AN INTEGRATED COLOR AND HAND GESTURE RECOGNITION CONTROL FOR WIRELESS ROBOT

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ABSTRACT

Recently, the interaction between humans and robots has become an important issue for extending the use of robots. The purpose of this project is to show how a real-time human-robot interaction with hand gesture recognition which can be constructed combining color and shape cues. Hence, it is required that the following two major questions be resolved in this study. Firstly, either staying in indoor or outdoor lighting conditions, the robot must be able to detect and spot hand gestures with a specific color from data of robot vision system. Secondly, it is necessary that the robot also can interpret hand gestures performed by humans.

KEYWORDS: *Hand Gesture, Gesture recognition, wireless robot*

I. INTRODUCTION

Several successful approaches to spatio-temporal signal processing such as speech recognition and hand gesture recognition have been proposed. A gesture is a form of non-verbal communication made with a part of the body and used instead of verbal communication (or in combination with it). Most people use gestures and body language in addition to words when they speak. A sign language is a language which uses gestures instead of sound to convey meaning combining hand-shapes, orientation and movement of the hands, arms or body, facial expressions and lip-patterns. Similar to automatic speech recognition (ASR), we focus in gesture recognition which can be later translated to a certain machine movement.

Hand gestures can be classified into two classes:

(1) Static hand gestures: This relies only the information about the angles of the lingers and

(2) Dynamic hand gestures: This relies not only the fingers' flex angles but also the hand trajectories and orientations.

The goal of this project is to develop a program implementing real time gesture recognition. At any time, a user can exhibit his hand doing a specific gesture in front of a video camera linked to a computer. However, the user is not supposed to be exactly at the same place when showing his hand. The program has to collect pictures of this gesture thanks to the video camera, to analyze it and to identify the sign. It has to do it as fast as possible, given that real time processing is required. We propose a fast algorithm for automatically recognizing a limited set of gestures from hand images for a robot control application. Hand gesture recognition is a challenging problem in its general form. We consider a fixed set of manual commands and a reasonably structured environment, and develop a simple, yet effective, procedure for gesture recognition. This paper is consisting of the two important parts software development and hardware development. The software consists of the different phases of conversion of the different hand gestures in to the signals or commands for the robot and hardware consist of details of the transmitter and receiver of the project.

II. RELATED WORK

Color-based target recognition is inherently difficult, due to variation in the apparent color of targets under varying imaging conditions. A number of factors might lead to the problem, namely, the color

of incident daylight, surface reflectance properties of the target, illumination geometry, and viewing geometry [1]. There have been numerous studies in the literature dealing with varying color in highly constrained environments, such as color constancy algorithms [2], but are generally not applicable to outdoor images. Buluswar and Draper [3] developed color models for illumination and surface reflectance for use in outdoor machine vision. Stachowicz and Lemke [4] presented a color recognition method to compress the color information in an image into a small feature space that still contains enough information to separate one image from another. Liu *et al.* [5] provided an approach combining multiple color models to make color-based object recognition stable under varying imaging conditions. Another idea is to establish a supervised learning mechanism based on neural network for color measurement [6].This approach offers good performance and is more convenient to be implemented in human-robot interaction. The ability to quickly and correctly recognize hand gestures plays an important role in human-robot interaction applications. Numerous approaches have been applied to interpreting hand gestures. More recently, combining color space transformation and color thresholding method to classify each pixel in an image into one of a discrete number of color classes has increased noticeably [7]. This approach offers good performance and is more convenient to be implemented in human-robot interaction. The ability to quickly and correctly recognize hand gestures plays an important role in human-robot interaction applications. Numerous approaches have been applied to interpreting hand gestures. In literature [8]-[10], several hand geometry based systems are proposed for measuring a hand shape to extract its features, including lengths and widths of fingers, and hand contour, for recognition. Other methods are developed for improving recognition efficiency by machine learning and supervised training algorithms, including fuzzy neural network and modified Fourier descriptors (FDs) [11], [12]. More recent studies in gestures recognition have focused on support vector machines (SVM). These approaches have produced highly accurate systems capable of recognizing gestures [13], [14].

The main objective of this work was the developing of a control system for a robot, based on gesture recognition. A web camera will be attached to a computer which will acquire live feed of gestures done by the operator. The operator's hand will have two different colors on it, one located on the thumb & the other on nuckel. The operator will give a gesture of thumbs up. Now when the thumb is pointing in upward direction, the command is 'move forward', when to left 'move left' etc.

III. SOFTWARE DEVELOPMENT

In this project, we propose a gestures recognition method to recognize a number of well-defined hand gestures representing a limited set of commands that the humans can give to the mobile robot 1. Firstly, by analyzing the distribution of the specific color in hue saturation intensity (HSV) color space, a color multithresholding method was developed for detecting hand gestures in video sequence under varying lighting conditions. Secondly, the feature extraction of hand gestures was performed by the detection algorithm and and by applying threshold value. Thirdly we can obtain the particular signal for robot movement subtracting the coordinates of the two colors. Finally, a real-time vision system on hand gesture recognition for a human-robot interaction is presented. The frames captured by the camera are in HSV format. We convert it to grayscale image. Then applying threshold value for one color the gray image is converted to binary image. In binary image the thresholded color turns white & the background becomes black. Now using moments we can find the co-ordinates of this blob. Same thing has to be done for the other color. Now we have the co-ordinates of the two colors. On subtraction of x & y co-ordinates we get the direction of the vector. Thus then we give command to the robot in this way.

Flow chart for recognizing gesture & give commands to the robot

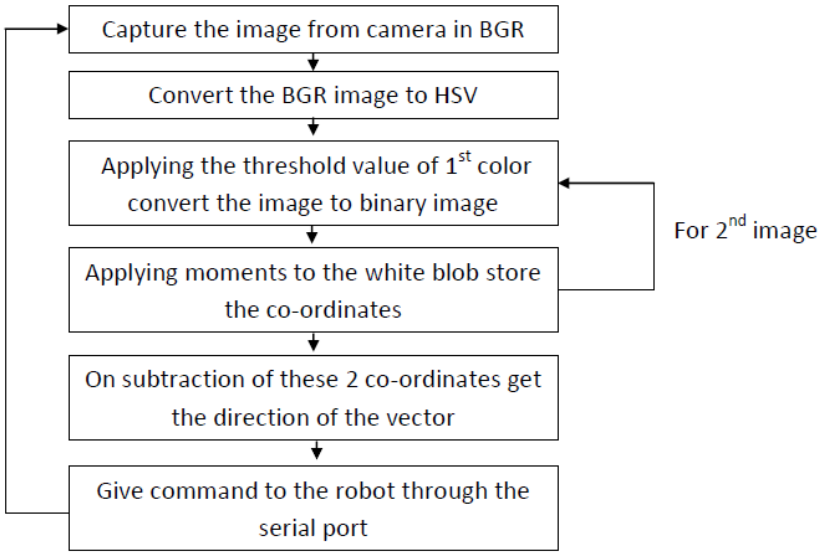

Fig.1 Flowchart of gesture recognition

Algorithm for the program which converts the gestures to commands for the robot is as follows:
1) Capture a frame from camera. It's in BGR format.
2) Convert this BGR image to HSV OR RGB. (HSV is preferred since it is more noise free than RGB).
3) Convert this image to binary image by applying lower range & upper range of desired color (i.e. to make desired color white & rest black).
4) Find out the moment of each color on thumb and nuckel.
5) From the moments find out the coordinates of the each color viz X coordinate and Y coordinate
6) Subtract the coordinates to find out the direction of the movement of the robot.

3.1 BGR TO HSV Conversion

This module consists of two phases namely the image acquisition and image processing phases. The acquired images using a web cam for each hand gesture are in BGR format. We will convert it to HSV or RGB image. We prefer HSV since it is more noise free than RGB. The image is then subjected to an image enhancement process to adjust the intensity values in HSV image to increase the contrast of the output image. Figure 2 shows an acquired image of a sample hand gesture after enhancement where the captured green portion is marked by a green circle & yellow portion by yellow circle. This gesture represents a vector in forward direction.

Fig.2 : Original HSV image

3.2 HSV TO Binary conversion (Thresholding)

Since we deal with the segmentation of color on thumb and nuckel color, a threshold value of the particular color level is chosen to convert the image to binary. The threshold value for the two colors must be different. This threshold value should be chosen carefully to avoid effect noise or any other color detection in the territory. Figure 3 shows the resulting black and white image called binary image after the thresholding process. We can convert this image to binary image by applying lower range & upper range of desired color (i.e. to make desired color white & rest black).

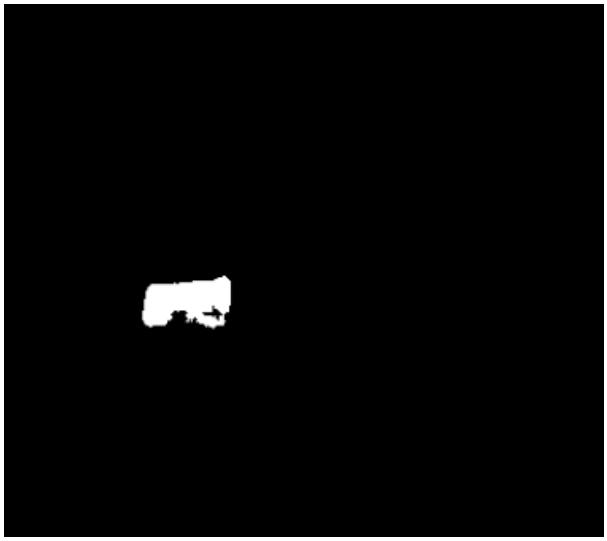

Fig.4 Binarized image showing the yellow marker. Here the original image is binarized with values to make yellow color highlight & background black.

We are going to use software opencv because opencv has a function to convert the HSV OR RGB image (step 2) into binary image directly. i.e. no need to convert image to grayscale & then to binary. The removal of these extra results in reduction in time complexity & space complexity.

3.3. FILTERING THE BINARY IMAGE

The binary image obtained as shown in fig.4 can be filtered with help of median smoothing algorithm. This filtering is required to remove the noise if any introduce by thresholding the grayscale image. Median smoothing algorithm is the simple algorithm used for removal of the noise from the signal or an image.

3.4 FINDING THE COORDINATES

Once we obtain the binary image from thresholding the colors we get two white blobs of two colors as shown in figure. By applying logic in physics we can find out the moment of the white blob. An Image moment is a number calculated using a certain formula. With help of the moment of the blob we can find out the co- ordinates of the color on the thumb with equation 1 and 2

$$X \text{ coordinate} = \frac{\text{Moment of X}}{\text{Total area of the white blob}} \quad (1)$$

$$Y \text{ coordinate} = \frac{\text{Moment of Y}}{\text{Total area of the white blob}} \quad (2)$$

Once we obtain the coordinates (X1, Y1) for the color on thumb, we are able to find out the coordinates of the other color on the nuckel(X2, Y2). Fig5 shows the coordinates obtained for the green color and yellow colored ring in the fig1 for forward direction.

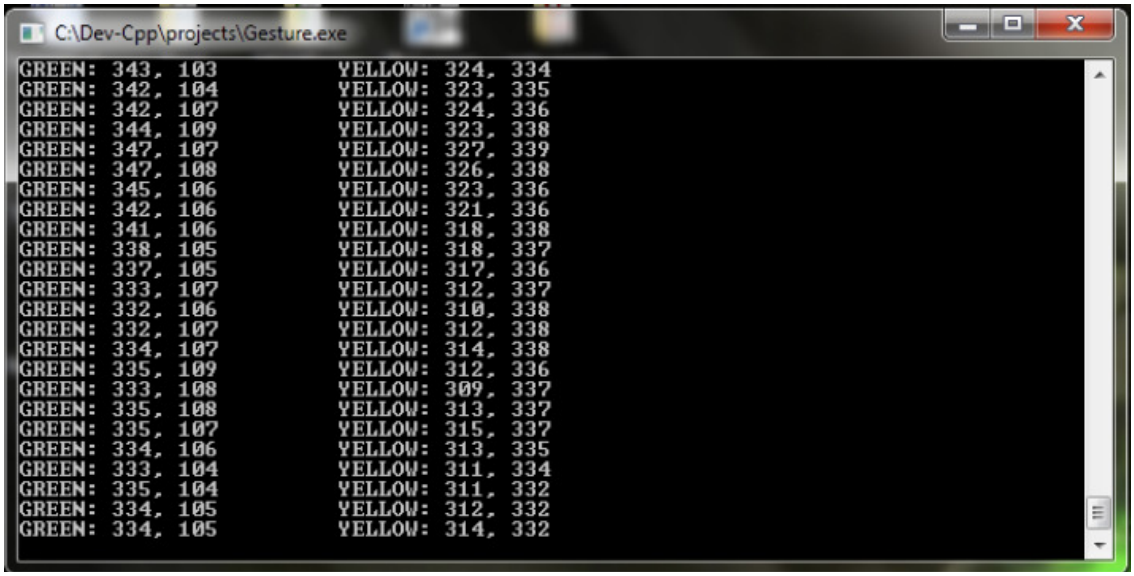

Fig. 5: Original image's captured co-ordinates.

3.5 Coordinate Subtraction

Find out which movement should be there (X, Y), we will need to subtract the coordinates of the two colors.

$$X = X1 - X2 \quad , \quad Y = Y1 - Y2$$

After subtracting the coordinates for two colors we are able to find direction of movement of the robot. According to the decisions made in the program the robot will move. Same procedure is followed for all the robot movements.

IV. HARDWARE ARCHITECTURE

The hardware architecture of this project is consist of two basic parts namely Transmitter unit, Receiver unit. The block diagram of these parts is as shown in figure 3.5 and figure 3.6 respectively. On the transmitter side it is consist of PC with gesture recognition software connected to web camera which in turn connected to RF transceiver through RS232 whereas the receiver unit is consist of blocks like RF transceiver module, PIC16F877 , L293 motor driver along with DC geared motor ,5V regulated power supply.

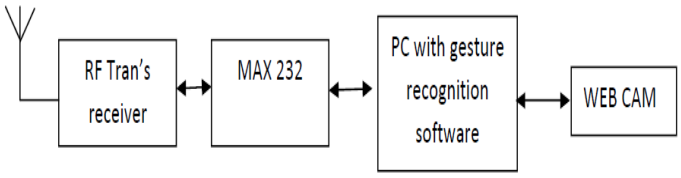

Fig.5 Block Diagram of Transmitter unit

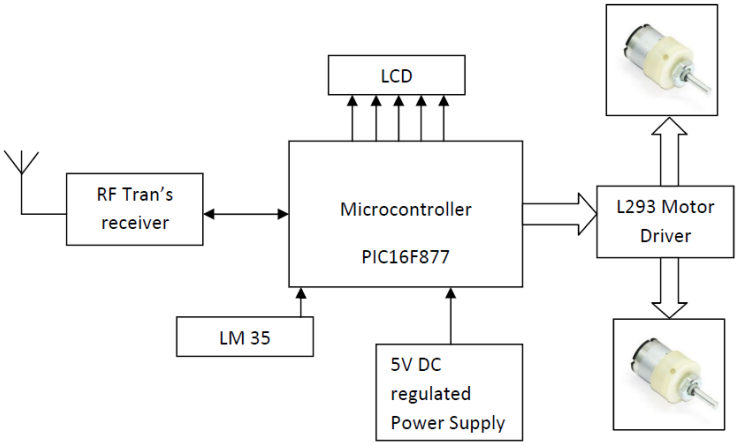

Fig.6 Block diagram of Receiver Unit

4.1 Microcontroller (PIC16F877)

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are available in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture. Following are some of the properties of the PIC16F877.

High-Performance RISC CPU

• Only 35 single-word instructions to learn

• All single-cycle instructions except for program branches, which are two-cycle

• Operating speed: DC – 20 MHz clock input DC –200 ns instruction cycle

• Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 byte of EEPROM Data Memory.

4.2 Motor Driver L293

The L293 is an integrated circuit motor driver that can be used for simultaneous, bidirectional control of two small motors. The L293 is limited to 600 mA, but in reality can only handle much small currents unless you have done some serious heat sinking to keep the case temperature down. Unsure about whether the L293 will work with your motor? Hook up the circuit and run your motor while keeping your finger on the chip. If it gets too hot to touch, you can't use it with your motor. The L293 comes in a standard 16-pin, dual-in line integrated circuit package.

4.3 DC Geared Motor

Carbon brush of DC motor for the main role to play for, for referring to the rotating armature winding components from one slip to another slip, the brush in the process of short-circuit current generated by components within Change of direction. For the poor performance at run-time is the electrical spark happened. Level and sparks more than a certain limit will cause the carbon brush and commutator surface damage, with the result that should not continue to run the motor. When the motor for the situation well, sparks larger, an increase of the electrical brush wear. Especially when the commutator surface oxide film is damaged, the wear will be increased significantly.

4.4 RF Transceiver

A transceiver is a device comprising both a transmitter and a receiver which are combined and share common circuitry or a single housing. When no circuitry is common between transmit and receive functions, the device is a transmitter-receiver. The term originated in the early 1920s. Technically, transceivers must combine a significant amount of the transmitter and receiver handling circuitry. The RF Transceiver uses RF modules for high speed data transmission. The microelectronic in the

digital-RF architecture work at speeds up to 100 GHz. The RF transceiver module which we are using is CC2500 RF module. It is a transceiver module which provides easy to use RF communication at 2.4 GHz. It can be used to transmit and receive data at multiple baud rates from any standard CMOS/TTL source. This module is a direct line in replacement for your serial communication it requires no extra hardware and no extra coding to turn your wired communication into wireless one. It works in Half Duplex mode i.e. it provides communication in both directions, but only one direction at same time (not simultaneously). This switching from receiver to transmitter mode is done automatically.

4.5 Web Camera

A webcam is a video camera which feeds its images in real time to a computer or computer network, often via USB, Ethernet or Wi-Fi. Their most popular use is the establishment of video links, permitting computers to act as videophones or videoconference stations. This common use as a video camera for the World Wide Web gave the webcam its name. Other popular uses include security surveillance and vision. Webcams are known for their low manufacturing cost and flexibility, making them the lowest cost form of video telephony.

4.6 RS232

In telecommunications, RS-232 (Recommended Standard 232) is the traditional name for a series of standards for serial binary single ended data and control signals connecting between a DTE (Data Terminal Equipment) and a DCE (Data Circuit-terminating Equipment). It is commonly used in computer serial ports. The standard defines the electrical characteristics and timing of signals, the meaning of signals, and the physical size and pin out of connectors. However, the limited transmission speed, relatively large voltage swing, and large standard connectors motivated development of the universal serial bus which has displaced RS-232 from most of its peripheral interface roles.

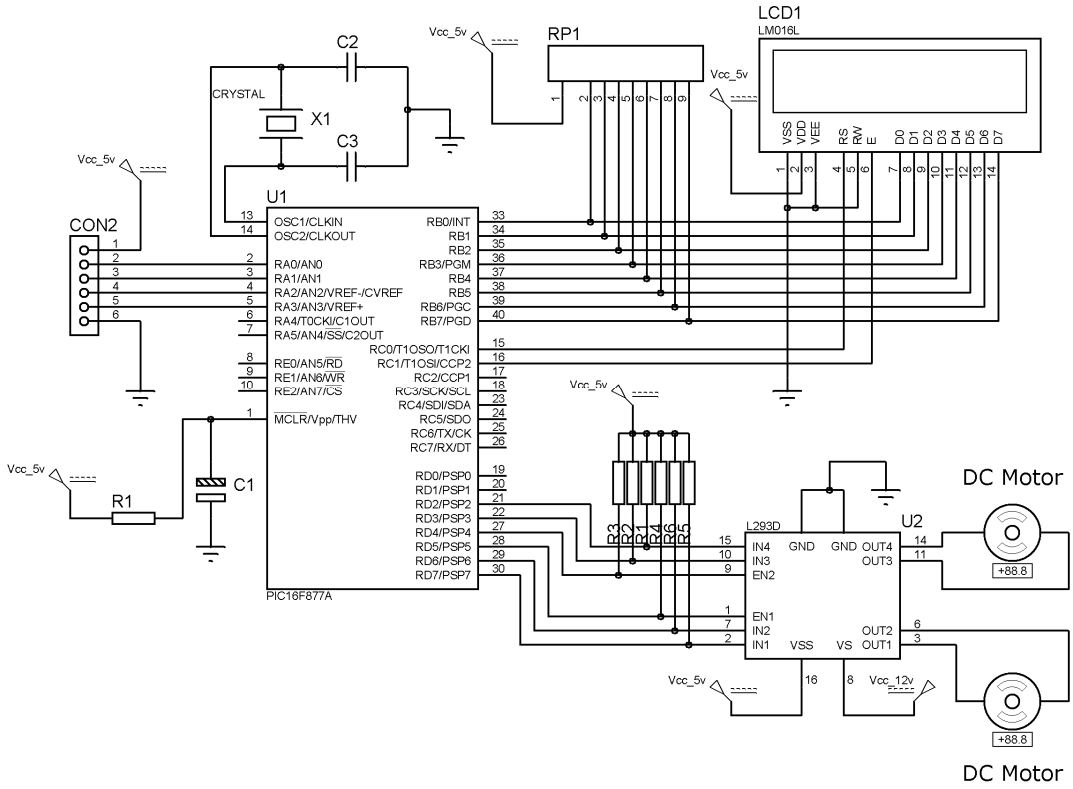

Fig.7 Detailed circuit Diagram

4.7 Power Supply

This circuit is a small +5V power supply, which is useful when experimenting with digital electronics. Small inexpensive wall transformers with variable output voltage are available from any electronics shop and supermarket. Those transformers are easily available, but usually their voltage regulation is very poor, which makes then not very usable for digital circuit experimenter unless a better regulation can be achieved in some way.

V. CONCLUSION

This project presented a gesture controlled wireless robot that does not require any special markers or gloves and can operate in real-time on a commodity PC with low-cost camera. Specifically, the system can track the coordinates of each color on the thumb and nuckel for each hand, assuming that a calibrated camera is viewing the hands from above with the palms facing downward. The motivation for this hand tracker was a desktop-based two-handed interaction system in which a user can select and manipulate 2D geometry in real-time using natural hand motions. The algorithm for gesture recognition is implemented in opencv and .net. This project presents a fast, robust and accurate method for hand gestures recognition under unconstrained scenes. The failure of the system to recognize the gesture is mainly due to the very changeable lighting conditions and moving objects (persons) entering the scene, operator's failure to move the hand to the proper posture. It must be emphasize that after a short experience operators get used to the system. Future work will be focused on algorithm improvement, by using a combination of segmentation techniques and robot motion control by tracking the arm movement and its speed.

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