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Human Following Robot Based on Motion Sensing Technology

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Abstract

In the current technological age, robots that follow humans are widespread. We can implement the technique of 'human following' in robots to follow a person inside a particular area. Human-robot communication is an integral component in this scenario. The human follower robot can assist us in both residential and industrial settings. Robots already exist to perform tasks at ease to assist humans has become a commendable and important development in the world of technology. Using an Arduino board along with an ultrasonic sensor and infrared sensors, the robot will detect motion and follow the person in motion.

Keywords: *Human following robot, motion sensing, Arduino, ultrasonic sensor, infrared sensor, L293D*

1.0 Introduction

The development of robotics is significant for humans in this high-tech era. Robots are quite useful since a more intelligent robot can work alongside a human to support the human [1]. A robot must be able to recognize and follow a human to help with their task. A human following robot can locate and follow people. To help or assist, a robot that follows humans needs to engage with them. This beneficial endeavour aims to follow the appropriate person or obstruction. In this robot, infrared sensors are utilized for both forward and reverse movement, and ultrasonic sensors are employed for detecting the motion of the human body in front of the robot. The robot can detect motion only when the human is in front of it and is at a particular distance from it. There are now more uses for robots as they get more sophisticated and well-developed.

The main objective of this project is to design a fully functioning Human Following Robot. The robot will follow any object with a motion that is within 30cm using infrared and ultrasonic sensors. It will be functioning through an Arduino Uno R3 microcontroller. The robot will be based on motion detection and proximity sensing.

The human following robot has many applications in today's world and can be used in industrial, medical, household, and military applications.

1. Materials handling: In industries, it can be used to carry heavy materials which will not be possible for humans to do on their own without the help of a robot.
2. Hospitals: In the medical industry the robot will be able to carry sterilized instruments throughout the hospitals and operation theatres.
3. Military application: To carry heavy military loads.
4. Restaurants: For no-contact food service.
5. Help disabled and aged people.

2.0 Literature Review

For the success of my prototype, I have reviewed two papers and have gone through them to get a better idea of a Human Following Robot and its working.

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1. W. W. Tai, B. Ilias, S.A. Abdul Shukor, N. Abdul Rahim, MA Markom, "A Study of Ultrasonic Sensor Capability in Human Following Robot System."
   From this published paper, I have received various knowledge on the different approaches and aspects of understanding the working of the human following robot. The paper also points out that the different robots available have similar objectives but have a few disadvantageous for which human following robots can be a better approach. For example, there is a robot that has several benefits for people because it may be utilized in both civil and industrial applications[1]. The robot, however, is unable to track and find an object on its own. Therefore, the robot needs a mechanism that can make decisions so that it can act appropriately and complete the task. The paper discusses that a sensor that can identify objects or impediments around the robot itself is the key mechanism. Numerous sensors, including laser, radio frequency, cameras, and others, can be used to enable the mobile robot to follow a person at a consistent distance. An ultrasonic sensor is utilized in this project published in this paper. To measure distance in real-time, the sound wave is sent out at a certain frequency and then returned. It has flaws, and because the sensor operates on a specular basis rather than an 8-restricted range scanning angle, it may be difficult for it to identify an object. Thus, to monitor an object, precision and accuracy work must be done.
2. Human Follower Robot: Priyanka P. Vetal, Dr. Mukta Dhopeshwarkar, Pratik S Jaiswal, Department of Computer Science and I.T, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (M.S)

In this study, a human-tracking robot powered by an Arduino board was developed. When a person or a person moving their legs is being tracked, the robot will move in lockstep with them, following them forward, left, and right. Robots can locate people by using ultrasonic sensors, which can also access and determine the distance between people and the robot. In their concept, a servo motor – a direct actuator that enables precise control of angular or linear position – is installed on an ultrasonic sensor[2].

3.0 Methodology

The robot prototype is based on the working of the sensors that are connected to the Arduino board. It has four battery-operated gear motors for it to move along with the object in motion. The main functionality of the robot is based on the work of the sensors. The ultrasonic sensor senses the object with motion i.e., a human in motion, within the given distance of 30 cm, which has been coded into the Arduino program. The ultrasonic sensor plays the main role to send the signal

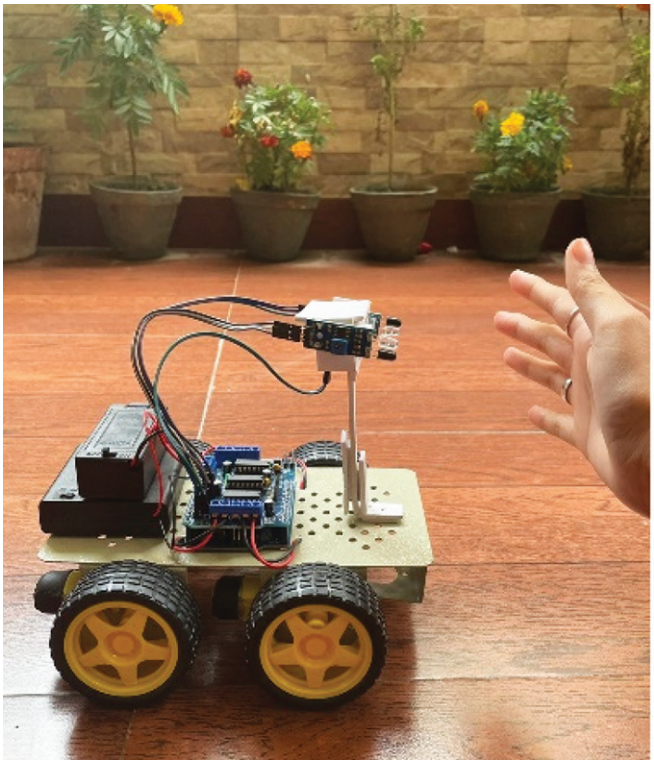

Figure 1: Motion Sensing through Sensors

to the robot to move or stop at a given distance from the person in front. The work of the infrared sensors is to detect the radiated heat from the human body which will allow it to detect in which direction the person is moving in.

The purpose of the project was to have a robot that will follow any object having motion and be able to understand the motion of the person it is following. The testing and learning period of the robot was the most crucial for me to understand the faults and how to resolve them and bring changes to the hardware as well as the software part of the project.

4.0 Components of the Robot

The main components used in this robot prototype are the Arduino UNO R3 microcontroller, L293D Motor Shield, an ultrasonic sensor, and two infrared sensors, and the robot is powered by a 15V DC battery.

1. Arduino UNO R3: The ATmega328P serves as the basis for the Arduino UNO microcontroller board. The sensors function according to the code programmed onto the Arduino board using the Arduino IDE.
2. L293D motor shield: It features four bi-directional DC motors that can rotate at speeds ranging from 0 to 255 revolutions per minute. Normally, an 8-bit microcontroller

would only permit arithmetic operations that produce integers between 0 and 255 (or from -127 to 128). The shield is perfect for creating four-wheel robot platforms since it has two L293D motor driver chipsets, each of which can drive up to four DC motors. Typically, an Arduino or other microcontroller cannot drive these motors directly. Motor shields or driver ICs are utilized in their place due to their higher current and power ratings.

3. Battery-operated gear motors: A geared motor is a component whose mechanism adjusts the speed of the motor, leading them to operate at a certain speed.
4. Ultrasonic sensor: An ultrasonic sensor is a piece of technology that measures the distance to a target item using ultrasonic sound waves and then converts the sound's reflection into an electrical signal.
5. Infrared sensors: An electrical device that monitors and detects infrared radiation in its environment is called an infrared (IR) sensor. Infrared radiation is produced by everything that emits heat (everything with a temperature higher than about five degrees Kelvin).

5.0 Robot Circuit and Working

Two five-pin screw terminals are located at the margins of the L293D motor shield in Fig.2 to connect the DC motors. The labels for these terminals are M1, M2, M3, and M4. The DC motors need a current of between 40 and 180 mA and have an operating voltage rating of between 3 to 12V when attached to the appropriate terminals. For this robot, there is an external power supply from one source of 15V. With the simple formula of power, we can find the power consumed by the gear motors:

$P = VI$

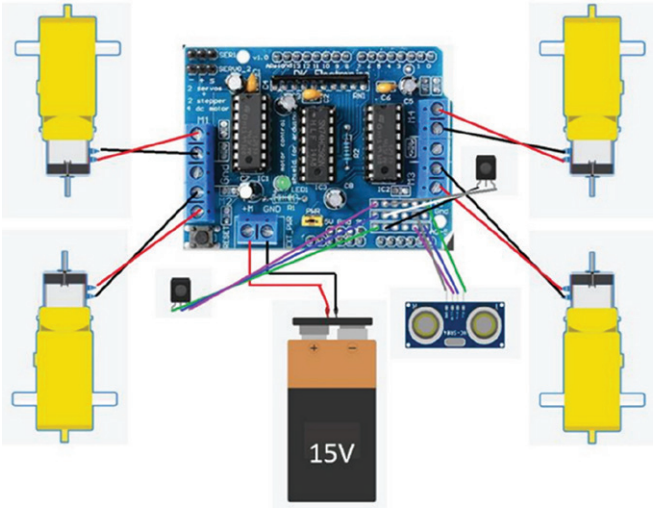

Figure 2: Robot Circuit

The DC motors need to be connected to the following pins:

- The motor port M1 is connected to Pin 11
- The motor port M2 is connected to Pin 3
- The motor port M3 is connected to Pin 5
- The motor port M4 is connected to Pin 6
- Pins 4, 7, 8, and 12 can be used as alternatives

In such cases, six analog pins including pins 2 and 13 remain free for use. The DC motors can be controlled using thee L93D motor shield driver and the AFMotor Library in Arduino IDE needs to be installed in order for the code to run. The IR and ultrasonic sensors are connected to the analog pins. Connections of the sensors on the motors shield:

- Left IR sensor is connected to A0
- Right IR sensor is connected to A1
- The echo pin of the ultrasonic sensor is connected to A4
- Trigger pin of the ultrasonic sensor is connected to A5

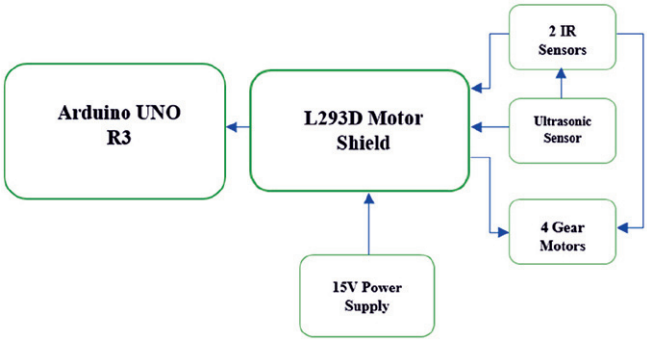

Figure 3: Robot Working Block Diagram

The ultrasonic sensor, infrared sensors, gear motors, and battery are connected to the L293D motor shield which is fixed to the Arduino Uno R3 board. In Fig.4, the ultrasonic sensor tries to detect any object within 30cm of the robot. The IR sensor will detect if the object is moving forward, right, or left. When both IR sensors will detect an object in front of it,

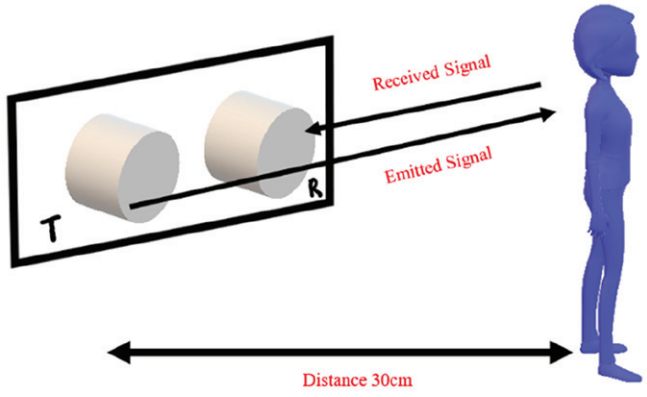

Figure 4: Working of Ultrasonic Sensor

it will move forward and all the gear motors will move at the same speed. If the right IR sensor only detects the object, it will start moving right. The gear motors will have different speed directions allotted to them. It will be vice versa for the left IR sensor. If there is no object detected with motion or if the object is out of range the robot will stop.

The ultrasonic sensor in Fig.4 works when: if (distance > 1) && (distance < 30), the ultrasonic sensor will check whether the value stays between 1 to 30.

The line graph in Fig.5 depicts the distance of the object from the ultrasonic sensor of the robot prototype at every second, taking the maximum distance it can detect up to is 30cm. The graph has been plotted after going through the outputs produced by the robot for fourteen seconds on the serial moniter of the Arduino IDE.

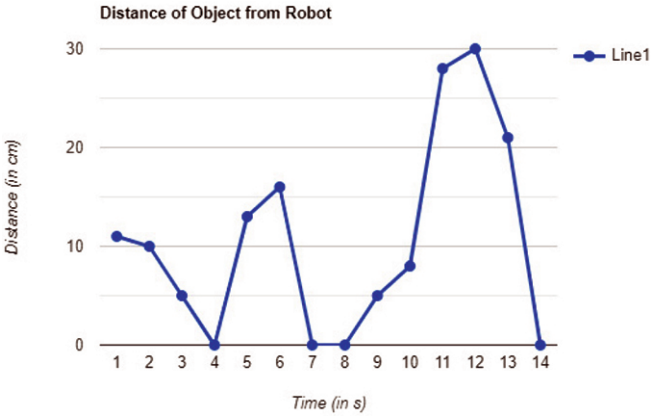

Figure 5: Distance of object detected by the Ultrasonic Sensor

Working of the IR sensors:

1. Left IR= = 1 && Right IR = = 1, then the robot will move forward.
2. Left IR = = 1 && Right IR = = 0, then the robot will move towards left.
3. Left IR = = 0 && Right IR = =1, then the robot will move towards right.
4. Left IR = = 0 && Right IR = = 0, then the robot will stop.

The IR sensors will only let the gear motors rotate in the specified direction depending on the direction the robot needs to move and the rpm of each motor will be set depending on the movement of the moving body.

The moving body needs to be within 30cm of the ultrasonic sensor to detect movement, which will send signals to the IR sensor to check the direction of movement, and then the gear motors will allow the robot to go in the desired direction.

In Fig.6, the output being monitored through the serial monitor for a random timestamp is being shown. It reflects the distance of the object from the robot and the IR sensor which senses the direction of the movement of the body.

```
12:06:50.375 -> distance20
12:06:50.375 -> RIGHT1
12:06:50.375 -> LEFT1
12:06:50.422 -> distance27
12:06:50.422 -> RIGHT1
12:06:50.468 -> LEFT1
12:06:50.468 -> distance20
12:06:50.468 -> RIGHT1
12:06:50.468 -> LEFT1
12:06:50.516 -> distance20
12:06:50.563 -> RIGHT1
12:06:50.563 -> LEFT1
12:06:50.611 -> distance20
12:06:50.611 -> RIGHT1
12:06:50.611 -> LEFT1
12:06:50.657 -> distance27
12:06:50.657 -> RIGHT1
12:06:50.657 -> LEFT1
```

Figure 6: Serial Monitor Output

6.0 Cost and Market Analysis

In Fig.7, the total cost of the prototype came to around INR 4375 or USD 53.06 inclusive of the overheads. The cost of each component may differ depending on which market it has been purchased from. The purchase of components for this prototype has been done in Indian Rupees. The cost of these components may differ in other countries.

With the growing market of robotic-based technology, there will be a huge advantage if this robot is placed into

Component	Component Price (in INR)	Component Price (in USD)
Arduino UNO R3	Rs 862	$ 10.45
L293D Motor Shield Driver	Rs 268	$ 3.25
Ultrasonic Sensor (Qty=2)	Rs 91	$ 1.10
IR Sensors (Qty=5)	Rs 299	$ 3.63
Jumper Wires	Rs 236	$ 2.86
DC BO Motors	Rs 399	$ 4.84
Chassis	Rs 240	$ 2.91
Battery 4xAA DC	Rs 160	$ 1.94
Battery 9V DC (Qty=2)	Rs 456	$ 5.53
Battery Holder 4xAA	Rs 275	$ 3.34
Battery Holder 9V	Rs 89	$ 1.08
Overhead	Rs 1000	$ 12.13
Total Cost=	**Rs 4375**	**$ 53.06**

Figure 7: Cost Analysis of the Prototype

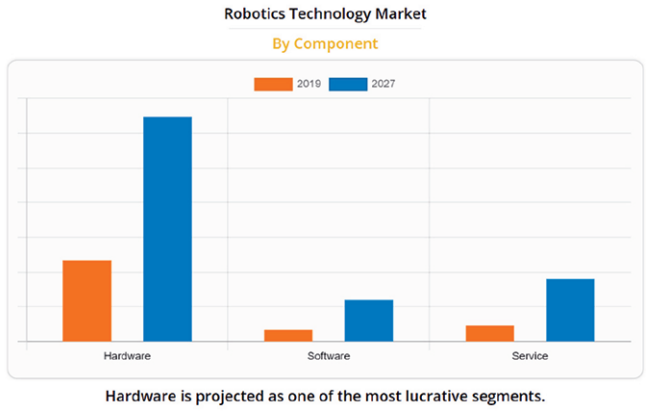

Figure 8: Robotics Technology market[3]

production along with its various applications in today's world. According to projections, the global market for domestic robots will increase from $9.2 billion to $19.3 billion by 2027[7] and the market for military robots would produce $25.70 billion in sales by 2028[6]. The human following robot having its need in both household as well as military purposes will be profitable. There are also increasing government initiatives for the development of robotic technologies. There will be growth in the market in hardware, software, and service industries in the robotics technology market.

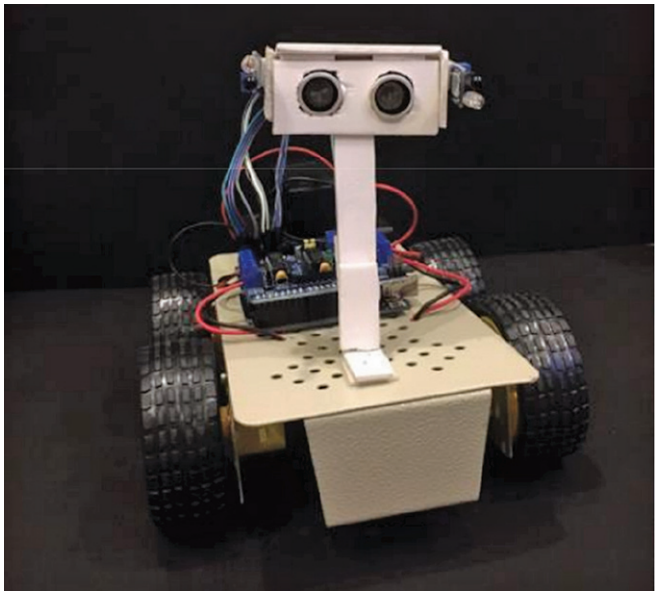

Figure 9: The Human Following Robot

7.0. Conclusion

The Human Following Robot can be an asset to today's Robotics Technology Market and there are various applications of it which can not only help presently but also in the future. After the COVID -19 pandemic, these robots can be used for non-contact services in malls, hospitals, museums, restaurants, and other public places. It will increase efficiency in industrial environments and heavy industries. The workload of human workers can be reduced drastically. The outcome has been successful. The designed robot functions accurately and properly. The prototype can detect the motion of moving bodies at the coded distance and sense the direction it needs to move in.

Practically and theoretically the robot can be easily understood and can be implemented with very easily available parts. It can be produced in various shapes and sizes, keeping the same mechanism behind it.

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