



Real Time Hand Gesture Based Robot

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Abstract

In this paper a prototype model of real time hand gesture based robot is proposed and is named “RoboCar” which is virtually controlled by hand movement. The main aim of designing RoboCar is to provide options for running car without any physically contact for controlling its functions. The design proposed here is about making a robot car that can be controlled by hand gestures using an arduino. When you move your hand, sensors detect the movement and send signals to the robot car through Bluetooth. The robot car then moves according to your hand gestures. It also has an ultrasonic sensor to avoid obstacles in its path. The system uses a flex sensor and an accelerometer to track hand movements. The Arduino reads these signals and controls the car’s motors. This robot car can be helpful in areas like security, searching unknown places, and during rescue operations. Designing and testing of proposed model of RoboCar is demonstrated in detail and it is ready to use as a product for humankind.

Keywords: Accelerometer, Arduino Uno, Bluetooth, Flex sensor, Microcontrollers etc.

1. Introduction

Robots or self-controlled devices help human life in many areas like industries, healthcare, and entertainment due to its ability of errorless and speedy work. When safety point is considered then robots play a vital role and it plays a wide role in manufacturing and assembly industry, healthcare and medicine field, agriculture, and also finds its wide applications in military and defense. Controlling a device especially robotic equipments are new era of technology and it has transformed the way of human interactions with the devices and controlling of the devices. Convenience, mobility, faster response, accessibility, efficiency, productivity and support for smart technologies make wirelessly controlled robots a boon to humankind. Robots can recognize hand gestures without needing extra devices like gloves or sensors, making interaction more simple and natural [1]. The geometric features of the hand can be used to better understand and recognize gestures [2]. Sensors using for various task capture information

about the hand's distance from the robot and its movement [3]. Different approaches are used to makes robots more interactive, autonomous, and responsive, especially in tasks like navigation, obstacle avoidance, and remote operations [4]. System are designed where cameras capture hand gestures, and the computer understands and reacts without needing any physical touch [5]. The best method for detect the exact position and angle of each finger and joint in real-time, allowing the system to understand complex and dynamic hand gestures. The system emits infrared light, which is invisible to the human eye [6]. The method uses infrared sensors to track hand movements in 3D space. It emits infrared light towards the hand, which reflects back to the sensor. The sensor measures the time it takes for the light to return, helping calculate the distance and depth of the hand. This allows the system to track the hand's position and movement in real-time [7]. The system devised for agriculture system and for farmer



the robot while performing tasks like crop monitoring, harvesting, or irrigation. The robot is controlled through hand gestures or a mobile app, making it easier for farmers to manage tasks without needing physical contact [8]. sEMG signals are used for noise, signal changes, and the difficulty of real-time processing and systems are particularly useful in environments where touchless interaction is required [9-10]. The dataset contains various hand gestures that are relevant to the task at hand. These gestures are manually labeled (annotated) to ensure the model can learn the specific characteristics of each gesture [11]. The ability to control a car using hand gestures, showcasing how gestures can replace traditional manual control, enhancing user interaction with robots [12]. The system uses hand gestures for controlling a robotic arm, providing an intuitive and hands-free interface. Sensors Uses Flex sensors on the forefinger and middle finger control the arm's claw and wrist, while a gyroscope tracks forearm and base movement [13]. Method uses the two hand-worn glove controllers to control a robot remotely. Each glove tracks the movements of the hands, and the gestures are sent to the robot using an Arduino platform. The user can control both a 5-axis robotic arm and a robot vehicle by simply moving their hands [14]. A gesture-controlled robot designed to help physically challenged and elderly people. The robot uses motion sensors to recognize five simple hand gestures, allowing users to control its movement, such as going forward, backward, or turning. It's a simple and easy way for users to move around without needing to physically touch or operate a traditional device [15]. The creation of a gesture-controlled robot with Arduino technology is covered in this paper. Rather than using conventional input devices like keyboards or joysticks, users can control the robot with hand gestures. The robot has an RF module for wireless communication, an accelerometer, and an arduino microcontroller [16]. The creation of a vision-based hand gesture recognition system for human-robot interaction (HRI) is the main goal of this paper. For natural, intuitive control, traditional input devices like a pen,

mouse, and keyboard are insufficient, particularly for patients, the elderly, and people with disabilities [17]. Method for controlling a robotic hand using hand gestures in front of a camera. The system uses real-time hand tracking to capture gestures, extracts features, and matches them with a gesture database for recognition. Once a gesture is recognized, the robot performs the corresponding action. The approach includes modules for gesture capture, feature extraction, pattern matching, and command execution by the robot [18]. A hand gesture-controlled robot that does not require joysticks or switches is presented. Hand gestures are also used to control the robot's speed [19]. Method focused on vision-based hand gesture recognition systems for sign language from 2014 to 2020. The study aims to identify progress and areas needing attention in this field [20]. It is a method that importance of sEMG signals in recognizing hand gestures and explores their use in assistive technologies, such as prosthetics and robotics [21]. [4]

The main objective is to design and build a RoboCar that can be controlled through hand gestures and used for military and security purposes. To achieve this, the prototype design focuses on:

- Developing the code and setup for both the hand controller (transmitter) and the robot (receiver).
- Creating reliable wireless communication between the controller and the robot using the ESP8266 microcontroller.
- Building a functional robot car that responds accurately to hand gestures.
- Equipping the robot with extra features like a gas sensor, temperature and humidity sensor, and a surveillance camera to improve its use in real-life defense operations. [5]

2. Proposed Design

The aim is to make a smart robotic system that can be guided wirelessly using natural hand movements, without the need for physical remotes or joysticks. For robots to be useful, people need easy ways to control them. One of the best ways to do this is by using hand gestures. Hand gesture control feels

natural and does not require pressing buttons or using a remote. RoboCar prototype model is designed here includes a hand gesture controlled robot car using an Arduino. This robot car moves according to the gestures made by your hand. Simply wearing a glove with sensors, and by moving your hand in different directions, you can make the car go forward, backward, left, or right.

The system uses:

- A flex sensor to detect the bending of your fingers. [6-9]
- An accelerometer to track the direction and tilt of your hand.
- An ultrasonic sensor on the robot car to avoid obstacles.
- A Bluetooth module to send signals wirelessly from your hand to the car.

The Arduino reads the values from the sensors and sends commands to the motors of the robot car. This helps the car move smoothly based on your hand movements. We tested the system and found that it works well. The car moves correctly when we make gestures and avoid the obstacles and take its decision by own. This type of robot car can be used in many areas like security patrol, search and rescue, or exploring difficult-to-reach places. The main idea of this prototype model is to make robot control easy, fast, and natural by using simple hand movements. It does not need any difficult controls, which makes it easy for anyone to use. [10]

3. Prototype Model Design

The prototype model design is divided into two main sections:

- Transmitting glove module
- Receiving robot car

The prototype developed in two main parts: a sensor-based glove for gesture input and a robot car for movement. The glove was equipped with a flex sensor and an accelerometer to detect hand gestures. These sensors were connected to an Arduino Uno, which processed the data and sent commands wirelessly using a Bluetooth module. The robot car had another Arduino Uno, a motor driver module, and an ultrasonic sensor. It received the Bluetooth signals

and moved accordingly—forward, backward, left, or right. The ultrasonic sensor helped the car detect and avoid obstacles. The system was tested and calibrated to ensure smooth and accurate movement based on hand gestures. [11-14]

3.1. Transmitter Glove

The transmitter is a wearable glove equipped with a flex sensor and an accelerometer is shown in figure. The flex sensor detects how much the fingers are bent, and the accelerometer tracks the direction and tilt of the hand. These sensors are connected to an Arduino Uno, which reads their values. The arduino processes the sensor data and sends specific commands using a Bluetooth module (HC-05). These commands are sent wirelessly to the robot car based on the gesture performed — for example, tilting the hand forward sends a command to move forward, and tilting it left or right sends turning commands (Figure 1) [15]

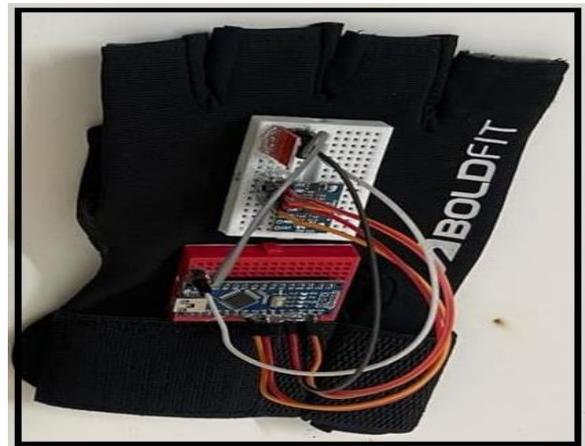


Figure 1 Transmitting Glove

- **Accelerometer (ADXL335):** Detects the tilt and direction of the hand. [16]
- **Arduino Uno:** Reads sensor data and sends control signals.
- **Bluetooth Module (HC-05):** Sends data wirelessly to the robot.

3.2. Receiver RoboCar

The receiver section is the RoboCar that contains another Arduino Uno, a motor driver (L298N), and a Bluetooth module to receive the signals from the

glove is shown in figure 2. Based on the received command, the Arduino controls the motors to move the car in the appropriate direction. Additionally, an ultrasonic sensor is placed on the front of the car to detect obstacles. If any object is detected within a certain distance, the car automatically stops or changes direction to avoid collisions. This helps the robot move safely, even in unfamiliar environments. (Figure 2) [16]

- **Robot Car Module:** Receiving RoboCar
- **Arduino Uno:** Receives data and controls the motors.
- **Motor Driver (L298N):** Drives the DC motors. [17]
- **DC Motors and Wheels:** Provide movement to the robot.
- **Ultrasonic Sensor (HC-SR04):** Detects obstacles in the robot's path.
- **Chassis and Battery Pack:** Physical body and power source of the robot. [18]

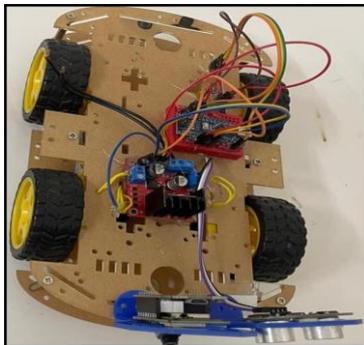


Table 2 Prototype Design Model Output

Distance (Meters)	Hands Movement Response				Overall Performance	Success %
	UP	DOWN	LEFT	RIGHT		
1	YES	YES	YES	YES	YES	100%
2	YES	YES	YES	YES	YES	100%
5	YES	YES	YES	YES	YES	100%
8	YES	YES	YES	YES	YES	100%
10	YES	YES	YES	YES	YES	100%
15	YES	YES	YES	NO	YES	90%
20	YES	YES	NO	NO	YES	80%

On practical testing the prototype design, the model is successfully working upto 10 meters distance but

Figure 2 Receiving RoboCar

Hand movements and commands details are shown in (Table 1)

Table 1 Hand Movement Commands RoboCar

Hands Movement	Command
Up	Forward Movement Of Robocar
Down	Backward Movement Of Robocar
Left	Left Movement Of Robocar
Right	Right Movement Of Robocar

The prototype model also have ultrasonic sensor in robocar so that if any obstacle found/ detected, it automatically stop. [19]

4. Result and Analysis

The proposed design of RoboCar controlled by hand gesture is tested from different distances and the performance output of the prototype model is shown in (Table 2)

with increase in distance the performance of the model decreases. The reason behind this is the



Bluetooth module limitation. [20]

Conclusion

This prototype design of a Hand Gesture Controlled Robot Car using Arduino and sensor-based technology is successfully demonstrates. By using flex sensors, an accelerometer, and Bluetooth communication, the system allows for intuitive and natural robot control without traditional input devices. The addition of an ultrasonic sensor further enhances the robot's ability to navigate safely by avoiding obstacles. Testing showed that the robot responds accurately to hand gestures and performs well in real-time conditions. This technology has promising applications in fields such as security surveillance, disaster recovery, and exploration of hard-to-reach or hazardous areas. Overall, the system offers a simple, cost-effective, and user-friendly solution for gesture-based robot control and is ready to be practically used as product. [21]

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