sum_{i=1}^{w} n_i^{\,2}\right) \quad (1)$$

Where h = height of the pixels of hand shape,

w = width of the pixels of hand shape

n_i = number of black pixels computed from the i^{th} horizontal perpendicular line and

n_j = number of black pixels computed from the j^{th} perpendicular line. The second feature is the width/height ratio [23].

IV. GESTURE CLASSIFICATION

The next step to be implemented after feature extraction is Gesture Classification. Gesture Classification can be done with variety of different techniques. Recognizing the gesture with the help of Neural Networks is one of the techniques. These Neural Networks are able to distinguish between gesture movements and daily non gesture movements. Neural Networks use different threshold for different features and accurately combine the features which are obtained as hidden information from the training data and distinguish between gesture and non-gesture movements. Hierarchical hidden Markov model is used further for gesture classification. Hierarchical HMM is derived from Hidden Markov Model. The HHMM is nothing but a statistical model that is developed to represent the sequential constraints. The flowchart of the algorithm is as given below in Fig.2 [24].

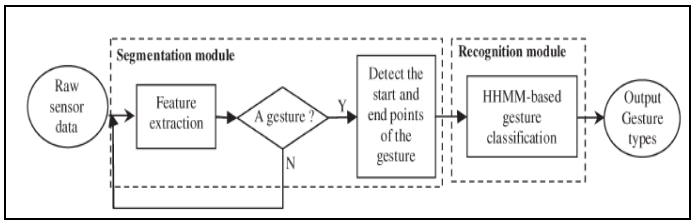

Figure.2. Flowchart: Hand gesture recognition Algorithm.

Many systems use various sensors other than camera for gesture recognition. One of the systems uses 3D accelerometer along with camera. The information that is acquired from camera and 3Dimensional accelerometer is combined and fed

to the Choquet integral. Then multimodal gesture recognition method is used that is depending on Choquet integral [25]. Some systems have used Smart Phones for gesture recognition. The smart phones are already equipped with, accelerometer, optical sensor and magnetometer. Accelerometer sensor and the other sensors mentioned above that are already embedded in the smart phones help in recognising the gestures. Different gestures are classified with the help of Fuzzy control technique .The system flowchart is as shown in Fig. 3[26]. Hand gestures are also recognised using accelerometers which are embedded in remote-control. This system is developed to control the Digital Television. As hand gestures are nothing but a pattern classification problem, two techniques that are based on Artificial Neural Network are developed. They are support vector machine and multilayer perceptron [28]. Some systems have developed an algorithm that uses surface electromyography (SEMG) signals and processes acceleration for recognizing gestures. An improved dynamic time-warping algorithm and a Bayes linear classifier are also used in the algorithm for accurate gesture classification [27]. Joint signals from accelerometer and gyroscope from the mobile device are used to classify 3D gestures. The proposed system makes use of averaging, 1D convolution, and max-pooling operations along with convolutional neural network.

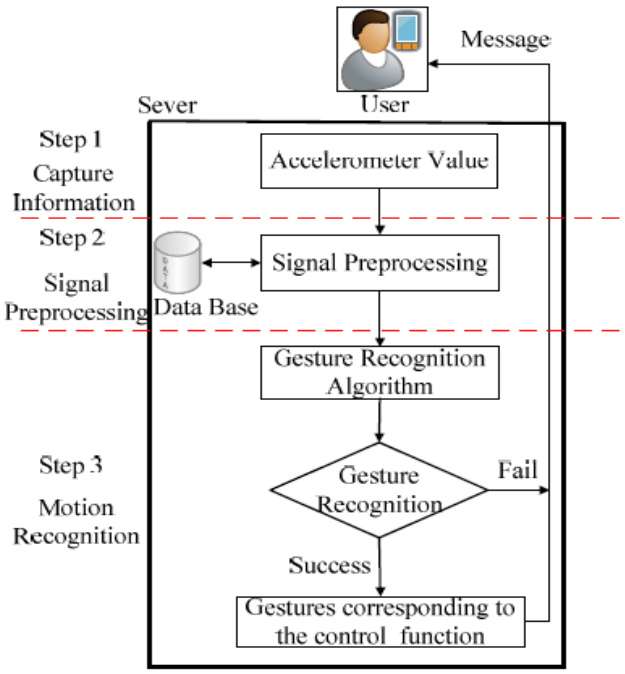

Figure.3. System Flowchart

Fixed-length input matrix is directly classified, which consists of normalised sensor data, which is nothing but a gesture to be recognised [29].

V. CONCLUSION

Every method for gesture recognition which is discussed in this paper is unique in its own way. Every method has its own benefits as well as drawbacks. K-Nearest Neighbours, Hidden Markov Models, Artificial Neural Networks and Support Vector Machines are some of the classification techniques for gesture recognition which are discussed in the paper. Selection of a particular classification method for gesture recognition depends on the type of application for which it is used. Vision based approach is easy to implement, does not require any hardware approach but the developer needs to have deep knowledge in the field of Image Processing. Whereas Sensor based approach requires hardware which increases the complexity of the system. Appearance based approach and model based approach are the two subclasses of the vision-based approach. 3D model based approach is one of them. Nearly every method used in model based approach is same but it varies only in algorithm. Advanced cameras give the depth information of image which is further useful for giving the strong gesture classification. Emotion or Facial Recognition methods prove to be very useful to detect whether the driver in the car is about to sleep or not. Ease of implementation, robustness of the system, less costly hardware devices if used, processing speed and accuracy of the system are the key factors which should be taken into account while developing any gesture recognition system. Accuracy of the system depends of background illuminating conditions, absence of any skin colored object in the background, steady state of the user while giving the gestures as input and the distance of gestures from camera. Further research in the field of gesture recognition is necessary to develop easy interfacing between humans-robots, humans-machines and humans-computers. Soon the time will come when humans will start interacting with the electronic objects around them with the help of gestures.

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