Arduino Based Hand Gesture Controlled Robot

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Abstract - *As robot capabilities become more complex, some, but not all, human tasks are supplanted by robots. Robots, on the other hand, rely on human programming and will continue to do so in the future.*

This paper explains how to simplify the difficult and complex techniques of operating robotic devices in a variety of applications. It's quite tough to use a remote or switches to control a robot or a specific machine. This advanced technology can recognize our hand motions or gestures and respond to our commands. A camera collects your hand gestures, and processing of image algorithms will be used to compare the previous and present hand motions. Based on the comparison result, the robot will get the appropriate command over a ZigBee wireless connection. This technology can thus be used to operate a specific machine.

***Key Words**: Hand gesture, Image processing, Interrupt, Microcontroller, Motor Polarity, Arduino, Hand Gestures, Robot, transmission, Sensors.*

1. INTRODUCTION

Technology has assisted humans in today's culture by enhancing workplace efficiency, regardless of hazardous working circumstances or a complex environment. Robots have simplified work to a simple process in a variety of fields, from medicine to industry [1]. Even as technology progresses, it will never be able to complete any job without the supervision of its master, i.e., humans. Apart from using external devices to control robots, simple gestures are the most natural and effective way to communicate with them.

2. Literature Review

2.1 Gesture Controlled Robot using Android & Arduino [2]

The Gesture controlled robot constructed in this task has many future scopes. The robot can be used for supervision objectives. The robot can connect to a wheelchair which can be run by the actions of the rider's hand.

Wi-Fi can be used for transmission instead of Bluetooth to allow it to a tremendous degree. Edge sensors can be integrated into it to prohibit the robot from declining from any ground. Some cameras can be placed which can document and deliver information to the close computer cell phone. It can be executed on a watch or in any home appliances a likewise Air conditioner. Modern ARDUINO chips help Intranet and Internet rapport which can be employed to an enormous degree. This robotic car can be enriched to function in the military surveillance where it can be transmitted to enemy headquarters and trace its actions via the Internet. With a sense full of inventiveness, the chances are vast.

In this paper, the aim and execution of Gesture Controlled Robot are illustrated and formulated using an Arduino microcontroller and Android Smartphone. An algorithm has been given and its work is accurate fully. Since the revising chances are huge, revamping the system has been kept as a future scope. The assembled tool is reasonable and is simple to hold from one place to another. The improvement of some extra sensors or cameras will provoke it more efficient. The restriction of the hardware being related to a system has been reduced to a great degree. As a future idea, the system will permit the user to regulate it in a way that decreases the extent between the real world and the digital world with an outcome more automatic.

2.2 Hand gesture robot using radar sensors for human-computer interaction [3]

A vast expansion and instantaneous improvement of radar based HGR was noticed in the former decade. This paper surveyed some of the studies associated with HGR petitions using radars. Currently, the experimenters depend on the economically accessible radars prepared by tech companies such as Infenion, Novelda and Texas Instrument. With these systems living on chips, much scrutiny has been spent on formulating the motion detection and acclaim algorithms. In the contemporary era, attention is changing from signal-processing-based HGR algorithms to deep-learning-based algorithms. Especially, variants of CNN have indicated assuring relevancy. Although radar sensors show numerous reasons over the other HGR detectors (i.e., wearable sensors and cameras), the adoption of radar based HGR in our everyday inhabits is still delayed behind these rivalling technologies. Awareness must be expended to imitating hardware improvement and real-time distinction algorithms' improvement.

2.3 Hand gesture recognition based on computer vision [4]

It is realistic to observe the research division since most research surveys focus on computer applications, indication language and interchange with a 3D object through an actual domain. Still, many study articles trade with improving frames for hand gesture recognition or formulating modern algorithms rather than enforcing a logical application with concern to fitness supervision. The enormous challenge experienced by the experimenter is in formulating a powerful structure that survives the most established problems with limited constraints and provides a valid and credible outcome. Greatly recommended hand gesture systems can be distributed into two sectors of computer vision methods. First, an easy method is to use image processing techniques via Open-NI library or OpenCV library and perhaps extra tools to provide interaction in real-time, which evaluates time consumption because of real-time processing. This has some constraints, such as setting issues, description difference, length threshold and multi-object or multi-gesture crises. A next technique uses dataset motions to approximate against the input gesture, where extensively more problematic habits

require a complicated algorithm. Deep learning techniques and artificial intelligence techniques to approximate the exchange gesture in real-time with dataset gestures including distinct attitudes or motions.

Although this strategy can specify a big amount of indications, it has some difficulties in some trials, such as losing some indications because of the class algorithms exactness discrepancy. In addition, it brings extra moment than first method because of the matching dataset in trial of using a big number of the dataset. In addition, the dataset of motions cannot be used by other shelves.

Hand gesture recognition deals with a fault in interaction systems. Regulating elements by hand is more natural, simpler, more creative and reasonable, and there is no necessity to rectify difficulties affected by hardware devices since none is employed. From prior categories, it was apparent to a desire to settle ampleaction into expanding durable and powerful algorithms with the benefit of utilizing a camera sensor has a certain aspect to confront social issues and obtain a credible result. Each procedure spoken of over, still, has its benefits and drawbacks and may attain well in some challenges while living secondary in others.

2.4 Hand Gesture Controlled Robot [5]

Hand Gesture Controlled Robot System lends a more realistic way of governing appliances. The government for the robot to drive in a certain path in the atmosphere is founded on the procedure of hand indications delivered by the user.

Devoid of utilizing any superficial hardware assistance for motion intake unlike the stipulated prevailing network, the user can govern a robot from his software station. The formulated system is favorable in a difficult climate where a camera can be connected to the robot and can be glimpsed by the user who is in his location. This system can also be assigned in the medical area where imitation robots are built that can help physicians with efficient surgery undertakings. For extra productive reaction, limit significances can be used to observe indications and progressive characteristics such as finger measures that empower several functional powers can be borrowed.

3. Proposed System

There are three steps to this image processing technique Capture, comparison, and signaling. Typically, the capturing operation is carried out through the system's webcam.

The hand gesture is processed, and the hand gesture's direction is relayed to the Robot via the ZigBee module, which subsequently goes in the indicated direction.

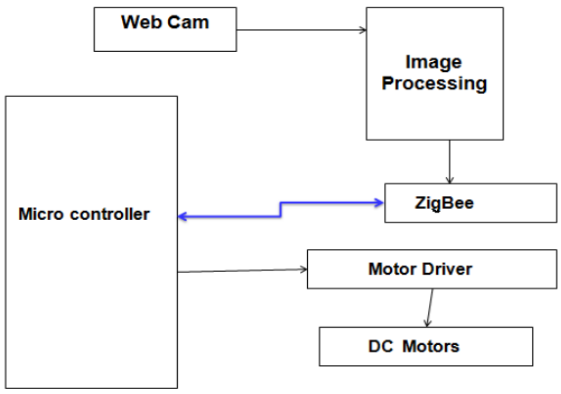

Fig.3.1 Block diagram

4. Technologies Used

The software station generates this signal, which is sent to the robot using ZigBee, a wireless technology with a 50-meter range.

4.1 Comparison of Hand Gesture

An image of the plain background is taken initially, followed by an image of the palm to detect the palm of the hand. A black and white image has been created.

Following dynamic movement, the palm is photographed, and a black and white image of this frame is created in the next stage [10].

4.2 Signal Generator

Java language is being used to create action commands for the system. To have the robot move forward, right, backward, stop, and left, simple values are expressed as f, r, b, s, and l, respectively [11]. The letter f, for example, represents the Forward command. The following sequence, which is to turn right, is denoted by the letter r, and so on.

4.3 Communication using ZigBee

As soon as the command is formed, it is delivered to the ZigBee (XBee) transmitter configured in the software component [9]. This transmits a digital signal to the robot's ZigBee receiver.

4.4 Accelerometer (ADXL335)

The ADXL335 is a low-power, three-axis accelerometer that is thin and compact. It is useful for measuring acceleration because it can count 3g of full scale. In tilt sensing applications, it can measure both the static acceleration of gravity and the dynamic acceleration caused by motion, shock, or vibration [12].

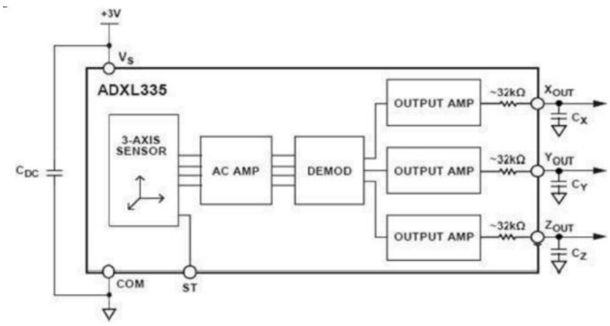

Fig. 4.1: ADXL335

4.5 Arduino UNO

The Arduino Uno is an open-source microcontroller that uses the AtMega328 AVR microprocessor (Fig.4), a detachable and dual inline microcontroller that provides flexibility, compactness, and versatility [13]. It can be interfaced with any type of electronic type to construct embedded systems and IoT projects. It's a less priced module that's easy to use for beginners.

Fig. 4.2: Arduino UNO

4.6 Comparator IC

The comparator IC that is being used is LM324 which compares the accelerometer's analogue voltage to a reference value before outputting a specific high or low voltage. The signal received is noisy, with a wide range of voltage levels. This IC compares the voltage levels and produces either a 1 or a 0-voltage level. This method is known as signal conditioning. The comparator integrated circuit is shown in the diagram below [15]. 1, 7, 8, and 14 are the output pins. When the LM324 IC's input is high.

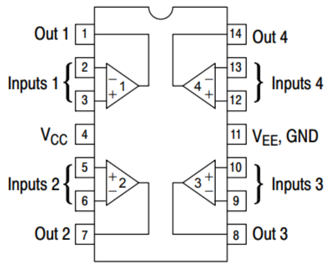

Fig. 4.3: LM324

4.7 Encoder IC (HT12E)

The HT12E controls remote applications. It will connect to RF transmitter modules in order to create secure single-channel or multi-channel RF remote control transmitters [16]. Each address/data input can be set to one of two logic states.

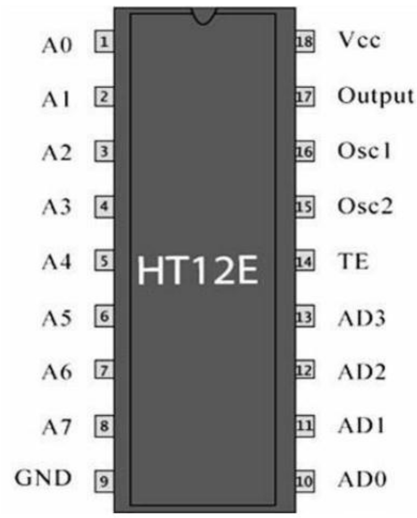

Fig. 4.4: HT12E

4.8 RF Module

Radio frequency is an oscillation rate that corresponds to the currents that carry radio communications and is measured in the range of 3 KHz to 300 GHz [18]. Even though radio frequency is a rate of oscillation, the term "radio frequency" or its abbreviation "RF" referring to the use of wireless communication rather than cable transmission. The RF module has a range of 50-80 meters and works at 315 MHz Receiver for radio frequency signals:

Fig.4.5: RF Transmitter

Fig.4.6: RF Receiver

5. IMPLEMENTATION

Each image acquired is converted into a supporting image file with the help of camera.

5.1 Imaging of Gesture

The software takes the backdrop image first when the camera or webcam is turned on. This image file is then compared to the backdrop image that was originally gathered. By comparing the differences between the hand picture and the backdrop image, that is, by assigning each pixel value to 0 (black) or 255 (white).

5.2Detecting Gesture

Horizontal scanning is performed on the obtained picture from the top of the image frame until a pixel spot with a value less than or equal to black is identified. Validation starts checking horizontally 30 pixels below the spot and 20 pixels below the spot.

The spot value, which is value (0) and value (1), determines the robot's direction (1). Value provides left and right directions (1). If value (1) is more than three-quarters of the image's width, move right; if value(1) is less than one-fourth of the image's width, move left. Move forward if value (0) is more than the height value; otherwise, go backward. If the value (0) and value (1) do not change and are the same, the direction is to stop.

5.3 Signal Simulation

For each of the indicated directions, a corresponding character is now sent. List of the characters used for transmission is depicted bellow:

- 'f' - The robot is progressing.
- 'b' - robot is moving backwards.
- 'r' - the robot is going towards right.
- 'l' - robot should go to the left.
- 's' - The robot should stop.

After then, the character will be transferred to the microcontroller, which will allow the robot to move. Zigbee technology is used for communication.

The three main steps in communication are:

- Initializing - initialization of the data takes place.
- Connection establishment – connections are then established
- Termination- transmission of signal takes place.

5.4 Movement of Robot

The PIC16F877A microcontroller receives the digital signals. According to the interrupt signals, the polarity of the motor is set as follows:

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)

The microcontroller's output is sent into a driver that generates 12V to power the robot's motors.

5.5 Experimental Result

Using the components, the hardware was assembled, culminating in the creation of a robot. The experiment was carried out using a Dell laptop, with the web camera functioning as the video capture input device. The hand motions were analyzed to establish the true orientation, and the picture processing software was created in Java.

With the use of Zigbee, the robot was sent the identified direction as characters. The robot's final movements are:

- Initially, the robot is stop.

- As the hand went to top, the robot moved forward.
- And it moved backward as the hand moved to the bottom.
- The robot moved in the direction of the hand, which was shown as an acute angle to the left on the screen.
- The robot moved in the direction of the hand, which was shown as an acute angle to the right on the screen.
- Because the hand was held motionless in reference to the environment, the robot was in stop mode.

6. Conclusion

Users may control products more naturally with the Hand Gesture Controlled Robot System. Unlike mentioned previous methods, the user can control a robot from his software station without requiring any external hardware support for gesture input. The direction-based technique directly indicates the robot's movement direction, whereas each finger count specifies an instruction for the robot to go in a specific direction in the environment.

The design and execution of a Gesture Controlled Robot is demonstrated and developed using an Arduino microcontroller and an Android smartphone. The system has been placed aside for the future because there are so many ways to update it. [19] The constructed equipment is low-cost and easy to move from one area to another. If some extra sensors or a camera are added, it will be more productive. Finally, the system will allow the user to control it in a way that bridges the gap between the physical and digital worlds while providing a more intuitive output.

7. Future Scope

The proposed method can be employed in a dangerous circumstance where the robot is equipped with a camera that the user at his station can monitor. This technology can also be applied in the medical field, where miniature robots are being developed to help doctors execute more efficient surgeries.

Advanced features such as finger counts can be used to send distinct functional instructions for a more efficient response. Threshold values can be used to identify gestures, and advanced features such as finger counts can be used to deliver different functional commands for a more efficient response.

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