

Digital Image Processing Based Hand Gesture Recognition Robot for Multiple Applications

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Abstract: In early days, for operation of robots a person should be present beside it. So it is necessary to design a robot which can be operated without a person being physically present. This paper is about operating a robot which is not near us and can be operated from a station; this is possible and is executed through a technique called IMAGE PROCESSING. In order to ease a feasible solution for user friendly interface, we can give commands to a wireless robot using hand gestures. Hand Gesture is frequently used in day to day life. The gesture recognition system consists of three stages image acquisition, feature extraction and decision algorithm. Once a gesture is recognized a command signal is generated and sent to micro controller. These command signals are then sent to the robot to operate it in a particular direction. One of the applications of the robot is to pick and place things where human intervention is not possible. The pick and place arm is a microcontroller based mechatronics system that picks the object from a source location and places it at a desired location, this action is controlled using a keypad switch. Further, the robot captures the video signals with its RF camera at 2.4GHz (mounted on the robot). The live video of the robot is received at the base station (computer). It is processed in the MAT Lab software and the video is processed in DSP code simultaneously.

Keywords: Digital Image Processing, Hand Gesture Recognition, Robot, MATLAB.

I. INTRODUCTION

Interaction between human and computer has become an important part in day to day life. It is concerned with the design, evaluation and implementation of interactive computing systems for human use. The most popular devices that are used for communication are keyboard, mice, light pen, trackball, keypads etc. These devices are familiar but not so natural for communication.

Due to the development of vision-based interface, now computers are able to see, which makes the human computer interaction rich. This employs a new communication and controlling facility that is more reliable, user-friendly and time saving. Plenty of research work has been done on hand gesture recognition based on different methods and techniques. The main purpose of using gestures is to provide a more natural way of controlling and provides a rich and intuitive form of interaction with the robotic system. This mainly involves Image Processing and Machine Learning for the system or application development.

This robot has multiple applications here we are demonstrating one of the application i.e. pick and place. This pick and place arm is controlled by 1*4 keypad switch. Further, the robot captures the video signals with its RF camera at 2.4GHz (fixed on the board of the robot). The live videos of the movement of the robot are received at the base station (computer). It is processed in the MATLAB software and the video is processed in DSP code simultaneously.

II. RELATED WORK

There are many techniques that are used to control the robot through gestures. We are using K-Curvature method.

A. Existing Systems

Many systems exist that are used for controlling the robot through gestures. Some gesture recognition systems involve adaptive color segmentation, hand finding and labeling with blocking, morphological filtering, and then gesture actions are found by template matching and skeletonising. This does not provide dynamicity for the gesture inputs due to template matching. Some systems uses machine interface device to provide real-time gestures to the robot.

B. Proposed System

In this system, user operates the robot from a control station that can be a laptop or a PC with a good quality in-built webcam or external webcam. This webcam is used to capture real time video stream of hand gestures to generate commands for the robot. Gesture commands are given using hand palm. Mainly five kinds of gestures are used which are explained further. Robot is moved in all possible directions in the environment using five possible types of commands which are Forward, Backward, Right, Left and Stop. Image frame is taken as an input and processed using Image Processing. Processed image is then used to extract the gesture command. This gesture command can have one of the five possible commands as specified. From this generated gesture command, signal is generated and it is passed to the robot using ZigBee (transmitter).

This generated signal is stored in the file at the control station. As soon as the ZigBee (receiver) on the robot gets command from the control station, it is passed to the PIC microcontroller. Microcontroller takes this signal as input from the ZigBee and generates some output signals that

are passed to the motor driver. This output signal generation depends on the gesture input, for every five possible gesture inputs, different output signal is generated. The motor driver is used to drive the DC motors of the robot. Once a command signal is given to the robot, it continues to move in that direction until the next command is given or any obstacle comes in its path. Fig. 1 shows the basic flow of the system.

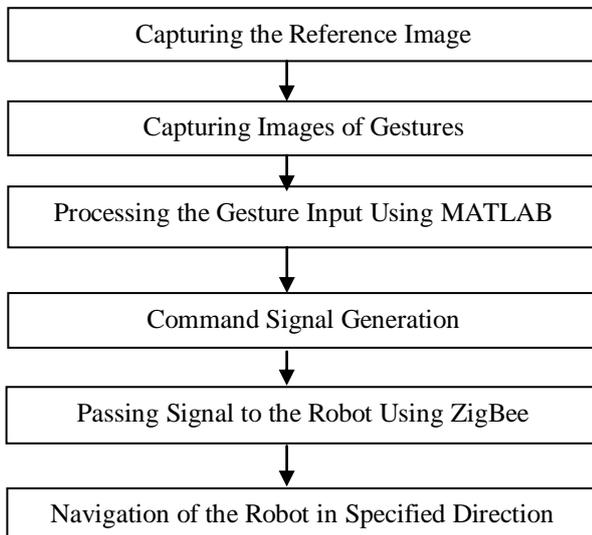


Fig:1 Basic Flow of the System

III. TECHNOLOGIES USED

A. MATLAB

We use MATLAB Image Processing Toolbox, but fortunately, no toolboxes are needed for most operations. Commands requiring the Image Toolbox are indicated with [Image Toolbox]. Some of the commands which we have used here are `imread` & `imwrite` which helps MATLAB to read and write images respectively. The user can run the MATLAB code to recognize the gestures in order to move the robot in the desired direction.

B. K Curvature algorithm

The gesture recognition is done by using the K Curvature algorithm. The K Curvature algorithm operates using the following procedure:

- Find angle between clockwise HB points that are k-terms apart from one another.
- If the angle falls above a certain absolute threshold, the point is marked as being of interest.
- Separate finger tips from web points by observing the sign change in angle values.

C. Embedded C

C is the most widely used programming language for embedded processors/controllers. Embedded C uses most of the syntax and semantics of standard C, e.g., `main ()` function, variable definition, data type declaration, conditional statements (`if`, `switch`, `case`), loops (`while`, `for`), functions, arrays and strings, etc. Here we used two embedded C code one to control the driver of the two DC motors used to control the movement of the robot and

another code is used to control the driver which is used to drive the two DC motors of pick and place arm.

D. MPLABX Tool

MPLAB is a free integrated development environment for the development of embedded applications on PIC and ds PIC microcontrollers, and is developed by Microchip Technology. This tool is used to execute the embedded C code.

IV. DESIGN

Our design is mainly divided into two parts. The first part focuses on hand gesture command recognition. Commands are generated at the control station and sent to the robot through ZigBee within the ZigBee range. The robot moves in the specified direction according to the specified command. The second part focuses on controlling the pick and place arm using the 1*4 keypad switch. The following section illustrates the steps carried out in the design.

A. Capturing Reference Image

The reference image is a plain background image which has to be captured using webcam before the user gives gestures. This image is necessary as it involves some background constraints to identify the hand palm correctly with minimum noise in the image hence the reference image must be a plain background.

B. Capturing Gestures

The final result of the hand gesture recognition system is to generate a command and these commands are used to control the robot. There are mainly five probable gesture commands that can be given to the robot i.e. forward, backward, right, left and stop. These gesture commands are given by the user based on the Finger Count. The hand gesture commands are given in front of the reference image using the webcam.

C. Hand Gesture Recognition

Once the reference image has been captured the user can run the MATLAB code to recognize the gestures in order to move the robot in the desired direction. Image frame is taken as input from the webcam on the control station and further processing is done on each input frame to detect hand palm. These recognized gestures are further transmitted to the receiver serially through an USB to UART converter

D. ZigBee

It is a simple and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. It is used to send signals from transmitter to the receiver which is at a distance of 100-200meters through wireless antenna. ZigBee has a defined rate of 250 Kbit/s. Here it is used to send the command signals from the control station to the robot. These command signals are then sent to the PIC microcontroller. Fig. 4 shows ZigBee.

E. Microcontroller: PIC 16CXX

All PIC microcontrollers employ an advanced RISC architecture. PIC16F8X devices have enhanced core

features, eight-level deep stack, and multiple internal and external interrupt sources. A total of 35 instructions (reduced instruction set) are available. Additionally, a large register set is used to achieve a very high performance level. PIC16F8X microcontrollers typically achieve a 2:1 code compression and up to a 4:1 speed improvement (at 20 MHz) over other 8-bit microcontrollers in their class. The PIC16F8X has up to 68 bytes of RAM, 64 bytes of Data EEPROM memory, and 13 I/O pins. A timer/counter is also available. Fig.2 shows PIC Microcontroller.



Fig:2 PIC Microcontroller

F. Arduino

Arduino board based ATmega328 microcontroller. ATmega328 is a CMOS 8 -bit microcontroller is a low - power RISC architecture. By executing powerful instructions in a single clock cycle, ATmega328 be approaching 1 MIPS (million instructions per second) per MHz allowing the system designed to optimize power consumption with the processing speed. The microcontroller on the board is programmed using the Arduino programming language (based on wiring) and the Arduino development environment (based on processing). Fig.6 shows Arduino.

G. RF433 MHz Receiver and Transmitter

It is often required to switch electrical appliances from a distance without being a direct line of sight between the transmitter and receiver. RF based wireless remote control system (RF Transmitter & RF Receiver) can be used to control an output load from a remote place. RF transmitter, as the name suggests, uses radio frequency to send the signals at a particular frequency and a baud rate. The RF receiver can receive these signals only if it is configured for the pre-defined signal/data pattern. Fig.5 shows receiver.

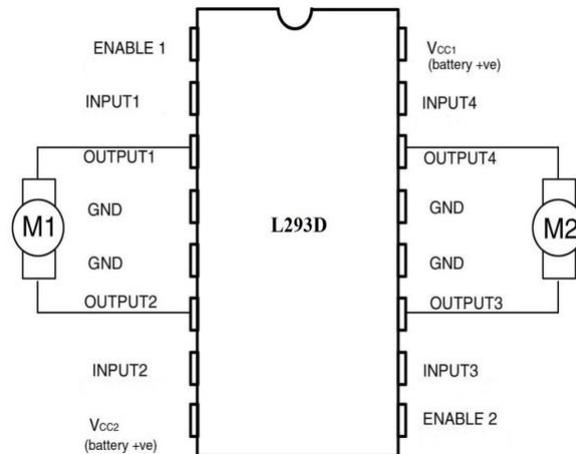


Fig: 3 L293D Pin Diagram

H. Motor Driver:L293D Circuit

Here we use two L293D circuits. One is used to drive the robot and other one is used for the movement of the pick and place arm. In the first circuit all the four input pins are connected to the digital pins of PIC 16CXX and the four outputs are connected to the DC motors of the robot. In the second circuit all the input four pins are connected to the digital pins of an Arduino and the four output pins are connected to DC motors of the pick and place arm. In both the circuits enable pins are used to enable input/output pins and Vcc is used for supplying external power to the DC motors. Fig.3 shows L293D Pin diagram.

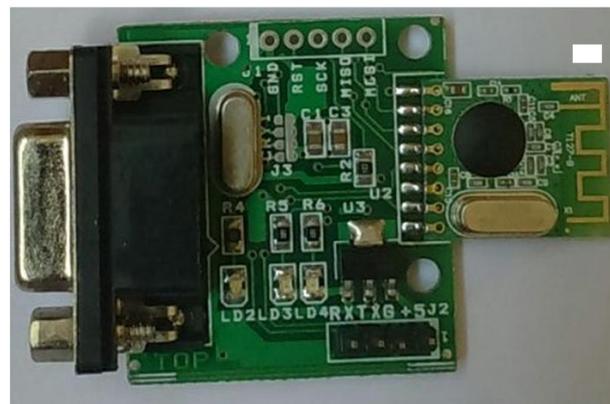


Fig:4 ZigBee

I. DC Motors

A DC motor is mechanically rotated electric motor powered from direct motor (DC). The stator is stationary in space by definition and therefore so is its current. The current in the rotor is switched by the commutator. DC motors better suited for equipment ranging from 12V DC systems in automobiles to conveyor motors, both which require fine speed control for a range of speeds above and below the rated speeds. The speed of a DC motor can be controlled by changing the field current. Fig.7 shows DC Motor.

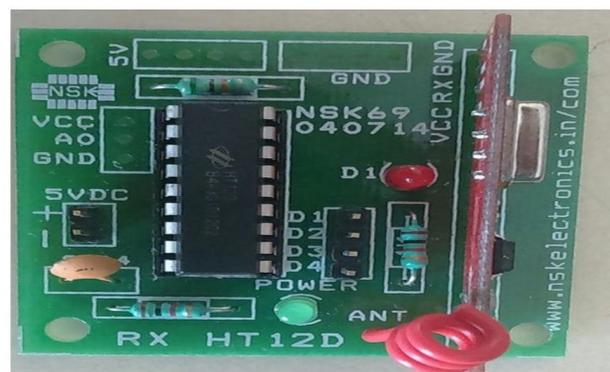


Fig:5 RF 433MHz Receiver



Fig:6 Arduino Board



Fig:7 DC Motor

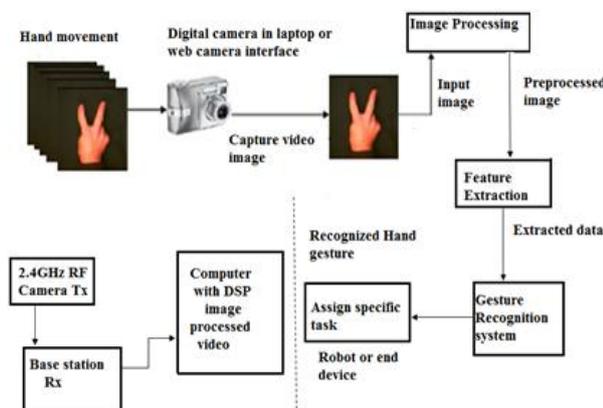


Fig 8: Architecture of the system

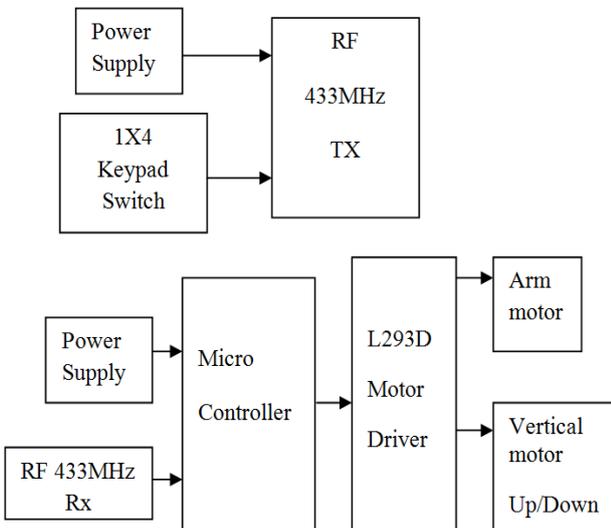


Fig9: TX and RX block diagram of pick & place unit

V. IMPLEMENTATION

A. Capturing Gesture Movements:

Image frame is taken as input from the webcam on the control station and further processing is done on each input frame to detect hand palm.. This involves some background constraints to identify the hand palm correctly with minimum noise in the image.

B. Hand Palm Detection

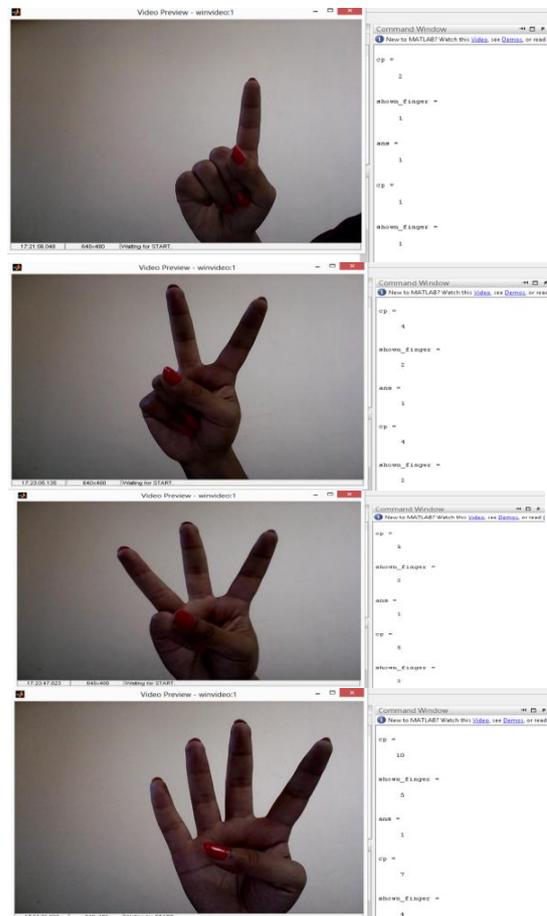
After capturing the image frame from the webcam, some basic operations are performed on this frame to prepare it for further processing of command detection. Following process is done to detect hand palm.

1) FEATURE EXTRACTION

An image frame is taken as input through webcam. The RGB input frame is converted to a grayscale image. After obtaining a grayscale image, we use Median filters to remove noise from input image, and then threshold the image to a binary one. Then we remove the unwanted portion of the image; we have to remove the unnecessary pixels (0) from original image. Binary Thresholding is then done on this image frame for the recognition of hand palm.

C. Command Detection using Specific Method:

After completion of pre-processing of an input frame, further processing is done on the extracted image according to specified technique. The method of giving gesture commands are as follows



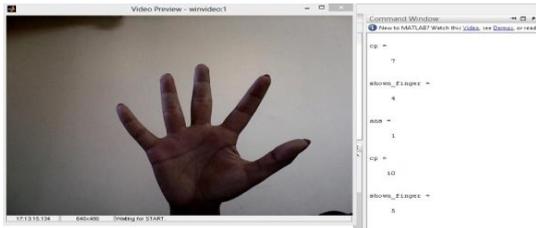


Fig: 10 Method of giving Gestures

Robot is moved in all possible directions in the environment using five possible types of commands which are Forward, Backward, Right, Left and Stop for the finger count of 1,2,3,4 & 5 respectively as shown in the above figure.

D. Generate Specific Signal:

After detecting gesture command specific signal value is generated, unique for every gesture command. This signal value is written in the file using MATLAB functions.

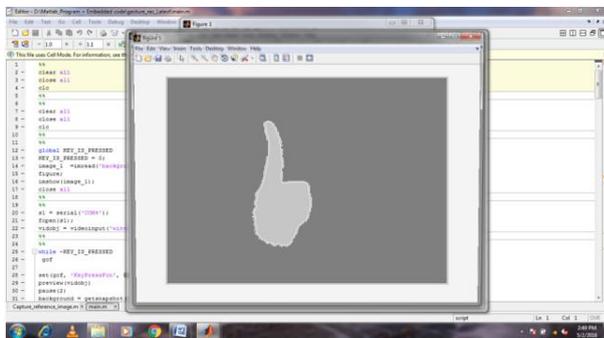


Fig: 11 Detection of Gesture

E. ZigBee:

As soon as the command is generated on the control station, it is written in a file with tagged word with it. This file is read by ZigBee after regular interval. As it is a wireless communication, so ZigBee communicates with the control station where control station is also in the same network. Both control station and ZigBee is provided with an IP address by using this IP address ZigBee accesses the information from the control station.

F. Micro-Controller: PICF816XX & Arduino

ZigBee is connected to the PIC board through stackable pins as shown in Figure .When the process of communication starts; ZigBee tries to connect itself with the control station, with the provided IP address of the control station. As soon as ZigBee gets connected to the control station, it continuously sends the command signals to the receiver. These received signal values are then passed to PIC which extracts command and calls which are specified for that command. PIC sends five digital signals as an input to the L293D(1) motor driver.

We also use Arduino board in order to control the pick & place arm with the help of push buttons. The command signals from arduino is given as input to the L293D (2) motor driver.

G. Motor Driver: L293D

We use two L293D driver circuit. L293D(1) takes digital signal as an input from the PIC and gives digital output to

the DC motors of the robot which helps in movement of the robot in the environment. Power supply to the circuit is given from the PIC board itself. A single L293D driver circuit can drive two DC motors simultaneously. L293D (2) circuit is used to drive the two DC motors of the Pick & Place arm. This L293D (2) takes the input from the arduino board.

H. DC Motors in Robot:

This is the final end product of robot consisting of all the hardware ZigBee, PIC board and L293D motor Driver circuit and pick & place robot on the robot chassis having power supply provided by the rechargeable batteries. Two DC motors are connected to this robot chassis as shown in Figure. This is controlled through gestures by the user at control station. The pick & place robot is controlled by the 1*4 keypad circuit.

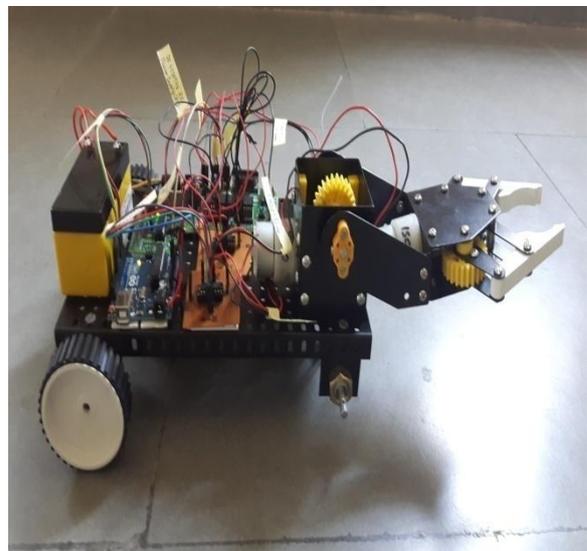


Fig: 13 Robot

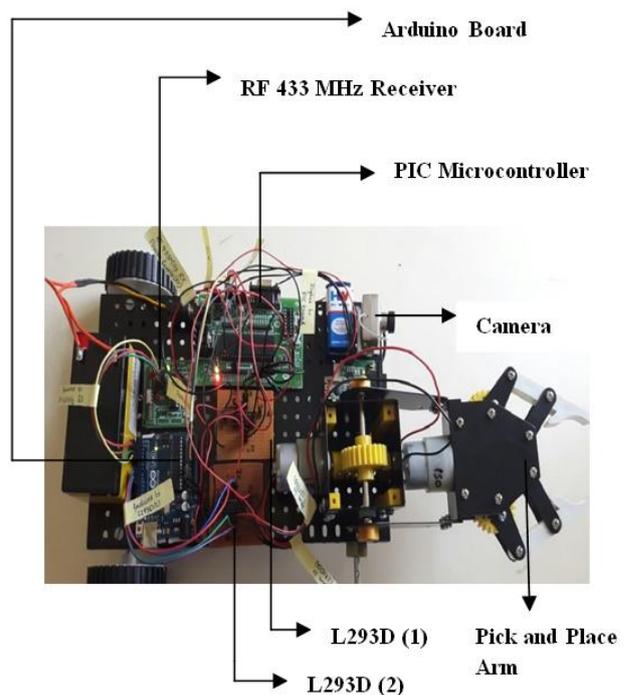


Fig: 12 Overall connection of the robot

VI. CONCLUSION

In this paper we have tried to control the robot in a novel method. Gesture control being a more natural way of controlling devices, makes control of robots more efficient and easy. We have used finger count techniques for giving gesture input. In which each finger count specifies the command for the robot to navigate in specific direction in the environment. After gesture recognition command signal is generated and passed to the robot, it moves in a specified direction. The pick and place arm is used to pick objects where human intervention is not possible.

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