Design And Implementation Of Static Hand Gesture Controlled Interface Of Surgical Pick And Place Arm

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ABSTRACT

In order to create a system to recognize specific human gestures which can be used to convey information this paper presents a k curvature algorithm. This paper aims at design and implementation of a Static Hand Gesture Recognition (HGR) system captured from a webcam in real time. And the recognized gesture is used to pick and place the surgical instruments which can be used in the operating room. The system consists of three stages: image acquisition, feature extraction, and recognition. In the first stage input image of hand gestures are acquiesced by digital camera in approximate frame rate. Features are extracted by processing the image and K-Curvature algorithm is applied to recognize the hand gestures. And the arm is designed and recognized gesture can be used for the surgical instruments to pick and place.

Keywords: Hand Gesture Recognition system, k curvature algorithm, HGR system interface with device.

I. INTRODUCTION

Gesture is a form of nonverbal communication or non vocal communication in which visible bodily movement communicate particular messages. Gesture includes movement of hands, face or other parts of the body.

A Gesture is categorized into two distinctive categories Dynamic and Static. Dynamic gesture is intended to change over a period of time where as a static gesture is observed at the spurt time. Static (posture or certain pose) requires less computational complexity. Dynamic (Sequence of postures) are more complex but suitable for real time environments.

Two approaches are commonly used for acquiring information necessary for gesture recognition system.

1. Methods which use Data gloves: mechanical or optical sensors are attached to a glove that transduces finger flexions into electrical signals for determining the hand posture. This approach forces the user to carry a load of cables which are connected to the computer and hinders the ease and naturalness of the user interaction.

2. Methods which are Vision Based: This method is based on the appearance of hand using skin color to segment the hand and extract necessary features. This is easy, natural, non invasive and less cost compared to other method.

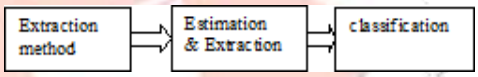


Figure 1: Block diagram of HGR System

Three steps are followed after image acquisition. 1. Extraction 2. Feature Estimation & Extraction 3. Classification or Recognition.

Input image of the hand gesture is acquiesced by camera. Extraction includes noise filtering, RGB to Gray scale conversion etc. feature estimation and extraction includes background separation, image enhancement, converting to binary image, edge detection etc. Depending on the algorithm used for classification, features of the image is extracted. Recognition or classification is a process of identifying the gesture, for which different algorithms like k-curvature, SVM, HMM etc algorithms can be used depending on the application.

After the recognition of the gesture, the command signal is generated according to the sign and it can be passed to the device for controlling.

The goal of this paper is to design and implement the hand gesture recognition system review the different methods of hand gesture recognition, which can motivate to create a system which can identify specific

hand gestures and use them for device control by overcoming few constraints which occur in the existing methods.

II. RELATED WORK AND CONTRIBUTIONS

Jean-Francois collumeau et al. introduced the simulation of gesture based remote control interface intended for operating rooms. They have explained the video processing chain in three steps, Detection, Segmentation, and Recognition. Detection is roughly marking the hand's spatial location using viola-Jones cascade classifiers. Haar features are extracted, it allows reduced processing time in situations where no hand is present in the image, and unnecessary image processing is skipped. Single classifiers have been trained for each of the six postures. For segmentation, three algorithms they have considered: K-Means method (K-Ms), Watershed algorithm and GrabCut (GC), concluded that K-Means algorithm yields the best result. Hand posture recognition is achieved by linear SVM classifier fed with feature vectors gathering the object characterization. A complete vision-based surgeon-computer interaction simulator has been introduced in this paper. System consists of a software image processing chain coupled with a virtual surgical lighting arm and a graphical interface [1].

Harish Kumar Kaura et al. implemented a system through which the user can give command to a wireless robot using gestures. Through this method, the user can control or navigate the robot by using gestures of his/her palm, there by interacting with the robotic system. Technologies used are C++ with Open CV and Arduino Duemilanove. After pre processing, the Convex Hull method is used for recognition. The drawback of this method is for finger count one, there is no large depth so it is difficult to recognize as it is count one or there is no such count so counts from two to five are used as command signal. Wi-Fi shield connects Arduino to a Wi-Fi connection. Implementation makes use of periodic polling from WiFly to the web server to access the command signal in real time. This method of periodic polling may overload the server [2].

Asanterabi Malima et al. developed an algorithm for recognizing a limited set of gestures from hand images for a robot control application.

It involves segmenting the hand based on skin color statistics as well as size constraints. Then centroid or Centre Of Gravity (COG) of hand and farthest point from the COG is found. Circle with radius 0.7 of farthest distance from the COG is drawn. 1D binary signal is extracted by tracking the circle. By counting number of zero to one transition in this 1D signal and subtracting one leads to the estimated number of fingers active in the gesture. This algorithm is possible to count the number of active fingers without regard to which particular fingers are active. Also it is scale invariant, rotation invariant and translation invariant. This technique does not require the storage of a hand gesture database in the robot's memory [3].

Nancy et al. has done the analysis of Hand Gesture recognition technique using finger movement detection based on color marker.

This approach is based on red color marker detection. Red color marker on fingertip of user's hand wearing white cloth glove is used. The system would only detect the red color marker and it makes possible to point a finger having red color marker. In this paper, they have used a pointed gesture with the help of red color marker, only the finger wearing red color marker is detected and it us used for pointing on the computer screen. The pointed thing is selected on the basis of spoken commands they have created mike sensitivity in MATLAB. In this approach, user can interact with the computer remotely through speech and gesture recognition. GUI of keyboard design is created in MATLAB. The inconvenience of placing markers on the user's hand makes this approach infeasible in practice [4].

Yikai Fang et al. proposed a real time hand gesture recognition method.

Gesture recognition process they followed is as follows

- Firstly, Hand detection with Adaboost is used to trigger tracking and recognition.
- Then adaptive hand segmentation is executed during detection and tracking with motion and color cues.
- Finally, scale space features detection is applied to find palm-like and finger-like structures. Hand gesture type is determined by palm-finger configuration.

In this method, they reduced the computation expense by detect multi-scale feature across binary image and make hand gesture interface more practical by combine this feature detection with hand tracking and segmentation. Altogether this method combines fast hand tracking, hand segmentation and multi-scale feature extraction to develop an accurate and robust hand gesture recognition method [5].

Tasnuva Ahmed presented a neural network based real time hand gesture recognition system.

They have explained the whole system of hand gesture recognition in four phases. Image acquisition; Image processing, Feature Extraction and HGR.

- They have used Kodak-easyshare-c340 digital camera to capture the desk area where the hand is located. The background of the image is taken as black with good lighting system.
- The algorithms sequentially used in this phase are graying, normalizing and histogram equalizing.
- 33 features are extracted for hand gesture. Feature 1: Relation between the height and the width of the hand

gesture. Feature 2-25: These features check how the black pixels are distributed in the image. Feature 26: calculate average distance between all the black pixels and the central point that invariant object rotation.

- Feature 27-33: calculate the central moments of hand gesture
- They used a feed-forward multilayer Artificial Neural Networks for HGR.

Feature of input image based on moment feature extraction method is used. So that the system can recognize hand gestures captured in different angle or orientation or size. As Artificial Neural Network is used to recognize the hand gesture, even it is rotation, translation, scaling and orientation independent, the delay occurs due to training needed for artificial neural network and switching delay between the nodes [6].

Mithun G Jacob et al. presented a method for surgical instrument handling and retrieval in Operating Room with a multimodal Robotic assistant. They have used a Microsoft Kinect sensor to acquire depth information used to segment the hand and localize the fingertips. 3D trajectory of the fingertips is used to classify the dynamic gesture, smoothened with Kalman filters and then quantized for classification with a set of Hidden Morkov Models (HMM) and they have used a microphone with the CMU Sphnix to recognize speech commands. The command is sent to robotic arm across the network to deliver the instrument. Here, each HMM is trained to obtain the parameters for recognition. A FANUC LR Mate 200iC robotic arm was used to deliver the instruments. For retrieval and disposing the instruments from the surgical site, the background/foreground segmentation is achieved using a GMM "with memory". The silhouette of each instrument is represented using 7 invariant Hu moments. For classification, a SVM is trained with a database of surgical instruments in various configurations and scales. They concluded that the multimodal system with modality training which employs both speech and gesture was shown to be 14.9% faster than the speech-only system on average [7].

III. SYATEM DESIGN & IMPLEMENTATION

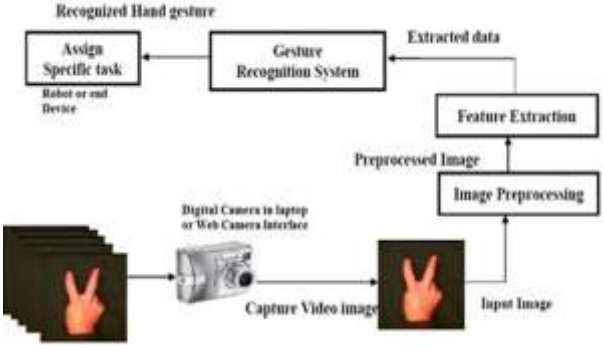


Fig 1: Architecture of the hand gesture recognition system

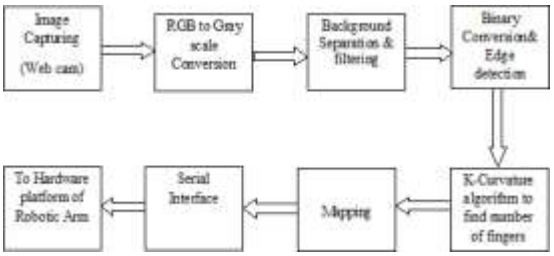


Fig 2 Block diagram

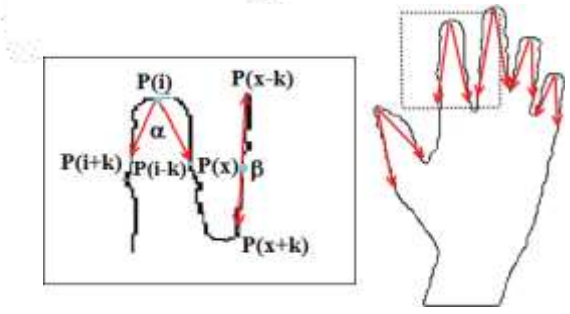
Image Acquisition/Image capture: Image of the hand is acquired using camera of the laptop. The output from the camera is video and this video is acquired by the system in the form of sequence of images. The image acquisition toolbox of Matlab acquires the output of the webcam in terms of frames.

Pre Processing & feature extraction:

- RGB to gray scale conversion is done to the image.
- Background separation is done by taking difference of background and the current Image.
- Median filtering is done to remove the salt and pepper noise which occurred through camera during image capturing.
- Image is converted to binary form.
- Edge detection is done by considering the 0 to 1 transition.

K-Curvature algorithm for Gesture recognition:

K-Curvature method is used to find the static hand gesture that is the count of hand fingers. The k curvature method will help to identify the peaks and valleys of the binary image. Using the co-ordinate values of tips and valleys, we plotted the captured image. From the number of peaks and valleys, we can identify the number of fingers in the current hand gesture.



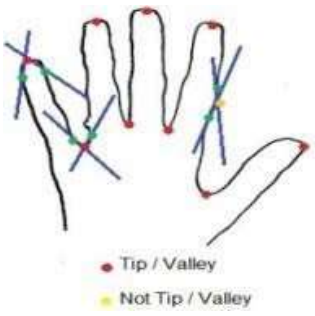


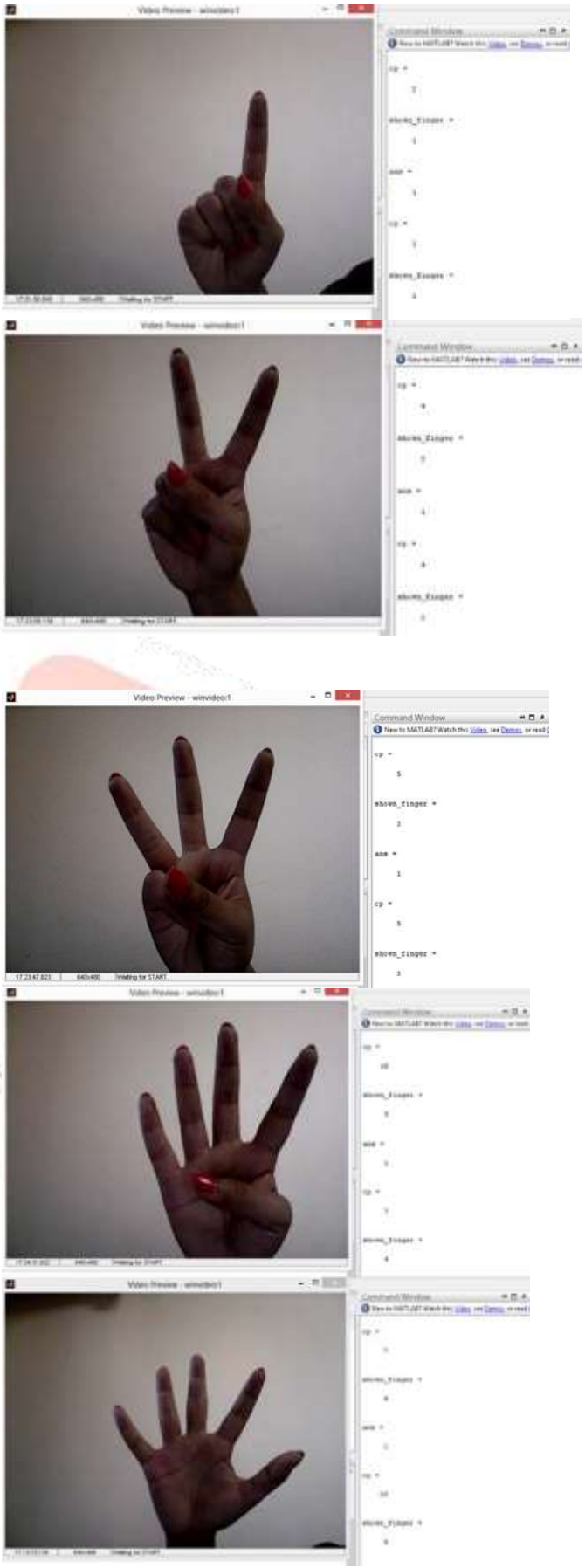
Fig 3: peak and valleys in k curvature

- Let X*i* represent the contour for the hand. Edge is used for the contour extraction. Now, matrix of connected components is created, out of the real contour matrix. This is achieved by assigning one particular label to pixels of same values. The returned matrix will be of same size as the input matrix.
- For each hand, an attempt is made to find pixels that represent peaks along the contour perimeters. This is done by obtaining a matrix containing (x, y) coordinate values of the complete hand perimeter. For initiating the process any three consecutive coordinate points are considered i.e. Xi-1 , Xi , Xi+1 .
- The desired requirement is to find the angle between these three points. For that slopes formed by these three points are calculated. Here the threshold angle is set between 60 degree to 90 degree.
- At each pixel j in a hand contour *i*, the *k*-curvature is computed which is the angle between the two vectors [X*i* (*j*), X*i* (*j* – *k*)] and [X*i* (*j*), X*i* (*j* + *k*)], where *k* is a constant (currently set to 30).

The equation that we have use for the angle calculation is

$$\tan A = (m_2 - m_1) / (1 + m_1 m_2)$$

Where
m1 = the slop of the line joining vector [X*i*(*j*), X*i*(*j* – *k*)]
m2 = the slop of the line joining vector [X*i*(*j*), X*i*(*j* + *k*)]



After recognition, the mapping is done to generate the command for device control. Through the serial interface, the communication is established with ZigBee and controlling of the device can be done.

Here, ZigBee transceivers operating at 2.4 GHz can be used for the passing the command to the arm. Designing of robotic arm is done by using PIC16F877A Controller is used to run the motors connected for action of arm to pick and place the instruments. Stepper motor (2Kg torque) and ULN 2003 Stepper Motor driver is used for
the rotation of the arm. Two DC motors operating at 12 volts & 60 RPM and L293D DC driver are used for the arm to bend and pick the surgical instrument.

Fig 4: Robotic arm to pick and place the surgical instruments

IV. CONCLUSION & FUTURE WORK

The implementation of Hand gesture recognition system using K curvature method is done. The system is tested with 5 hand gestures. It is capable of recognizing with satisfactory results. Robotic arm to pick and place the surgical instruments is also designed. The future work can be further improvement of the system for rotation invariant and to make work with different light conditions. And the recognized gesture command can be tested for the designed arm in real time.

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