Fuzzy Hand Gesture Recognition Based Human Computer Interface Intelligent System

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Abstract— **In early days computers are operated by various interface devices, which are developed by the humans to interact with the computer. Starting from Punch-cards to touch screens man have changed the human life into an unimaginable state, right now we are stepping into an another era of computer technology, where the system makes things easier and simple and more powerful. A novel method of dynamic hand gesture recognition based on human computer interface intelligent system is proposed. The main aim is to interact with the computers without using mouse clicks and keystrokes. An architecture for hand posture, gesture modeling and recognition system is introduced, which is used as an interface to make possible communication with the sensory challenged (hearing impairment and gustatory impairment) people by simple hand gestures. The system transforms the preprocessed data of the detected hand into a fuzzy hand-posture feature model by using fuzzy neural networks. Based on this model, the developed system determines the actual hand posture by applying fuzzy inference. Finally, from the sequence of detected hand postures, the system will recognize the hand gesture of the user. Moreover, the computer vision techniques are developed to recognize a dynamic hand gestures that make interpretations in the form of commands or actions.**

Keywords—***Hand Gesture Recognition, Fuzzy Neural Networks, Computer Vision Techniques, Machine Intelligence.***

I. Introduction

Today, computers play an increasing role in day today life. The importance of intelligent systems aims to improve living conditions of human beings. In some cases, these systems are realized in a way that the usage of the systems becomes as easy as possible, while the presence of the system does not about bother its users. This leads the way to the basic idea of ubiquitous computing means developing an intelligent space that comprehend human interactions and able to react to them.

In this paper, hand gesture trajectory recognition is introduced to interact with the computers without using mouse and keyboards. Dynamic hand gesture recognition is made along with the color tracking that can be done to differentiate the skin color from a group of RGB colors. Web camera is used to identify the hand gestures that I turn will be used for interaction. Hand gestures can be recognized using multiple frames to detect its trajectory direction. All the frames are assigned with Theinstructions and stored as a preprocessed data. These datasets are used to interact with the computers using the hand motions.

andimplemented for hand-gesture recognition. The system proposedimplemented for hand-gesture recognition. The system proposed by [6] is based on the idea of a divide and conquer strategy: It breaks hand gestures to basic postures and movements, whichcan be treated as primitives for syntactic analysis based ongrammars. The system consists of a two-level architecture that decouples hand-gesture recognition into two stages, i.e., the low-level hand-posture detection and tracking and the high-level hand-gesture recognition and motion analysis.

For the low-level hand-posture detection, it uses a statistical approach based on Haar-like features, whereas for the high-level hand-gesture detection, it employs a syntactic approach based on the linguistic pattern recognition technique to fully exploit the composite property of and gestures. The detected hand postures and motion trajectories are sent from the low level to the high level of the architecture as primitives for the syntactic analysis so that the whole gesture can be recognized according to the predefined grammars.

In this proposed system, Pseudo-Two-Dimensional Hidden Markov Models (P2-DHMMs) are used for the hand gesture recognition. The basic idea is the real-time generation of gesture models for hand-gesture recognition in the content analysis of video sequence from a charge-coupled-device camera. To avoid the problem caused by the exponential complexity of the algorithm of fully connected 2-DHMMs, the connectivity of the network has been reduced in several ways, thus gaining P2-DHMMs, which retains all of the useful Hidden Markov Models (HMMs) features. The models can be similarly trained to neural networks.

The fuzzy neural network architecture is based on incorporating the idea of fuzzy Adaptive Resonance Theory Mapping (ARTMAP) in feature recognition neural networks. The inputs of the neural network consist of fuzzy membership function values, which are determined from the gray-level value of each pixels of the monochrome image. A gesture recognition fuzzy neural network is used (with four layers, excluding the input layer) for feature recognition. The implemented system offers a flexible framework for gesture recognition and can be efficiently used in scale invariant systems.

This approach has several novelties and advantages when compared with known techniques. As a feature model, it introduces a new fuzzy Hand-Posture Model(FHPM). For hand-posture recognition, a modified Circular Fuzzy Neural Network(CFNN) architecture is proposed together with a

reduced time training procedure. As a result, compared with the robustness and reliability of the hand-gesture identification isimproved, and the complexity and training time of the used neural nets are significantly decreased.

This paper is organized as follows: Section II, review the related work. Section III, describes the System architecture and methodologies involved. In Section IV, implementation is shown In Section V, Conclusion and future work is discussed.

II. RELATED WORK

Color information [1] presents a method for finger detection based on the skin color. Color information [2] can be used to quickly segment interesting image regions for further processing. Color histogram based approach [3] to detect human face in color images. To improve efficiency and detection speed, principal component analysis (PCA) is used to reduce the dimensionality of the histograms and apply skin detection as a pre-processing step to reduce the search space. Support vector machine is used for both skin detection and face detection.

Hand posture and gesture modeling and recognition system [4] is introduced, which can be used as an interface to make possible communication with smart environment (intelligent space) by simple hand gestures. A robust hand tracking [5] method for gesture-based interaction of a wearable computer with a visual helmet is proposed. Motion history image [6] based hand moving direction detection method is introduced. Visual hand tracking is aimed to giving computers the ability to segment, track and understand poses and gestures. Computer vision hand and face tracking is developed in a novel approach for hand pose recognition by using key geometrical features of hand is introduced.

other solutions,

An online [7], video-based framework for view-invariant, full-body gesture spotting is discussed. After extracting view-invariant pose features using multi-linear analysis from visual hull data, hidden Markov models (HMMs) are trained for gesture recognition by using these pose features as observations.A method to control the movement of a mouse pointer [8] using simple hand gestures and a webcam is proposed.A novel simple and practical approach to recognize dynamic hand gestures based on motion trajectories and key frames is presented.

An extensive survey of various techniques for static hand detection and recognition is presented. A wearable gestural interface, which attempts to bring information out into the tangible world, is experimented. Human Computer Interaction [9] in the field of input and output techniques has been developed. This paper introduces techniques and devices using the humans hand gestures for the use with multi-touch tablets and video recognition and techniques for voice interaction. Thereby the gesture and speech recognition take an important role as these are the main communication methods between humans and how they could disrupt the keyboard or mouse rates.

III. THE PROPOSED SYSTEM ARCHITECTURE

The system consists of the following modules. A). Color Detection and Filtration B). Hand Gesture Recognition C). Computer Vision Techniques. D). Gesture Detector E). Digital world Interaction. Figure 1 shows the architecture diagram of the system. The system receives the coordinate model of the detected hand with colored markers as input, transforms it into an FHGM (Fuzzy Hand Gesture Model) using CFNNs (Circular Fuzzy Neural Networks), and then determines the motion of the hand using the FIM (Fuzzy Interface Machine).

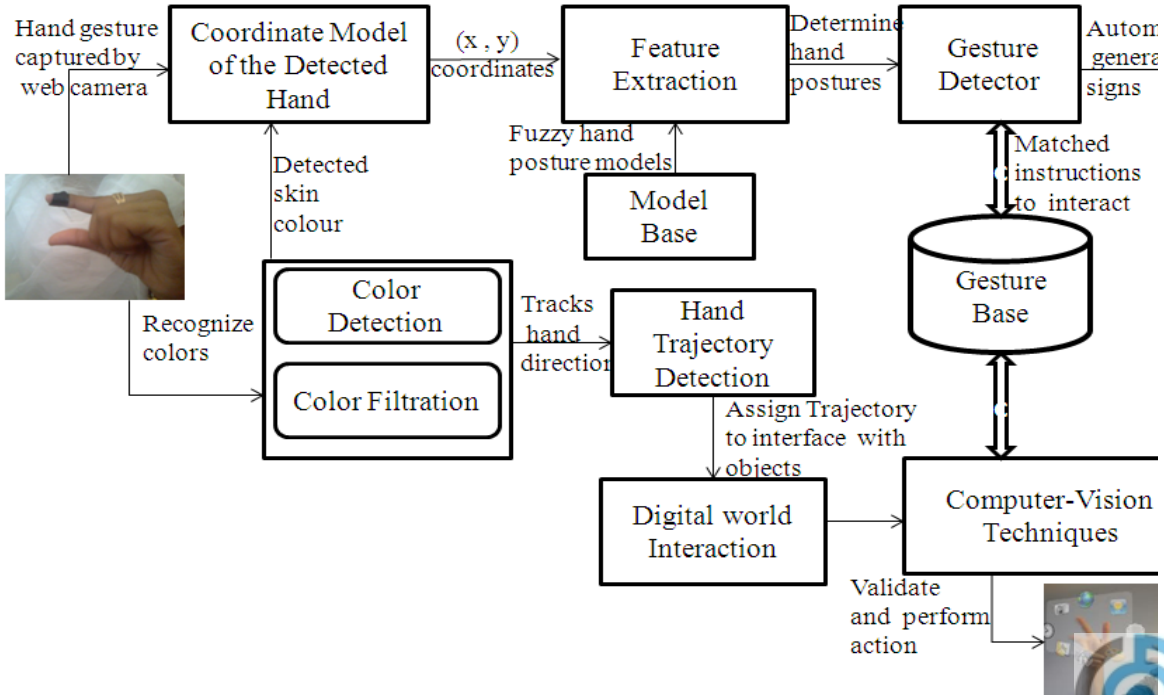

Fig.1 Interface Intelligent System

The Gesture Detector module observes the output of the FIM and searches for matches with preprocessed data in the gesture base. The handgesture is identified in case of fuzzy matchingwith any stored hand gesture or is refused if thehandgesture is unknown for the gesture base.

A. *Color Detection and Filtration*

This module is used to identify an individual color which is wearied in the fingers. Color markers in the fingers will be detected to identify each color in a finger from a group of RGB colors. Back projection technique is adapted to separate the colors. Colors will be detected and then filtered to find the position of the fingers. The following algorithm demonstrates the color detection module.

Algorithm 1: Color Detection And Filtration

Begin

Step1: detect the video by capturing the frames.

Step2: separate individual colors from group of RGB colors.

Step3: Get the range of the colors and set the threshold.

For each pixel

{

1. compute the distance between that pixel and the reference color(D)

2. if D<Threshold then Currentpixel is accepted else current pixel is NOT Accepted

}

Step4: Convert the sequence to Gray scale except detected pixels.

Step5: Repeat the steps 2-5 untill the color is detected.

Step6: Filter the color and locate the range of the color in therange (x,y).

Step 7: End

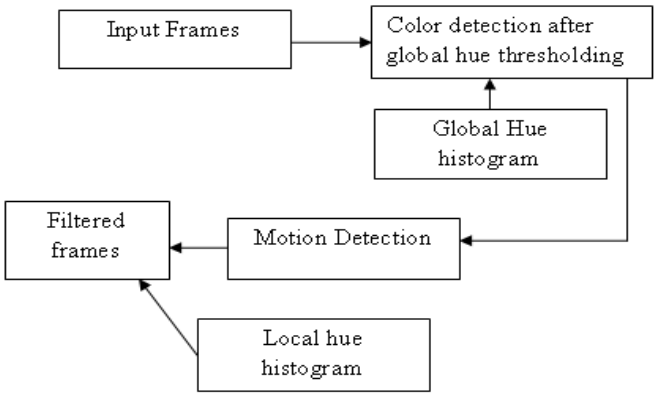

Fig 2 Overview of adaptive color detection

The color detection can be basically done by using Hue Histogram of back projection technique as shown in figure 2.This will adapts itself to the color of the marker in the video sequence. The limitation in color detection is that in the presence of veryhigh intensity lighting conditions,thebackgroundwill also reflected in the output filter.

B. *Hand Tracking*

Hand tracking algorithm proposed here is simple, efficient and also easy to understand so that it can be applied to real timeapplications. This algorithm is based on the color detection and motion of hand. The frames are converted into grayscale images, then a frame matching algorithm is used to analyze the movement of the hand direction. The following equations represent the motion of the hand and thresholding algorithm todetect the white pixels by the Eq. (1) in the image due to noise in the images respectively.

$F_{dif}(x,y)=F_{cur}(x,y)-F_{prev}(x,y)$

$$F(x,y) = \begin{cases} 0; & \text{If } 0 < Fdif(x,y) < 30 \\ 255; & \text{If } Fdif(x,y) \geq 30 \end{cases} \quad (1)$$

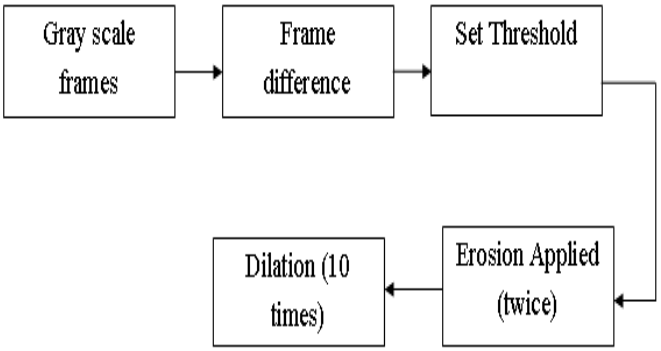

Fig.3 Flowchart to represent hand tracking direction

Since the video captured from regular web camera, random noises from frames causes a large variations in certain pixel values. These noises can be removed by using erosion operation in the frames. This will reduce the area of interest; it may be compensated by using the dilation operator. This is illustrated in figure 3. The combination of color detection and hand tracking will retrieve the motion of the hand and the approximate region of the hand. The area detected may be more than expected so the region must be selected within the frames.

C. *Computer Vision Techniques*

Computer vision is the technology in which machines are able to interpret/extract necessary information from an image. Computer vision technology includes various fields like image processing, image analysis and machine vision. It includes certain aspect of artificial intelligence techniques like pattern recognition. The machines which implement computer vision techniques will detect the hand gesture which is shown in front of the computers. It will categorize the skin pixels among the other non skin pixels. The computer Vision is applicable in varies field of interest.

The computer vision technique basically includes four processes.

1. Recognition: One of the main task of computer vision

technique is to determine whether the particular object contain the useful data or not.

2. Motion Analysis: Motion analysis includes several tasks related to estimation of motion where an image sequence is processed continuously to detect the motion at each point of the image or in the 3D scene.
3. Scene Reconstruction: Computer vision technique employs several methods to recreate a 3D image from the available images of a scene.
4. Image Restoration: The main of aim of this step is to remove noise from an given image. The simplest method involves using morphing techniques. In order to get better quality recognition of hand gestures the erosion and dilation of morphing can be applied to remove the noise in the detected hand region.

These are the main steps involved in computer vision techniques to recognize the hand gestures to interact with the computers. The recognized gestures will be detected with the help of *Gesture Detector*.

D. Gesture Detector

Gesture recognition is a technology which is aimed at interpreting human gestures with the help of mathematical algorithms. Gesture recognition technique basically focuses on the motion recognition of the hand gesture. Gesture recognition technique enables humans to interact with computers in a more direct way without using any external interfacing devices. It can provide a much better alternative to text user interfaces and graphical user interface which requires the need of a keyboard or mouse to interact with the computer. An interface which solely depends on the gestures requires precise hand pose tracking. In the early versions of gesture recognition process special type of
hand gloves which provide information about hand position orientation and flux of the fingers. In the Sixth Sense devices colored markers are used for this purpose. Once hand pose has been captured the gestures can be recognized using different techniques. Neural network approaches or statistical templates are the commonly used techniques used for the recognition purposes. Time dependent neural network will also be used for real time recognition of the gestures.

The ID of each recognized hand gesture is put in a queue, which is monitored by the Gesture Detector module. It searches for hand-gesture patterns predefined in the Gesture-Base, and in case of matching, it will perform the action (in our realization: Interaction) of the detected hand gesture as the output of the system, i.e., it identifies the gesture. The high number of possible FHPMs offers an easy way to choose the meaningful hand gestures. In this case, a detected unknown hand gesture caused by false detection(s) can be corrected to the nearest known hand gesture. This can be done by the following way: From the detected hand gesture, a *similar* hand gesture can be created by changing one fuzzy feature value to its neighboring value and then run the FIM with the new hand gesture as input. This is repeated for all the possible *similar* hand gestures, the result of the inference will be the hand gestures that correspond the most to any of the *similar* hand gestures.

E. Digital World Interaction

The Hand Gesture Recognition finds a lot of application in the modern world. This interface bridge the gap by bringing the digital world into the real world and in that process, it allows the users to interact with the information without the help of any machine interfaces. Prototypes of the hand gesture interfaces have demonstrated viability, usefulness and flexibility of this new technology. According to the development, the extend use of this new device is only limited by the imagination of human beings. The practical applications implemented by recognizing the hand gestures are given below.

a. Sensory Impaired Communication

An application of the hand gesture recognition from the sequence of detected postures is to interact with the sensory impaired people. When the people show their gestures in front of the camera, the above mentioned techniques shown in figure 4will help to identify the postures and make a communication with the people. This hand gesture recognition follows the ASL(American Sign Language) standard to interact with them.

b. *Cursor Movement*

Human Computer Interaction with the help of hand gesture recognition is introduced to interact with the computers in order to avoid the mouse usage. It helps to provide afamiliarity of the mouse without actually requiring a physical mouse.

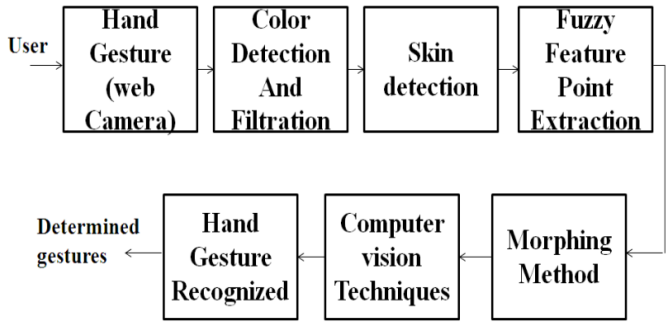

Fig.4 Overview of system workflow

Even though the computer hardware technology has been developed to a greater extent, still there has been no proper substitute for a physical mouse.

This new invention aims to remove the requirement of having a physical mouse altogether but still it provides the feeling of a physical mouse that users are familiar with. It basically consists of ancolored markers which is wearied by the users in the fingers and a high quality camera. Both the markers and camera are embedded together with the computer in the training phase explained in section v. The user cups their hand, as if a physical mouse was present underneath, and the markers in the will be identified by the camera and its corresponding pixels will be detectedusing computer vision.

Accordingly, the hand which is in contact with the camera will be moved. The change in the position and arrangements of thecounter blobs are interpreted as mouse cursor movement and mouse clicks.

IV. IMPLEMENTATION SET UP

The experimental setup for analysing the efficient interaction of hand gestures is described as follows. The interface devices must be arranged in a pendant like device or the projector can be mountedon a head to project the information onto the surfacewalls. Web camera has to be placed to recognize the colored markers and trajectory direction. Depends upon the resolution of the camera, the accuracy of the motion detection will be increased and the camera can be placed within the distance according to the range of the pixels of camera. The algorithmsare running in a PC and can be implemented using *Microsoft Visual studio 2010*.

Throughout the process, the following parameters have to be considered. The input frames can be 8bit/channel with dynamic red, blue and green colored markers at resolution of 640 X 480 pixels. The images (i.e. back projection and gray scale representation for fuzzy matching) were single channeled with same parameters.After the back projection technique only the pixels having brightness (i.e. Value in the HSV space) has to beretained. Others which has the value less than the thresholdingparameter has to be discarded. The experimental setup can be viewed in two phases to implement the hand gesture recognition. I.e. A. Training Phase B. Exploitation Phase

A. Training Phase

The first step in the training phase is to detect the motion history in the video frames which plays an important role in finding the direction of movement. The motion gradient of the different frames over predefined intervals indicates the direction of motion. The trajectory of motion is drawn on the basis of motion history of images. Using this motion history of images, global motion vector can be calculated. Trajectory of motion is calculated from the angle of the global motion vector. The subsequent points of the trajectory are using the motion vector. The main purpose to detect the trajectory is to find the gestures and commands to interact with the computers. After detecting and training the trajectories, the gesture base has been collected with subsequent set of trained gestures for interaction. Thesetrained gestures can be exploited in the next phase.

B. Exploitation Phase

The trained sets of gestures are now used to form a trajectory. Hand gestures with the motion are assigned with the particularset of action. The gestures are simple to detectand thus the computation time will be reduced.Four basic trajectories detected in the hand gesture recognition are: Left, Right, top and Bottom. Fast motion of the hand in front of the screen will make the cursor to move around the screen. Slow motion or waiting up to 2 seconds in a trajectory makes the file to be opened.The trajectories formed can also be used in wide range of applications. The trajectories can be worked well after finding theregion of interest..It can be calculated by satisfying the two conditions.

- There should be a motion on minimum 100 captured frames.
- There should be no motion after 40 frames.

First condition is to ensure there is enough motion occurs and there is no false alarm generated. Second condition is to ensure that the position of the userisstable and an identifiable region of interest can be extracted.

V. CONCLUSION AND FUTURE WORK

Hand gesture Recognition Based Human Computer Interface Intelligent System have been proposed and implemented. This interface makes human users to control smart environments by hand gestures. The developed system is able to classify different simple hand postures and any hand gestures that consist of any combination of the predefined hand postures. The developed system recognizes the objects around us and displays the information relating to those objects in a real time environment. The system allows the user to interact the information through hand gestures. This method is quiet efficient when compared to the text and graphic based user interface. Moreover the system has the potential to form the transparent user interface for accessing the information around us.

In future, the set of Fuzzy Hand Posture Modeling will be extended. The hand-gesture identification method will be improved. In addition more applications will be developed in the digital world interaction and more number of postures will be identified to make a better communication with the sensory impaired people. The remaining part of this work will be developed with the greater accuracy and improving performance.

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