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Hand Gesture Controlled Robot

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Abstract— this paper describes how to reduce the hard and complicated methods of controlling robotic gadgets in various applications. It is quite complicated to control the robot or particular machine with remote or switches. This intelligent system can identify the motion or gesture of our hand and can work according to the instructions. A camera will be capturing your hand gestures and by using image processing techniques, comparison of the previous and present hand motion will be processed. According to the comparison result, the corresponding command will be send to the robot by a wireless connection called ZigBee. This transmitted command is received by the robot, which will decode the command and will move according to the command. Thus, by using this system, a particular machine can be controlled by the user without anybody's help.

Index Terms— Hand gesture, Image processing, Interrupt, Microcontroller, Motor Polarity, Pixel, ZigBee

1 Introduction

Robotic technology began in the 19th century onwards . In this modern world, technology has played a vital role to humans by providing faster productivity in work results regardless of the harmful work situation or complex environment. From health field to industrial sector, robots have been creating work into a simple means. Even though technology is growing, it cannot do any work without command from its master, that is, we humans. Machines are actually controlled devices either by some means of remotes or switches. Apart from using such external devices for controlling robot, the best and natural way to communicate with them is by using simple gestures.

1.1 Existing Systems

Hand gesture based systems had been existing since early times. Even though all of the systems had the same goal of moving the robot, difference was in the different technologies used for hand gesture recognition. One of the approaches used in [1] refers to the use of an accelerometer for the hand gesture recognition.

Accelerometer is a device used for sensing the acceleration. The paper proposed the use of MEMS accelerometer. MEMS refer to Micro Electro Mechanical Systems which means sensors, actuators and other devices confined onto a single silicon substrate. The problem associated with this technique is the special training required for the user on the use of this system, as accelerometer is a sensitive device. Another technique which was specified in [2] suggests the use of three shape-based features: segmentation, feature calculation and classification. Segmentation refers to the process of converting an image to black and white image. In feature calculation different features of the hand are used in combination. From this the compactness and the radial distance is calculated. The problem with this technique is that it can only be applied to stationary than varying objects.

Another method specified in [3] recognizes the hand gesture by using a multi camera. But the use of multi camera causes the variation in the centre of gravity of the hand which leads to instability in hand gesture recognition. Another method was proposed by Davis and Shah in [4] wherein markers are placed on finger tips. The inconvenience of placing markers on the user's hand makes this an infeasible approach.

Curvature Scale Space [5] hand gesture recognition technique involves finding the boundary contours of the hand. Even though it's a robust technique it is computationally more difficult.

1.2 Proposed System

The system proposed in this paper uses image processing technique for hand gesture recognition. This image processing technique happens in 3 steps. They are: Capture, comparison and signaling. Usually the capturing process can be done by the webcam of the system. The image thus captured is then converted to black and white image and is then compared with the background image to extract the hand gesture alone.

Based on the hand gesture the direction specified by the hand gesture is analyzed and is send via ZigBee module to the Robot which then moves in the specified direction. The robot movement is actually controlled by the polarity of the motor which varies as per the signal send by the ZigBee module. The block diagram in Fig 1 describes the overall working of the system using image processing.

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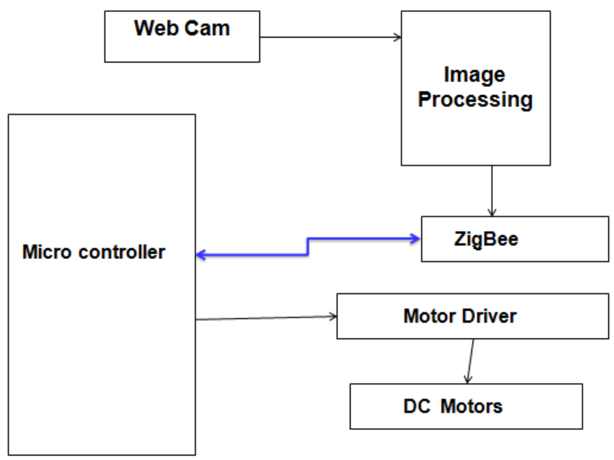

Fig 1: Block Diagram of System

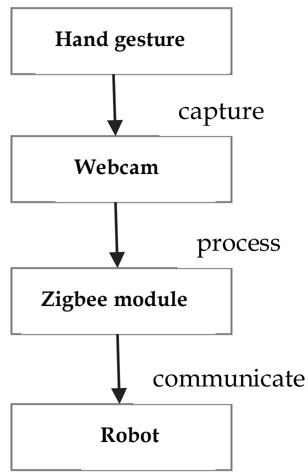

Fig 2: Flow Diagram of the system

2 Generic System

Hand gesture controlled robot is a system consisting primarily a laptop and a robot. The movements of the robot are controlled by the gestures shown by the hand. Thus, the different hand gestures shown by the user acts as the input to the system. The output of the system is the different movements of the robot in the specified direction. In order to enable the communication between the robot and the laptop the system uses a Zigbee module.

A Zigbee module usually consists of a transmitter and a receiver. Zigbee transmitter is usually connected to the laptop and the Zigbee receiver is usually connected to the robot. In order to connect the Zigbee transmitter with the laptop, the system uses a USB to UART bridge connector. The Zigbee receiver is powered by the battery which is used to power the robot.

The generic view of the system can be well explained by the flow diagram in Fig 2. The three main processes that occur here is the capture, process and communicate. In capture, the hand gesture shown by the user is captured by the webcam of the laptop. The hand gesture is then processed to communicate with the robot so as the robot moves in the specified direction.

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3 Technologies Used

The proposed system primarily focuses on hand gesture recognition. This signal is generated from the software station and sent to the robot through ZigBee, which communicates within the range of 50 m. The robot moves in the specified direction according to the gesture direction provided. The steps in the design are as:

3.1 Hand Gesture Comparison

In order to detect the hand palm, at first the image of the plain background is taken and then the image of the palm is taken. This image is converted into black and white image.

In the next step, an image of the palm after dynamic movement is taken and a black and white image of this frame is created. By black and white image, it means that the difference of the image is compared to that of background and accordingly the difference is set to black and white image for easier processing. From this image, movement of the palm to any direction can be found out.

The end result of gesture recognition system is to generate a command based on the dynamic movement of the palm and that is given to the robot. There are mainly four possible gesture commands that can be given to the robot (Forward, Backward, Right and Left). These gesture commands are given by the user based on the direction of the hand palm.

3.2 Signal Generator

Gesture command generated at software is written using Java. A particular value is written into the file for given command. To make robot move in forward, backward, right, left and stop direction simple values are written as f, b, r, l and s respectively. For example, Forward command is represented as f.

As soon as there is a change in gesture command, file is updated. Similarly for the next command to turn right, it is represented as r and so on.

3.3 ZigBee Communication

Its connected in the HTTP port 80 in the software system. As soon as the command is generated it is send to the ZigBee (XBee) transmitter set in the software component. This transmits digital signal to ZigBee receiver that is present in the robot. Thus a single way transmission occurs in the system.

3.4 Micro-Controller: PIC16F877A

ZigBee is connected to PIC16F877A , which provides the desired direction command to which the robot is to be moved . Each time a command signal reaches the micro controller; all the commands are considered as interrupts that are to be serviced. According to the commands, the micro controller will set polarity values to the motors. These values are send to L293D as four input signals.

3.5 Motor Driver: L293D

This takes in the input signals provided by the micro controller and provides these to the DC motors. L293D is used for driving the motors of the robot .Without these, movement of the robot will be null as more voltage is required for the robot to move efficiently which is thus provided by L293D.

3.6 DC Motor

This is the area where the motion of the robot occurs. The L293D Driver supplies power to the motor that executes the action of the robot. This movement is handled by the user who provides the gestures through image processing.

4 Implementation

The proposed system runs in a specific function to give the appropriate results. Each image that is captured by the camera or webcam of the system is converted to corresponding supporting image files. These are then used for the determination of the direction of the robot.

4.1 Gesture Images

The software captures first the background image as soon as the camera or webcam is on. At the next stage, the image that consists of the hand is captured and is converted to its compactable image file. This image file is then compared with the background image that was captured initially. From comparing the difference from the hand image as well as background image , a black and white image of the hand is set ,that is , by setting each pixel value as 0(black) or 255(white).

4.2 Gesture Detection

From the hand image that is black and white, horizontal scanning is processing from the top of the image frame till a pixel spot of value less and approximately to black is found. At the detection of this spot, the validation of this spot is required. Validation begins to check horizontally from the spot 30 pixels and 20 pixels below the spot .By this spot, corresponding gesture commands are sent to the robot movement to be executed.

The spot value that is value (0) and value(1) determine the direction of the robot. The value(1) is used to provide left and right direction. When the value(1) is greater than three-fourth of the width of the image than move right , and if value(1) is almost lesser than one-fourth of the width of the image then move left. When the value(0) is greater compared to the height value then move forward else move backward. If the value(0) and value(1) has no change and is the same then the direction is to stop.

4.3 Signal Transmission

Thus , by analyzing the image, the direction to which the robot is to move, is determined. Now for each of the direction identified a corresponding character is send. The following are the characters used for transmission.

- ‘f’ -Robot should move in the forward direction
- ‘b’ -Robot should move in the backward direction.
- ‘r’ –Robot should move right
- ‘l’ -Robot should move left
- ‘s’ -Robot should stop

The next step is to send the character to the microcontroller so that the robot can move. Here Zigbee technology is used for communication.

The three main steps in establishing the communication are:

- Initialization
- Connection establishment
- Termination.

In the first step , all the available ports in the laptop are identified. From this the one which is compatible for serial communication is then selected. The second step checks whether the port is open for use or is it being used by another application. If the port is available for use then connection is established. The characters are the converted into byte array, and is then written to the port , which will then be transmitted by the Zigbee transmitter. The Zigbee receiver connected to the robot will then receive the character and further processing continues.

4.4 Robot Movement

The received commands from the ZigBee receiver is then send to the PIC16F877A microcontroller as digital signals. These signals or commands are processed as interrupt signals in the microcontroller . By the interrupt signals , the polarity of the motor is set accordingly as follows :

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SIGNAL	POLARITY	
	MOTOR 1	MOTOR 2
'f'	(0,1)	(0,1)
'b'	(1,0)	(1,0)
'r'	(0,1)	(1,0)
'l'	(1,0)	(0,1)
's'	(0,0)	(0,0)

Table 1 :Motor Polarity of Robot

The microcontrollers is attached to the L293D Motor driver that drives the DC Motors . The output of the microcontroller are provided as input to the Driver that provides 12V which helps to run the motors of the robot .

5 Experimental Results

By using the above mentioned components the hardware was setup, thus resulting in the formation of a robot. In order to implement the experiment a Dell laptop was used, whose web camera acted as the input device for capturing the video. The software part was developed in Java for image processing wherein the hand gestures were analyzed to extract the actual direction. Eclipse Ide was used for developing the java code.

The direction thus identified was send as characters to the robot with the help of Zigbee. XBee S2 version of Zigbee was used for enabling the communication. The final movement of the robot can be concluded as follows:

- At the beginning the robot was in a stop mode.
- As the hand moved from bottom to top, the robot moved in the forward direction.
- As the hand moved from top to bottom, the robot moved in the backward direction.
- As the hand was shown as an acute angle towards the left, the robot moved towards the left direction.
- As the hand was shown as an acute angle towards the right, the robot moved towards the right direction.
- As the hand is kept stationary with respect to the environment, the robot was in the stop mode.

From the experiment, about 80% of the implementation worked according; the remaining was less due to background interference which is a negative marking to the implementation.

6 Conclusion

Hand Gesture Controlled Robot System gives a more natural way of controlling devices. The command for the robot to navigate in specific direction in the environment is based on technique of hand gestures provided by the user.

Without using any external hardware support for gesture input unlike specified existing system, user can control a robot from his software station.

7 Future Scope

The proposed system is applicable in hazardous environment where a camera can be attached to the robot and can be viewed by the user who is in his station. This system can also be employed in medical field where miniature robot are created that can help doctors for efficient surgery operations

For more efficient response, threshold values can be used to detect gesture and advanced features such as finger counts that provide different functional commands can be used.

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