IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 3, March 2016

Collaborative Wireless Gesture Controlled Robotic System

Prof. Amol Sankpal[1], Surabhi Chawan[2], Saif Shaikh[3], Arzoo Tisekar[4]

Department of EXTC, M.H.S.S.C.O.E, Mumbai, India[1,2,3,4]

Abstract: Many techniques have been developed to control robotic systems using various human computer interaction (HCI) mechanisms. One such method is by using gestures. We have implemented a prototype using gesture as a tool for communicating with machine. Command signals are generated using certain gesture control algorithm. These generated signals are then given to the robot for navigation in specific direction. In previously developed systems, if the robot experiences any obstacles, it either becomes immobile or collides with it. Therefore, we present in our prototype a robotic arm, which will try to remove any obstacle in its path. Gesture command can also be used to operate any robotic system which helps to simplify human task. This paper provides an aid to collaboratively control robot with robotic hand using real time image processing.

Keywords: HCI; gestures; command signals;navigation; image processing.

I. INTRODUCTION

Main purpose of gesture recognition is to identify a particular gesture and execute command related to the required gesture. Hand gesture recognition can be used to control any robotic system thereby bridging the gap between human and machine [1]. Robotic system wirelessly replicates the commands generated using real time image processing. One of the most important parameters to make system efficient and reliable is Human Computer Interaction (HCI) [5]. This project is product of expansive study of prior work done in related field.

This project falls under three domains; Real time image processing, Robotics and Wireless Communication. A prominent benefit of such system is that it presents a natural way to send information to robot [1]. There are some systems that have been developed in same field using various techniques. Each technique has its own pros and cons; our aim is to develop a robotic system that can overcome the problems related to previous developments.
This paper is organized as follows. Section II consist of the methodologies used in existing systems and the literature review. In section III proposed method has been discussed. An algorithm explaining the method of hand gesture detection and processing of hand gesture is also discussed. Section IV gives brief details of technologies used in our project. Results of the experiments for performance are discussed in section V. conclusion, strengths and limitation of the paper is given in section VI with scope of future work.

II. METHODOLOGIES USED IN EXISTING SYSTEMS

A method for realising this task was implemented using accelerometer. This approach requires predefined data which includes the maximum and minimum value corresponding to a gesture so that real time hand gestures can be compared with it [1]. In another method, the pattern matching method involves comparing the current value of global maxima and global minima generated with previously stored values [2]. Another method for gesture recognition was implemented using Microsoft's Kinect sensors; such sensors are capable of capturing both RGB and depth data. This approach involves looking at specific hand motions in addition to full body motion for more refined gestures. However, this method is quite expensive due to high cost of Kinect sensor [3].

The implementation of hand detection for human computer interaction was implemented using Open CV as a tool where count was generated by the convexity defects by drawing a contour of the hand and developing its convex hull using image processing [4]. A humanoid robot controlled by body gestures and speech was developed by using Kinect sensor and calculating the angles between joints of the body gesture generated by human [5]. Robot navigated by flex sensors was developed for military purposes. The glove limits the free movement of hand [6]. Gesture controlled robot using Wi-Fly shield to wirelessly control a robot using thresholding, contour and convex hull was developed in [7]. A robotic arm whose movements were wirelessly controlled by gesture recognition using colour recognition was presented in [8]. A mathematical approach for calculating the gesture given was put forward in [9]. This involved calculating centroid of palm and then masking a circular region of specific radius around it so that the number of fingers can be counted.

III. PROPOSED SYSTEM

We propose a system in which human can navigate a robot using hand gesture as a medium. The gesture commands are generated using Matlab as software platform for image and video processing. As soon as our system detects the gesture, it generates the command for the robot to move in a specific direction. We plan a prototype wherein we connect a robotic arm on our bot. This is because whenever the robot comes across any obstacle, the robot either stops suddenly or is unable to avoid that obstacle.

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Now, as soon as the robot detects any obstacle, robotic arm helps to pick and place the obstacle out of the way thereby allowing the robot to continue moving on the same path.

A. GESTURE SIGNALS

In order to communicate between human and robot we make use of hand gestures. These gestures are then programmed in a way so as to generate commands for the robot to move forward, backward, right and left. More number of gestures can be incorporated for navigating in different directions. Gesture is an analog activity that can be acquired using various sensors. In our project, we use camera as a sensor for capturing gestures.

B. GESTURE SIGNAL PROCESSING

The following flowchart explains the flow of gesture capture, processing and recognition. It starts with capturing image of the gesture. Then the processing of the gesture takes place by comparing the gesture with the given database. According to that it will generate command signal. This signal is then given to the robotic system and the robot moves in the desired direction.

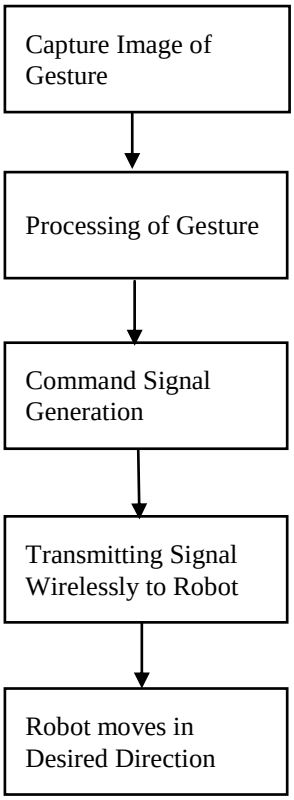

Fig.1. Flowchart

First, the image of gesture is captured by the camera located on a laptop or PC. Then according to the need, extraction of useful information from image is done by performing image processing on the gesture. This is done by doing image segmentation and image morphology. According to the gesture shown, when it is interpreted by the use of an algorithm, the command signal is generated. Then, this signal is transmitted wirelessly to robotic system, which moves accordingly in desired direction.

Algorithm:

1) START
2) INITIALIZE THE WEBCAM.
3) NITIALIZE SERIAL COMMUNICATION BETWEEN MATLAB AND ARDUINO.
4) SET PROPERTIES OF VIDEO OBJECT.
5) START VIDEO ACQUISITION.
6) GET SNAPSHOT OF CURRENT FRAME.
7) CONVERT IMAGE TO GRAY SCALE.
8) SUBTRACT RED COMPONENT.
9) FILTER THE NOISE.
10) CONVERT IMAGE TO BINARY IMAGE.
11) GENERATE THE COUNT.
12) COMPARE WITH DATABASE.
13) SEND COMMAND SIGNAL.
14) IF OBSTACLE IS DETECTED AND WITHIN PREDEFINED DIMENSIONS,
    INITIATE SEQUENCE FOR ARM
    ELSE
    KEEP MOVING.
15) STOP.

IV. TECHNICAL SPECIFICATIONS

A] COMPONENTS USED:

1) Micro-controller: Arduino (UNO)

Arduino is the Micro-controller board made up of several Micro-controllers. To program the Micro-controller Arduino provides Integrated Development Environment (IDE) and it supports C and C++ programming languages. Most of the boards works on 5V DC supply and 16 MHz Crystal oscillator. Here to drive the robot, input gestures are captured by the camera. These gestures are then processed and sent it to the Micro-controller1. This controller then sends the signal to the micro-controller2 via ZigBee module. The command signals then drive the motors through Motor driver circuit L293D. The Micro-controller1 is used to control the robot and Micro-controller2 is used to control the robotic arm.

2) ZigBee module:

ZigBee is IEEE 802.15.4 standard used to create wireless Personal Area Network (PAN). It has low power consumption and has a range of 10m to 100m. ZigBee has a data rate of 250kbps. It works on 2.4 GHz. Here we are using the ZigBee module to transmit signal from Micro-controller1 to Micro-controller2.

3) Motor driver circuit (L293D):

L293D IC is used to drive 2 DC motors at a time.it has 16 pins and can drive 2 motors simultaneously. The IC has H-bridge circuit which allows high voltage to flow from either direction. The circuit works on 5v power supply and can drive motors with 36V and draw up to 600mA. Here we are using 4 motors to control the robot. This IC gets command signal from Micro-controller2 and drives the motors accordingly

4) Ultrasonic Sensors:

These are the transducers which are used to convert ultrasonic waves into electrical signals. The sensors are used to detect any obstacles coming in between the path of

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the robotic system. The range provided by the sensor is 2cm to 3m and works above 18 kHz.

V . PROCESSING OF GESTURE

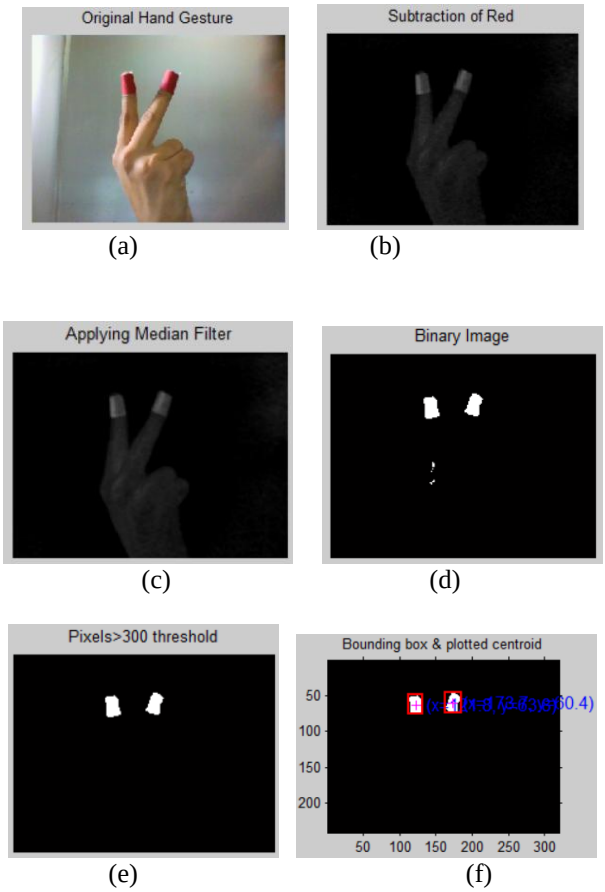
Firstly, a video input is taken from laptop's webcam. This video is then divide into stack of frames. Information about each gesture is obtained by analysis of each frame. Fig.2. (a) shows the image of original hand gesture. We have attached a red colour marker cap to our fingers for colour identification. In order to increase the precision of gesture recognition, a particular colour component of image is focussed upon.

Now in order detect only red colour from the entire background or image we subtract red component from original image this is shown in Fig.2. (b).

Next we filter out the noise in the gesture image using a median filter as shown in Fig.2. (c).

Once the image is filtered, it is then converted to the binary image as shown in Fig.2. (d).

Next, the highlighted areas are located by computing the centroid as shown in the Fig.2. (f).



(a) (b) (c) (d) (e) (f)

Fig .2. Various stages of image processing

Now, count is generated using Matlab command, i.e., for two fingers shown, count 2 is generated. These counts are then serially sent to Arduino microcontroller. Programming is done in such a way that when count is read by Arduino, it makes the corresponding pin high and thus by using motor driver circuit, we are able to run our motors. Different gestures were used to steer the robot in required directions.

Commands used in Matlab to process the image and output action of each command is shown in following table:

Matlab commands	Output actions
vid =videoinput('winvideo',1);	Capturing video frames
data=getsnapshot(vid);	Getting the snapshot of current frame
diff_im=imsubtract(data(:,:,1),rgb2gray(data))	Obtaining the red component of image
diff_im=medfilt2(diff_im,0.18)	Filtering out the noise in image
diff_im=im2bw(diff_im,0.18)	Converting the filtered image to binary
Stats =regionprops (bw, 'bounding box', 'centroid')	For setting the properties of each labeled region
Cc=bwconncomp(bw)	Displaying count or number of objects
bb=stats(object).bounding box	Displaying bounding box
S=serial('com3','baud',9600);	Define baud rate
fopen(vid)	Open serial port

VI. CONCLUSION

The main goal of our project is to create a unit that is autonomous and can be easily controlled with hand gestures. Unlike systems that require glove based flex sensors, our system does not restrict the freedom of movement of the hand. It can be efficiently used in conditions where human intervention may cause harm to the person involved.

STRENGTHS

- Can be used in adverse conditions where human mediation is not feasible.
- Allows free movement of hand.
- Useful for military operations, aid for the disabled, industrial applications and surgical operations.

LIMITATIONS

- Appropriate lighting is required for red color detection.

- MATLAB involves some additional time for processing and causes delay.
- Range of Laptop Camera is limited.

FUTURE SCOPE

- More gestures can be involved for greater variety of directions.
- Speed of response can be increased by faster computational software.
- The arm can be improved upon for greater load of obstacle tackling

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