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Procedia Engineering 38 (2012) 3180 – 3191

Procedia Engineering

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International Conference on Modelling, Optimization and Computing (ICMOC)

# Intelligent System for Human Computer Interface Using Hand Gesture Recognition

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**Abstract**

In early days computers are operated by various interface devices, which are developed by the humans to interact with computers. Starting from Punch-cards to touch screens man has changed the human life into an unimaginable state. In this paper, a novel method for dynamic hand gesture recognition based on human computer interface intelligent system is proposed. The main objective is to interact with computers without using mouse clicks and keystrokes. An architecture for hand posture, gesture modelling 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. This proposed system first transforms the pre-processed data of the detected hand into a fuzzy hand-posture feature model by using fuzzy neural networks. Second with the proposed 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

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doi:10.1016/j.proeng.2012.06.369

## 1. Introduction

In recent days, computers play a major role in day to day life. The importance of intelligent systems aims to improving the sophisticated conditions of human beings. In many situations, intelligent systems are realized in such a way that the usage of these systems becomes as easy as possible when compared with earlier systems. This system provides the way to the basic idea of ubiquitous computing for developing an intelligent space that comprehend human interactions which are able to react according to human hand gestures.

In this paper, hand gesture trajectory recognition is introduced to interact with the computers without using mouse and keyboard. Moreover in this system dynamic hand gesture recognition is also designed along with the color tracking that can differentiate the skin color from a group of RGB colors. Web camera is used to identify the hand gestures that in turn will be used for interaction. Hand gestures are recognized using multiple frames to detect its trajectory direction and these frames are assigned with instructions that are stored as a pre-processed data. These datasets are used to interact with the computers using the hand motions. Recently, several systems have been reported and implemented for hand-gesture recognition. The system proposed implemented for hand-gesture recognition. The proposed system is based on the idea of a divide and conquers strategy: It breaks hand gestures to basic postures and movements, which can be treated as primitives for representing the American Sign Language (ASL). The system consists of a two-level architecture that decouples hand-gesture recognition into two stages, i.e., the low-level hand-posture detection in training phase and the high-level hand-gesture recognition and motion analysis in exploitation phase.

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

In this proposed system, Pseudo-Two-Dimensional Hidden Markov Models (P2-DHMMs) are used for the hand gesture recognition. The basic idea is that the real-time generation of gesture models for hand-gesture recognition in the content analysis of video sequence captured from a web 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. This can be achieved by training the features using neural networks.

The fuzzy neural network architecture incorporates the idea of fuzzy Adaptive Resonance Theory Mapping (ARTMAP) in hand gesture 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 with fuzzy neural network is used (with four layers, excluding the input layer) for feature recognition. This proposed and 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 existing techniques. In this feature model, we introduce 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 using Haar-Classifier and Clustering. The robustness and reliability of the hand-gesture identification is improved by decreasing the complexity and training time of the neural nets.

This Research paper is organized as follows: Section 2 reviews the related work in this area. Section 3 presents the interface devices. In Section 4, the System architecture and techniques involved is described.

Section 5 explains the proposed and implemented work of the system. Section 6 analyzes the results and compares them with the existing work. Finally section 7 concludes the proposed work and suggests the future works.

## 2. 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 [14] 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 [7] by using key geometrical features of hand is introduced.

An online [8], 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 [9] using simple hand gestures and a webcam is proposed. A novel simple and practical approach to recognize dynamic hand gestures based on motion trajectories [10] and key frames is presented.

An extensive survey of various techniques [11] for static hand detection and recognition is presented. A wearable gestural interface [12], which attempts to bring information out into the tangible world, is experimented. Human Computer Interaction [13] 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.

## 3. Interface Devices

'Hand' is a gestural interface that augments the physical world around us with digital information and use natural hand gestures to interact with that information. The hardware components for hand gesture prototype are comprised of a pocket projector, a mirror, colored marker and a camera. Software then processes the data that is collected by the capturing device and produces the interaction. The software that is used for hand gesture recognition is of open source type.

### *3.1. Camera*

It captures the image of the object in view and tracks the user's hand gesture. The camera recognizes individuals, images, pictures, gestures that user makes with their hand. The camera then saves this data for processing the hand gesture. Basically the camera forms a digital eye which connects to the world of digital information.

### *3.2. Colored Marker*

There are colored markers placed at the tip of user's finger. Marking the user's fingers with red, yellow, green and blue colored tape helps the webcam to recognize the hand gestures .The movements and arrangement of these markers are interpreted into gestures that act as an interaction instruction for the projected application interfaces.

## 4. Proposed architecture

The proposed and implemented system architecture for hand gesture recognition is shown in figure in figure 1. This system consists of the following five modules namely Color Detection and Filtration, Hand Gesture Recognition, Computer Vision Techniques, Gesture Detector and Digital world Interaction. This system receives the coordinate model of the detected hand with colored markers as input, transforms it into an Fuzzy Hand Gesture Model (FHGM) using Circular Fuzzy Neural Networks and then determines the motion of the hand using the Fuzzy Interface Machine (FIM).

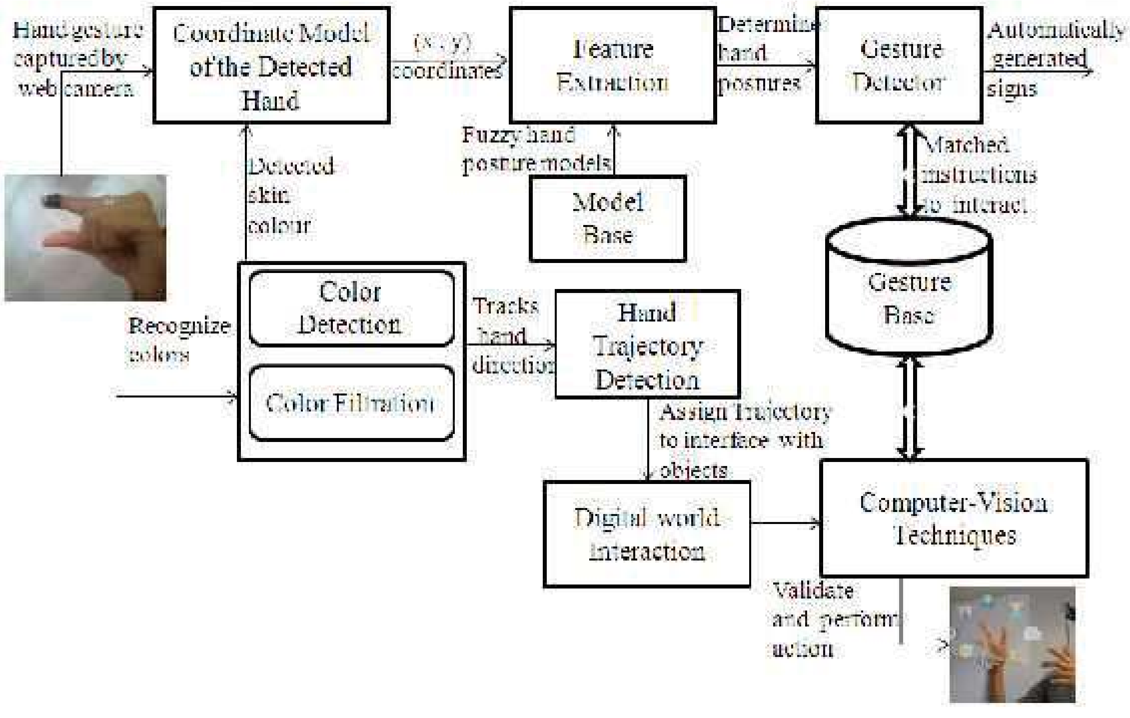


Fig.1 Intelligent System for Human Computer Interface using Hand Gesture Recognition

The Gesture Detector module observes the output of the FIM and searches for matches with stored preprocessed data in the gesture database. Using Fuzzy matching points the hand gesture is identified by comparing them with the trained data sets or rejects if the hand gesture is not trained in the learning stage or the gesture is not in the database. The five main modules of this proposed architecture is explained as below.

### *4.1. Color Detection and Filtration*

This color detection and filtration module is used to identify an individual color which is wrapped in the finger. The colored marker in the finger will detect and identify each color in a finger from a group of RGB colors. In this proposed system, Back projection technique is used to separate the colors. Colors are detected and then it is filtered to find the position of the fingers accordingly. The color detection is achieved by using Hue Histogram of back projection technique as shown in figure 2. This technique adapts itself to the color of the marker in the video sequence. The following algorithm has been designed to detect the color in this 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 in the frame.
Step3: Get the range of the colors and set the threshold value.
Step4: For each pixel
a. Compute distance between the detected pixels (D) and the threshold value(V).
b. if D<V then
Accept current pixels else rejects
Step4: Convert the sequence of frames to Gray scale except detected pixels.
Step5: Repeat the steps 2 to 5 until the color is detected.
Step6: Filter and locate the range of the color in (x, y) coordinates.
Step 7: End

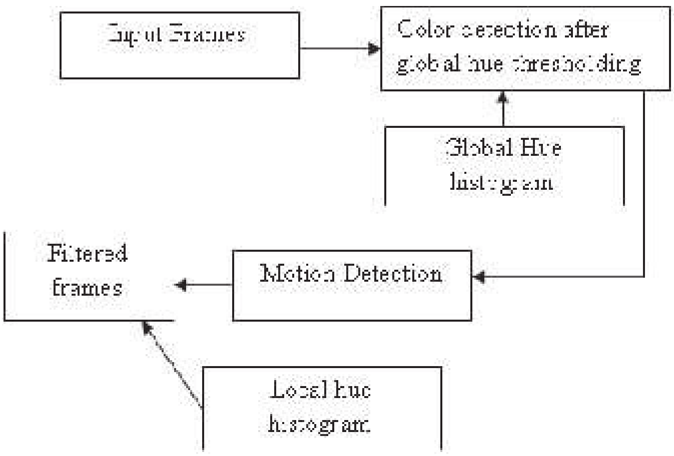


Fig 2 Overview of adaptive color detection

### 4.2. Hand Tracking

The proposed method for hand tracking is simple, efficient and easy to apply for real time applications. This method detects the color and motion of the hand. The detected frames are converted into gray scale images and then the frame matching algorithm is used to analyze the movement of the hand direction. The formula given in eqn. (1) represents the motion of the hand and thresholding value to detect the white pixels in the frame due to noises in the images respectively.

$$F_{dif}(x,y)=F_{cur}(x,y)-F_{prev}(x,y) \quad (1)$$

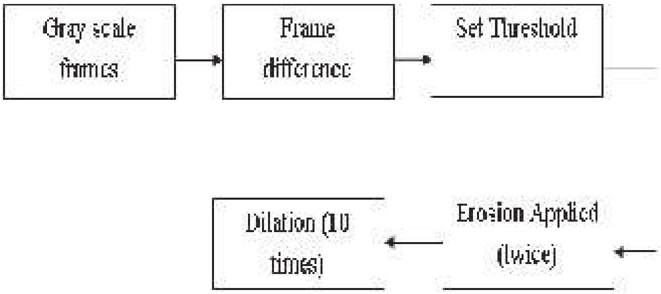


Fig.3 Flowchart to represent hand tracking direction

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 operation. Figure 3 represents the hand tracking detection. The combination of color detection and hand tracking will retrieve the motion of the hand and the approximate region of the hand. If the area detected is more than the expected value then the region must be selected within the frames.

### 4.3. Computer Vision Techniques

Computer vision is a technique that is able to interpret/extract necessary information from an image. Computer vision techniques have various components like image processing, image analysis and machine vision. It also includes certain aspect of artificial intelligence techniques such as pattern recognition. The system that implements computer vision techniques will detect the hand gestures which categorize the skin pixels among the other non skin pixels. This Computer Vision technique can be applied to various applications. In this proposed system two applications have been designed such as mouse control and sign language detection.

The computer vision technique involved in four main processes namely recognition, motion analysis, scene reconstruction and image restoration.

a) Recognition: One of the main task of computer vision technique is to determine whether the particular object contain the useful data or not.

b) Motion Analysis: Motion analysis provides several tasks related to estimate the motion where an image sequence is processed continuously to detect the motion at each point of the image or in the 3D scene.

c) Scene Reconstruction: Computer vision technique employs the method to recreate a 3D image from the available images of a scene.

d) Image Restoration: This technique helps to remove noise from a given image. The simplest method involved in this is morphing technique. To get better quality recognition of hand gestures the erosion and dilation of morphing is applied to remove the noise in the detected hand region. The recognized gestures will be detected with the help of *Gesture Detector.*

### *4.4. Gesture Detector*

Gesture recognition is a technique that interprets human gestures with the help of mathematical algorithms. Gesture recognition technique focuses on the motion recognition of the hand gesture. Gesture recognition technique also enables humans to interact with computers in a more direct way without using any external interfacing devices. Moreover it also provides a best interfacing technique for human computer interface when compared with other existing techniques. 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. Once hand pose has been detected and captured the gestures can be recognized using different techniques. Neural network approach 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 are monitored by the Gesture Detector module. It searches for hand-gesture patterns predefined in the Gesture- Base, and if it matches, 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 is achieved as follows: From the detected hand gesture, a *similar* hand gesture will 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.

### *4.5. Digital World Interaction*

Hand Gesture Recognition finds a lot of application in the modern world. This interface bridges 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 proposed system. According to the development, the extend use of this technique is only limited by the interaction of human beings. The practical applications implemented by recognizing the hand gestures are given below.

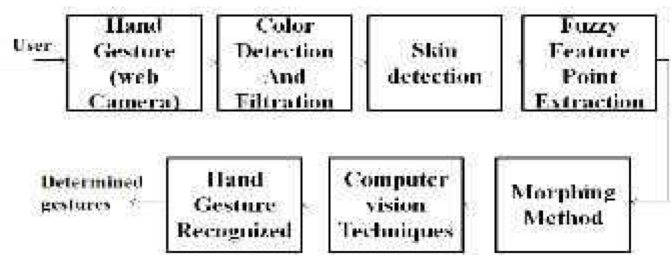


Fig.4 Overview of system workflow

#### *4.5.1. 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 4 will 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.

#### *4.5.2. 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 a familiarity of the mouse without actually requiring a physical mouse. 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 an colored 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 detected using computer vision. Accordingly, the hand which is in contact with the camera will be moved. The change in the position and arrangements of the counter blobs are interpreted as mouse cursor movement and mouse clicks.

## 5. Implementation Setup

The experimental setup for analyzing 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 mounted on a head to project the information onto the surface walls. 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 algorithms are 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 coloured 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 be retained. Others which has the value less than the thresholding parameter 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.

### *5.1. 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. 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. These trained gestures can be exploited in the next phase. Figure 5 demonstrates the trained hand gestures for recognition.

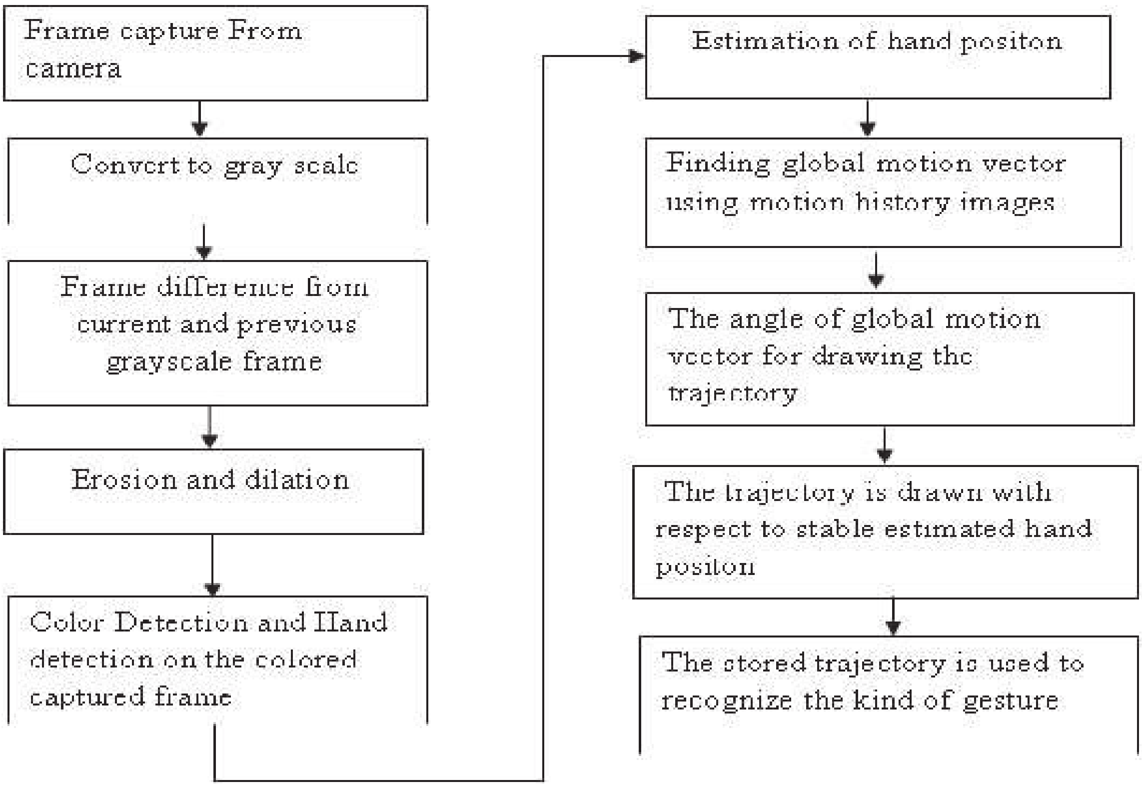


Fig.5 Training Phase

### *5.2. Exploitation Phase*

The trained sets of gestures are now used to form a trajectory. Hand gestures with the motion are assigned with the particular set of action. The gestures are simple to detect and 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 the region of interest. .It can be calculated by satisfying the two conditions.

a) There should be a motion on minimum 100 captured frames.
b) 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 user is stable and an identifiable region of interest can be extracted.

## 6. Performance Evaluation

The results obtained for skin detection are analysed using the graph shown in Figure 6. The skin colour from the group of RGB colour is differentiated by using the Histogram Back projection Technique. By calculating the values of *Hue*, *Saturation* and the *Value,* the skin detection can be performed. In order to obtain better results of skin detection, I have combined the HSV (2) colour space with Ycrcb (3) colour space. Thereby I can identify nearly 90% skin pixels by using the threshold range.

$$H = \arccos \frac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{((R-G)^2+(R-B)(G-B))}}$$
$$S = 1 - 3\frac{\min(R,G,B)}{R+G+B}$$
$$V = \frac{1}{3}(R+G+B) \quad (2)$$

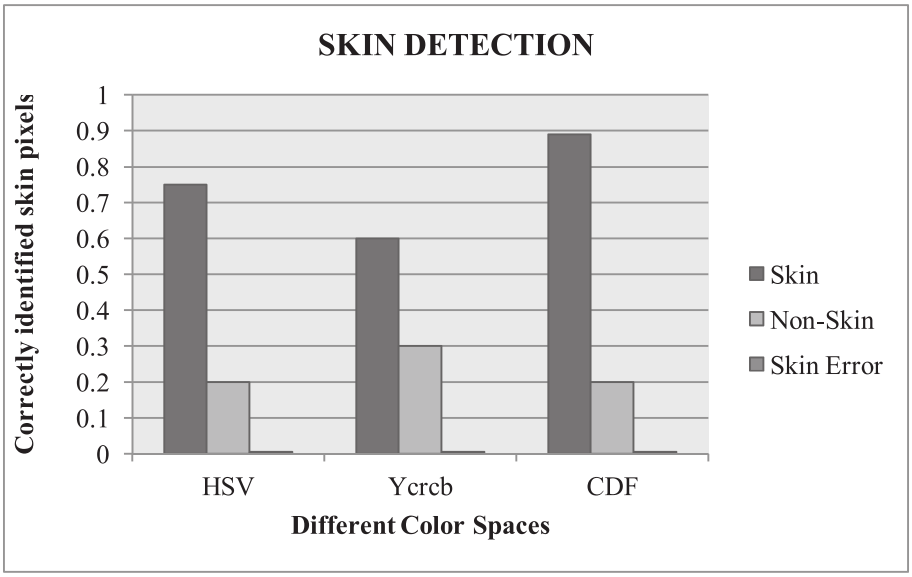


Fig.6 Graph illustrates 90% of skin pixels can be identified by using these algorithms

As in the similar manner the pixels are converted into ycrcb colour space by using the formula shown below. This colour model will help to identify the colour pixels when the video is in motion whereas the HSV will help to identify the skin pixels when the pixel is in still image.

$$Y = 0.299R + 0.587G + 0.114B$$
$$C_r = R - Y$$
$$C_b = B - Y \quad (3)$$

After identifying the skin pixels from the above graph, it is mandatory to check whether the developed system works well or all opened and closed postures. Nearly 50 samples have been taken to analyze the performance of the system. Using *Computer vision tecchnique* the system can identify the detected postures and compared with the trained samples to list number of fingers it has detected. By using *Fuzzy reasoning Based Classification* the contour hull is developed for skin pixels. After that the Convexity defects wii be calculated to show the depth of the finger. The analysed performance of the system is shown in figure 7.

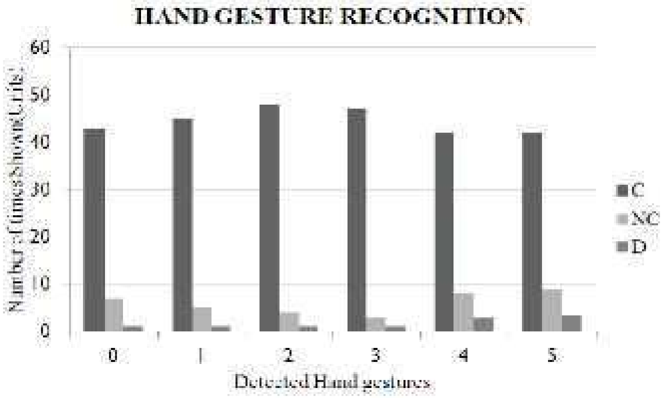


Fig.7 Recognized hand gestures with c=correctly identified patterns, NC= Non correctly identified gestures, D=deviations

## 7. 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 Modelling 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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