HAND BASED GESTURE CONTROLLED ROBOT

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Abstract - This paper basically focuses on using the concept of gesture recognition to control robots with higher degree of precision, it is well known fact that controlling complex systems with remote and switches can be a tedious task especially when several interfaces are working concurrently in a system. Hand gesture recognition is a challenging problem, but with the help of OpenCV it has become easier to work in such domains. OpenCV is a computer vision library focused on real time computer vision. The proposed system comprises of OpenCV which performs set of operations on the image procured by the webcam in python. The socket connection between laptop and ESP8266, it acts as client and python program acts as server. The information obtained is sent to Arduino through FTDI programmer serially. The microcontroller commands the robot according to the gestures detected and the robot includes sensors for temperature and CO gas concentration estimation. It sends a message if the concentration level or temperature sensed is higher than the normal values.

Key Words **:** Image processing, gesture control, camera, OpenCV, python, Arduino, Sensors, WiFi module.

1.INTRODUCTION

Gestures have been one of the oldest way of communication. Hand gestures have been developed as part of languages which are used to communicate with disabled people. Gestures are usually classified into two categories namely static and dynamic. Static gestures are easier to handle than dynamic gestures. Static gesture basically involves a certain pose for indicating a certain instruction whereas dynamic gesture involves analyzing movement for certain amount of time. Allowing users to use gesture to control devices makes computer human interaction more natural.

With the increase in computation power of microprocessors, one can imagine endless possibilities. This can be seen with the rise in several fields like machine learning, image processing which did not exist few decades ago. Nowadays the focus has shifted towards software instead of hardware, this implies that the total cost of the gadgets has been decreasing also there is an enrichment in the user's experience.

Though the complexity of the techniques used have increased but with the aid of high computational power these are becoming more robust and feasible. From industrial sector to health sector the use of gesture based systems are increasing. In tough environments where effective motion of a human cannot be tracked easily, it is necessary to focus more on algorithms that are more efficient and are stable in noisy conditions.

2.LITERATURE SURVEY ON METHODS OF HAND GESTURE RECOGNITION

Different technologies have been implemented for hand based recognition system and few of them have shown good results. The ultimate goal is to control certain systems like smartphones, air conditioners using these techniques. One of the most common approach is data glove based approach [1]. In this approach there are sensors attached to glove which acquire the gestures and the signals generated by sensors are processed and corresponding instructions are performed. One example of this is gesture to speech conversion [2] in which hand gestures are converted into speech with the help of complex computational algorithms.

Accelerometers are attached to the gloves as sensors to convert positional changes of hand into signals which are then interpreted by the processor to perform the instructions [3]. The industrial robot is programmed by gestures and speech by natural means. ANN was applied for gesture and posture recognition.

Vision based approach involves using cameras which capture image of hands and decode it to perform instruction [4]. Either a single camera or multiple cameras camera can be used. Several complex algorithms are applied to perform feature extraction which are used to train classifier using several machine learning strategies. Color glove based approach is a hybrid of vision based and glove based approach in this different segment of the glove has different marker, this allows the geometric features to be extracted from the glove and thus helps in localizing the gesture performed. One such implementation is done by Lamberti L. et al.[5] .Their system is based on three steps. The first is identifying the hand region in the image. The second involves feature extraction which comprises of finding centroid and major axis of magenta region followed by finding 5 centroids of cyan and yellow region indicating fingers. Then for each of the five regions, the angle between the line connecting the centroid of the palm and each finger and the major axis. The four angles and five centroids form

the nine dimension vector. The third step involves building classifier using learning vector quantization.

3.PROPOSED SYSTEM

This paper presents a system which involves capturing video through webcam and then using image processing tools to isolate segment of hand to perform particular instruction. The number of defects identified in the hand correspond to a particular instruction. OpenCV has inbuilt function to identify convexity defects, the angle between the defects is calculated and the number of angles less than 90 degree indicates number of defects between the fingers.

The instructions were then transmitted to Arduino Uno board through the laptop and a motor driver was used to direct the robot. The sensor readings were shown in an LCD display. The sensors used were temperature sensor and CO gas sensor. These sensors are essential because they can help in surveillance, it is well known that CO is a poisonous gas and its leakage is a serious problem in certain industrial units and A/C units.

4.TECHNOLOGIES USED

4.1Arduino Uno

Arduino Uno is a microcontroller board containing ATmega328. It has 14 digital input/output, 6 analog inputs, a USB connection, a 16 MHz crystal oscillator, a power jack and reset button. It has Atmega16U2 programmed as a USB to Serial converter. It has lot of documentation and several projects available on its website [6], which helps in understanding how to use the microcontroller to build projects.

Figure 1: Arduino Uno microcontroller

4.2 OpenCV/python

OpenCV was started in Intel and the first release came out in 2000. It supports lot of algorithms related to computer vision and machine learning through its vast pool of inbuilt functions that keep expanding day by day. It is open source and supports a variety of programming languages like python, C++, Java.

Python is a general purpose programming language founded by Guido van Rossum, it is very popular because of its simplicity and code readability. It has Numpy library for arithmetical operations which highly optimized and allows easier processing of images.

4.3 ESP8266

The ESP8266 is a low cost Wi-Fi microchip develop by Espressif Systems. It has full TCP/IP stack and microcontroller capability. In this paper, the server client connection between laptop and ESP8266. The socket programming involves initialization, connection and termination. The HTTP port 80 is used to send the content of the file in the python program to the ESP8266 and the FTDI programmer is used to serially send the data to Arduino UNO at 9600 baud rate.

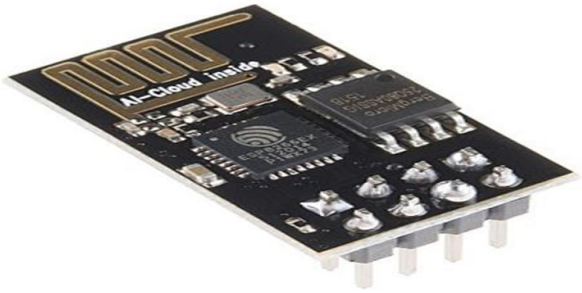

Figure 2: ESP8266 microchip

4.4 FTDI PROGRAMMER

FTDI stands for Future Technology Devices International, it is a semiconductor device company specializing in USB technology. FTDI USB to TTL cable is used to transmit data serially to Arduino, it is chosen considering the fact that ESP8266 operates on 3.3V.

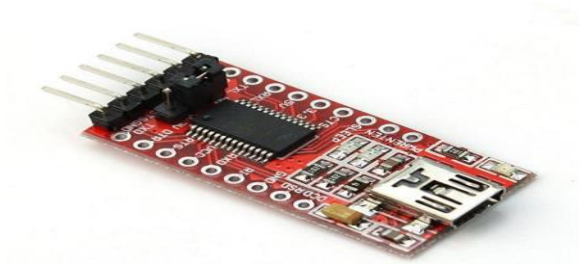

Figure 3: FTDI programmer

4.5 MOTOR DRIVER L239D

L239D is used to drive two motors simultaneously. It is dual H-bridge motor driver IC. It acts as a current enhancing device as the output from the Arduino cannot drive the motor independently.

Figure 4: L239D

4.6 MQ-7

MQ-7 is a gas sensor. It is used to detect CO gas concertation in air. It is simple to use but careful calibration is required in order to get proper readings. The sensor is highly sensitive and has fast response time. The sensor output is analog signal and is operated at 5V.

Figure 5: MQ-7 sensor

4.7 LM35

LM35 is a precision temperature sensor IC. Its output voltage is linear to the temperature in Celsius.

Figure 6: LM35 temperature sensor

4.7 SIM 900A

The SIM900A module is a complete dual-band GSM/GPRS solution. It is used in the robot to send message through GSM if the concentration level indicated is higher than the set values in the Arduino program.

Figure 7: SIM900A GSM/GPRS module

5. DESIGN PROCEDURE

The webcam is used to procure the image which is processed in python if the input gesture matches to one of the five gestures, then the corresponding instruction is sent through file on HTTP port to ESP8226 which is connected to the remote system consisting of chassis with wheels and motor, Arduino as a microcontroller, the sensors are connected to analog pins of the microcontroller. LCD and motor driver are connected at digital pins of Arduino. The ESP8266 is a very cheap WiFi module and is used to transmit data to Arduino, it is programmed using Arduino IDE. The power supply is a 5V battery to Arduino. The motor driver used for the project was L239D.

The Arduino program acts an intermediary between python and the motors. Python communicates with Arduino and instructs the motors to perform specified operations.

In the next section, a clear explanation is given on the development of the gesture recognition code this is the primary component of the paper.

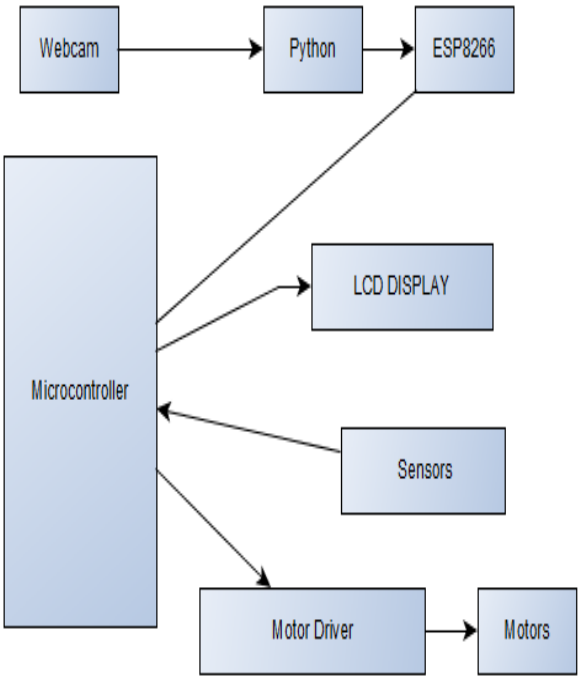

Figure 8 : The outline of the proposed system

6. PROGRAM OUTLINE

The program involves obtaining a rectangular box through which we can get hand data. The rectangular box is created with a predefined set of points. The user is required to place the hand within the box. The image is cropped, leaving only the rectangular area. This image is converted into grayscale. It is further processed to reduce noise in the image, Gaussian blur is applied before thresholding[7]. The Gaussian blur uses Gaussian function to cause blurring in image which reduces detail. It is implemented using Gaussian kernel which consists of values of Gaussian curve in 2-D. Convolution operation is performed between the Gaussian kernel and input image pixels to obtain the output pixels.

Otsu's binarization method[8] is applied for thresholding .This method involves finding intensities of the pixels in the grayscale image and converting them into monochrome image. This is obtained by setting threshold levels and measuring the variance of pixel values around the threshold. The image is divided into two classes the background and the object. The weighted class variance is obtained and finally they are added together to form within class variance. The optimal threshold is the one that optimizes the object function in other words, the threshold value that gives the best separation of classes is the optimal threshold.

The Contour which is a curve joining points with same intensity is plotted using OpenCV inbuilt function. Convex hull is basically the smallest convex envelope that contains the data points. Sklansky's algorithm [9] is used to obtain the convex hull of the hand. Since the polygon is a simple figure any popular convex hull algorithm should work. Convexity defects are found out and then the angle between the defects is found, the cosine formula is used to find the angle. If the angle is acute then the defects are added. There can be maximum five defects. Each number of defect involves execution of a particular instruction. The command is sent through WiFi module to Arduino which controls the robot, a gas sensor, a temperature sensor and a LCD monitor.

6.1 Algorithm for gesture extraction

Step-1 Initialize the webcam and input the frame and set the baud rate for serial transfer.

Step-2 if (frame value!) return error, else create rectangle and crop image inside the rectangle.

Step-3 Convert RGB to grayscale.

Step-4 Apply blurring and thresholding.

Step-5 Find contours and select max(contour Area)

Step-6 Create bounding box and find the convex hull which contains all the data points.

Step-7 Find the convexity defects

Step-8 Find the angle between the defects using cosine rule if(angle<90) ,count++

Step 9 Transfer the count to the Arduino controller using ESP8266. It performs instructions corresponding to the count.

Number of Defects	Instruction
• 1 • 2 • 3 • 4 • 5	• Forward • Backward • Full right • Full left • Display the temperature and CO gas reading

Table 1: Sample Instruction set for the robot

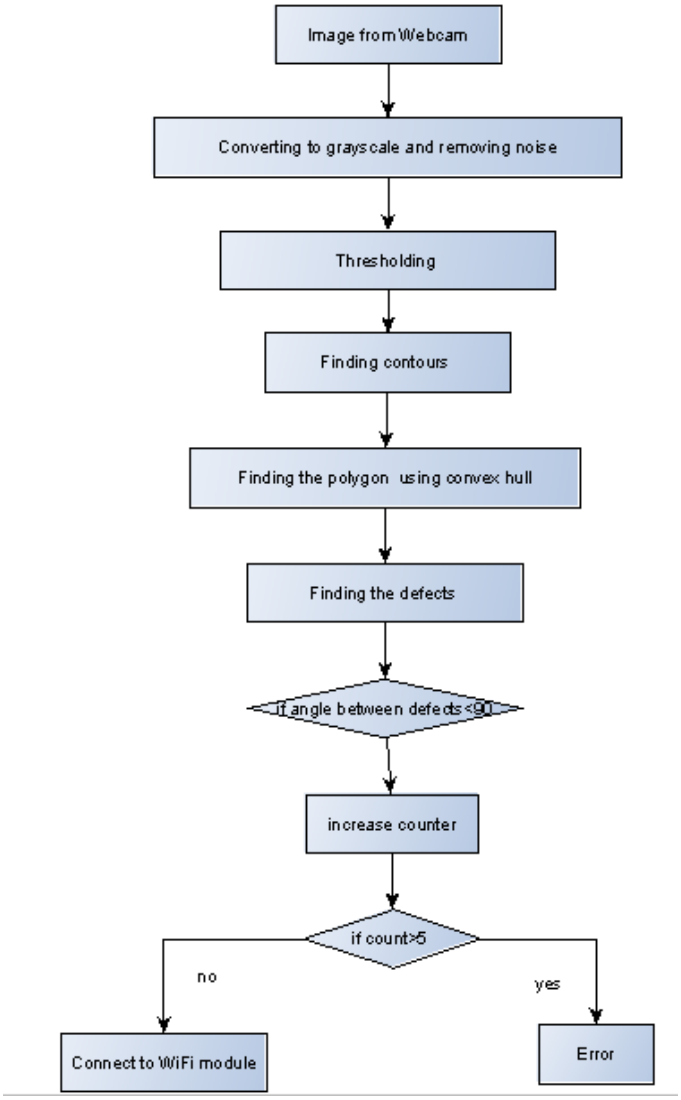

Figure 9: Process Flowchart for hand gesture extraction

7. EXPERIMENTAL RESULTS

The Robot was able to move according to the gestures, the number of defects corresponded to each instruction. The components were assembled on a metal chassis and the instructions were sent from the laptop to the robot through WiFi using WiFi module. The webcam used was of logitech. The images were processed and then the corresponding instructions were sent as a file through HTTP port 80 to ESP8266 Wi-Fi microchip. The Wi-Fi microchip and the Arduino were connected through FTDI programmer. The baud rate of Arduino was set at 9600.The sensors were added to demonstrate the application of gesture controlled robot in places where smoke has been generated thus it will be able to indicate the level of poisonous gas present as well as the temperature of the surroundings. Arduino IDE was used to program Arduino to control the movement of the motors and take the readings from the sensors. The CO gas sensor was MQ-7, it was calibrated and the readings were verified with known values of CO levels. GSM module was to send message in case the reading was higher than the normal limit.

Figure 10: Detecting 5 defects in the hand gesture.

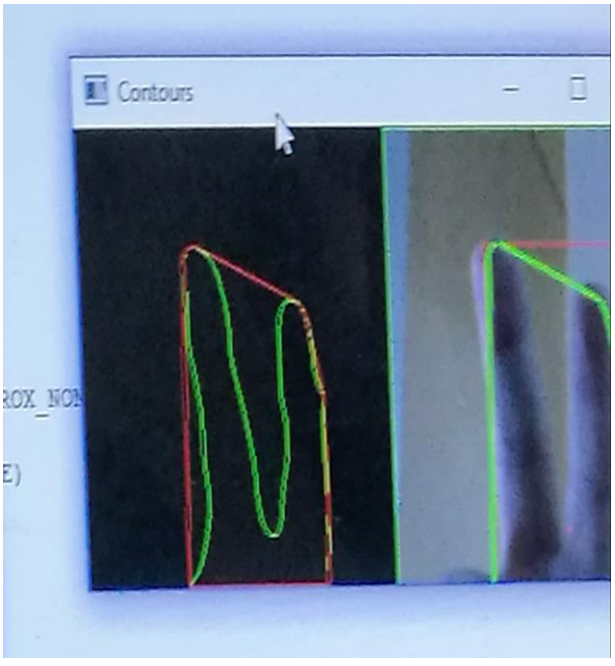

Figure 11: Detecting 1 defect in the hand gesture.

Figure 12: The hand gesture controlled robot

8. CONCLUSION

In this paper, a hand gesture controlled robot using simple image processing is proposed. The webcam sent individual frames and the gesture recognition algorithm was processed on them and instruction based on certain gestures of hand was performed, since the main application was to control the robot equipped with sensors, the instruction set was limited.

9. FUTURE SCOPE

The program can be modified to take into account different external factors like inadequate lighting, one way of doing this could be improving the segmentation process by filtering the image. The proposed system could then be used in hazardous conditions. Using specially designed filters depending upon particular environment the accuracy of the gesture prediction can improve significantly. One good application of a big scale model of the gesture controlled robot is the gesture controlled wheel chair which will help disabled people in locomotion.

10. REFERNCES

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