ISSN: 0976-3104
ISSUE: COMPUTER SCIENCE

ARTICLE

HAND AND GESTURE RECOGNITION TECHNIQUES

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ABSTRACT

Gestures help to communicate in a natural way between user and computer system in a virtual environment. Hand gesture is a method of non-verbal communication for human beings to express much more other than their body parts. Hand gesture recognition has a great role in designing an efficient human computer interaction system. In this report, a survey of various gesture recognition approaches is provided with particular emphasis on hand gestures.

KEY WORDS
HCI,HMM,FSM,GAs,ANN, Oriented Histogram,Cluster Algorithms

INTRODUCTION

Gestures and facial expressions can be used to communicate with the computers which require the computer system to understand and analyze the signals to perform a particular movement [2]. Recently the designing of special input devices proved to facilitate the interaction between humans and computers. Gesture recognition has been applied in a large range of application areas such as recognizing sign language, human computer interaction (HCI), robot control, smart surveillance, lie detection, visual environments manipulating, etc. Now a days different techniques and tools have been used for handling gesture recognition that vary between mathematical models like Hidden Markov Model (HMM) and Finite State Machine (FSM) to approaches based on software computing methods such as fuzzy clustering, Genetic Algorithms (GAs) and Artificial Neural Network (ANN). Since human hand is a complex articulated object which is controlled by 35 muscles and requires 27 degrees of freedom to be versatile in all the movements, it is a thrust area of research [3]. In today' digital field implementing gesture recognition system requires different type of devices such as cameras, instrumented gloves and coloured markers.

HAND GESTURE TECHNOLOGY

For any technology to come in action it first need to collect data to accomplish a specific task. For hand gesture recognition system different technologies are used for acquiring data. Present technologies that are used for recognizing gestures can be divided into vision based, instrumented glove and coloured marker approaches.

Received: 20 Mar 2019
Accepted: 11 May 2019
Published: 4 June 2019

Vision based approach

In this type of approach the system requires only camera to capture images required for the interaction between human and computers and no extra device is needed as shown in Fig-1. Although this approach is simple but a lot of challenges rose such as the complex background, lightning variation and other skin colour objects with the hand objects. Beside this system requires various measurements such as velocity, recognition time, robustness and computational efficiency [4][5].

Fig.1: Vision based Hand Gesture.

Instrumented glove approach

This type of glove uses sensor devices for capturing hand postures, motion and position. This approach can provide accurate coordinates of palm and finger's location and orientation and hand configurations. However the approach requires the user to connect with the computer physically which is a barrier

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ISSN: 0976-3104

between the interaction of computer and the user as shown in Fig- 2. The price of this instrumented glove is quite high and is inefficient for working in virtual reality [5] [6] [7].

Fig.2: Glove based approach.

Colored marker approach

In this type of approach marked gloves or colored markers are gloves that are worn by human hands with some colors to direct the process of tracking the hand and location of the palm and fingers which provide the ability to extract the geometric features necessary to form the hand shape [8]. The color glove shape might consist of small regions with different colors or as applied in where different colors are used to represent the fingers and palms, where a wool glove was used as shown in Fig-3.

Fig.3: Color Marker.

VISION BASED HAND GESTURE RECOGNITION APPROACHES

Vision based technologies use a hand to extract the information needed for recognition of hand, these methods are natural [8] [9], easy, and the user directly interacts with the system. Vision based technology deals with some image characteristics such as texture and color for acquiring data needed for gesture analysis. There are many techniques that are applied for detecting hand object after some image pre-processing operations [9]. These methods can be divided into two parts.

Appearance based approaches

In this type of approach, visual appearance of input hand image is modelled using the feature extracted from stored image. Appearance based approaches are simpler and easier than 3D model based approaches due to the easier extraction of features in a 2D image. The common method used in this approach is to detect the skin coloured regions in the image; however this method is affected by changing illumination conditions and other background objects with skin like color.

3D model based approaches

This type of approach used 3D model description for modelling and analyzing the hand shape. In these approaches search for the kinematic parameters are required by making a 2D projection from 3D model of the hand to correspond edges images of the hand but a lot of hand features might be lost in 2D projection. 3D Model can also be classified into volumetric and skeletal models. Volumetric models deal with 3D visual appearance of human hand and usually used in real time applications. The main problem with this modelling technique is that it deals with all the parameters of the hand which are huge dimensionality. Skeletal models overcome the volumetric hand parameters problem by limiting the set of parameters to model the hand shape from 3D structure as shown in Fig-4.

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ISSN: 0976-3104

Fig. 4: 3D Approach.

GESTURE RECOGNITION TECHNIQUES

In this, the recognition of gesture involves several concepts such as pattern recognition, motion detection & analysis and machine learning [10]. For these different tools and techniques are utilized in a gesture recognition systems such as computer vision, image processing, pattern recognition and statistical modelling [9].

Artificial neural networks (ANN)

The use of neural network for gesture recognition has been examined by many researchers. Most of the researches use ANN to classify gesture recognition process, while some others use it to extract the shape of the hand. Maung (2009) presented a system for hand tracking and gesture recognition using Neural Network System to recognize Myanmar Alphabet Language (MAL). Adobe Photoshop filter is then used to find the edges of the input image and the histogram of local orientation employed to extract the image feature vector which would be an input to the supervised neural network system. Maraqa & Abu-Zaiter (2008) used two recurrent neural network architectures to recognize the Arabic Sign Language (ArSL). Elman partially recurrent neural network and fully recurrent neural networks have been used separately. A coloured glove used for input image data, and for segmentation process, the HSI colour model is applied. The segmentation divides the image into six colour layers, one for the wrist and five for fingertips. 30 features are extracted and grouped together to represent a single image. Fifteen elements are used to represent the angles between the fingertips and between them and the wrist, and fifteen elements to represent distances between fingertips; and between the fingertips and the wrist. This input feature vector is the input to both neural network systems. 900 coloured images were used as training set, and 300 coloured images for system testing. Results had shown that fully recurrent neural network system with recognition rate 95.11%, which is better than the Elman neural network with a 89.67% recognition rate.

Histogram based feature

Many researches have been applied based on the histogram, where the orientation histogram is used as a feature vector.

The first implementation of the orientation histogram in the field of the gesture recognition system and real time was performed by Freeman & Roth (1995), they presented a method for recognizing a gesture based on pattern recognition using orientation histogram. For digitized input image, black and white input video was used, some transformations were made in the image to compute the histogram of the local orientation of each image, then a filter is applied to blur the histogram, and plot it in polar coordinates. The system consists of two phases training phase and running phase. In the training phase, for different input gestures the training set is stored with their histograms. In running phase input image is presented to the computer and then the feature vector for the new image is formed, Then comparison performed between the feature vector of the input image with the feature vector (oriented histogram) of all images of the training phase using Euclidean distance metric and the less error between the two compared histograms will be selected. The total processing time was 100 millisec per frame.

Fuzzy clustering algorithm

Clustering Algorithm is a simple term that comprises of all methods that divide the given set of sample data into subsets or clusters. According to this the pattern that share same characteristics are grouped together to form a cluster. Xingyan Li (2003) Presented fuzzy clustering algorithm to recognize hand gestures in a mobile remote. A camera was used to acquire input raw images. The input RGB images are converted into an HSV colour model, and then the hand is extracted after some pre-processing operations to remove noise and unwanted objects and then thresholding using to segment the hand shape. 13

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ISSN: 0976-3104

elements were used as a feature vector, first one for aspect ratio of the hand's bounding box, and the rest 12 parameters represent grid cell of the image, and each cell represents the mean gray level in the 3 by 4 blocks, partition of the image, where the mean value of each cell represents the average brightness of those pixels in the image.

Hidden markov model (HMM)

Many researches were applied in the field of gesture recognition using HMM. HMM is a stochastic process with a finite number of states of the Markov chain and a number of random functions so that each state has a random function. Keskin, Erkan & Akarun (2003) presented HCI interface based on real time hand tracking and 3D gesture recognition using hidden Markov models (HMM). Two coloured cameras for 3D construction are used. To overcome the problem of using skin colour for hand detection because of hand overlapping with other body parts markers is used to reduce the complexity in hand detection process. Markers used to segment the hand from complex backgrounds under invariant lighting conditions. The markers are distinguished using marker detection utility and a connected components algorithm was applied to find marker regions using double thresholding. For fingertip detection, simple descriptors were used where the bounding box and four outmost points of the hand that defining the box is determined. The bounding box in some cases needs to be elongated to determine the mode of the hand, and the points used to predict the fingertip location in different modes of the hand. Kalman filter was used for filtering trajectory of the hand motion. For 3D reconstruction of finger coordinates, calibration utility was implemented for the specific calibration object.

IMPLEMENTATION TOOLS

A lot of implementation, hardware and software tools have been used for recognizing gestures depending on the application fields they are used.

Hardware implementation tools

The input devices used in a gesture recognition system are many and different according to system and application used in the recognition process. In this only a single camera can be used for posture recognition since this environment might be inconvenient for other types of image based recognition. Stereo cameras that consist of two lenses with an isolated sensor for each lens which imitates human visual system, therefore, the 3D effect of views is created. Stereo cameras can be used to make 3D pictures for movies or for range imagining [28]. In this tracking device such as instrumented data gloves measure the finger movements through many types of sensors. It provides accurate information about the position and orientation of the hands using magnetic or inertial tracking devices [6][7]. In Controller-based gestures, controllers represent a complement of the human so that when body moves and creates some gestures, these motions are captured using some software. Mouse gesture is an example of such controllers [28].

Softwares implementation tools

Software tools are programming language and windows system that are used for implementing the gesture recognition system. Some research has used programming languages like C, C++ and Java language. Then to simplify the work, especially when image processing operations are needed, MATLAB ® with image processing toolbox is used.

APPLICATION AREAS OF HAND GESTURES SYSTEM

The hand gestures recognition system has been applied to different applications on different areas, as it is mentioned in [7][9] including; sign language translation, virtual environments, smart surveillance, robot control, medical systems etc. Some of the hand gesture application areas are mentioned below-

Sign language recognition

Since the sign language is used for interpreting and explanations of a certain subject during the conversation, it has received special attention [9]. A lot of systems have been proposed to recognize gestures using different types of sign languages [17]. For example, recognizing American Sign Language ASL using boundary histogram, MLP neural network and dynamic programming matching. [20] recognized Japanese sign language JSL using Recurrent Neural Network, 42 alphabets and 10 words. [19] recognized Arabic Sign language ArSL using two different types of Neural Network, Partially and Fully Recurrent neural Network.

Graphic editor control

The graphic editor control system requires the hand gesture to be tracked and located as a preprocessing operation [23][24] used 12 dynamic gestures for drawing and editing graphic system. Shapes for drawing are; triangle, rectangular, circle, arc, horizontal and vertical line for drawing, and commands for editing graphic system are; copy, delete, move, swap, undo, and close.

ISSN: 0976-3104

Virtual environments (VEs)

One of the popular applications in gesture recognition system is virtual environments VEs, especially for communication media systems [7]. [25] provided 3D pointing gesture recognition for natural human computer Interaction HCI in a real-time from binocular views. The proposed system is accurate and independent of user characteristics and environmental changes.

Number recognition

Another recent application of hand gesture is recognizing numbers. [26] proposed an automatic system that could isolate and recognize a meaningful gesture from hand motion of Arabic numbers from 0 to 9 in a real time system using HMM.

Television control

The hand postures and gestures are used for controlling the Television device [18]. In [27] a set of hand gesture is used to control the TV activities, such as turning the TV on and off, increasing and decreasing the volume, muting the sound, and changing the channel using open and close hand.

3D modeling

To build a 3D model, a determination of hand shapes are needed to create, built and view the 3D shape of the hand gesture[18]. Some systems build the 2D and 3D objects using hand outlines. 3D hand modeling can be used for this purpose also which still a promising field of research.

CONCLUSION

Building an efficient human machine interaction is an important goal of the gesture recognition system. Many applications of a gesture recognition system range of virtual reality to sign language recognition and robot control. In this research, a survey of various tools and techniques of gesture recognition system has been provided with an emphasis on hand gesture expressions. The major tools surveyed include HMMs, ANN and fuzzy clustering have been reviewed and analyzed. Most researchers use coloured images for achieving better results. Comparison between various gesture recognition systems have been provided with explaining the important parameters needed for any recognition system which include segmentation process, feature extraction and the classification algorithm.

Still, there are many conditions which are needed to be fulfilled. The first and the foremost thing which needs to be done are to enhance the recognition capability for various lighting conditions when using cameras. Then there is a need to obtain accuracy in the field of hand gesture recognition. There is need to implement a number of gestures and to identify them and applying gesture recognition for accessing internet applications.

CONFLICT OF INTEREST

None.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to Accendere Knowledge Management Services for their valuable comments that led to substantial improvements on an earlier version of this manuscript.

FINANCIAL DISCLOSURE

None.

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