

Real-time Robotic Car Control using Brainwaves and Head Movements

Prof. V.S. Phatangre¹, Mr. Jayesh Chavan², Miss. Akshada Avhad³, Miss. Mansi Iste⁴

¹Prof. Dept. of Electronic & Computer Engineering, Amrutvahini College of Engineering, Sangamner, India

^{2,3,4}Students, Dept. of Electronic & Computer Engineering, Amrutvahini College of Engineering, Sangamner, India

Abstract - Robot Car is that device that can be remotely controlled using the user's brain signals. This system uses BCI (Brain-Computer Interface) to provide communication between our brain and the robotic car. It uses an MEMS/EMG/EEG (Electroencephalogram) headset to acquire data, classifies and interprets the data set on the hardware, and achieves desired commands on the robotic car based on the provided classification. The data is transferred through a Bluetooth module, while the commands are executed by Arduino. The purpose of the robot-car is to demonstrate the feasibility of applying in BCI application, as we will be shown in this paper to controlling the robotic car.

Key Words: ATmega 2560, ADXL335, Alcohol Sensor, Head Movement, Robotic Car

1. INTRODUCTION

The Today, Robot Car is that device that can be remotely controlled using the user's brain signals. This system uses BCI (Brain-Computer Interface) to provide communication between our brain and the robotic car. It uses An Gyro/EMG/EEG (Electroencephalogram) headset to acquire data, classifies and interprets the data set on the hardware, and achieves desired commands on the robotic car based on the provided classification. The data is transferred through a Bluetooth module, while the commands are executed by control board. The purpose of the robot-car is to demonstrate the feasibility of applying in application, as we will be shown in this paper to controlling the robotic car.

The Head Movement Controlled Robot utilizes sophisticated sensor technologies and machine learning algorithms to interpret and respond to human hand movements. By capturing and analyzing gestures in real-time, users can effortlessly command the robot to

perform specific tasks or navigate its surroundings. This intuitive interaction fosters a more natural and user-friendly interface, eliminating the need for complex manual controls or remote devices. Moreover, the implementation of head movement control is particularly valuable in scenarios where hands-free operation is crucial, such as industrial settings, medical environments, or situations where the user's hands may be occupied. This technology enhances efficiency, safety, and accessibility, making it a compelling solution for a wide range of applications.

With the world's progress everyone wants to be advanced, as the automation in the field of engineering is increasing, it can be best understood by the laser operations where automation works, it has increased the success rate. For brain mapping we use a technique electroencephalogram (Gyro/EEG/EMG), which works on the electric pulses generated in the brain, by extracting these nerves we can track the state of the mind, for example attention, meditation. An electroencephalogram (Gyro/EEG/EMG) gives us with different frequencies which can be further decoded as the states of mind, propensity to have writing and specific sort of epilepsy. For the people with disabilities, it can be used to control a car or it can be implemented for anything which needs to be handled for movement through wheels. Products are available with which control through voice recognition or some sort of sensors. With a step ahead of them we are using brain to control the proceedings. The brain potential recorded by electrode placed on the scalp are transformed into commands to control the robotic arm, exoskeleton. The basic idea of BCI is to translate user produced patterns of brain activity into corresponding commands. A typical BCI is composed of signal acquisition and signal processing. The brain signals that are widely used to develop EMG/EEG-based BCIs include P300 potentials, which are positive potentials deflections on the ongoing brain activity at a latency of roughly 300ms after the

random occurrence of a desired target stimulus from non-target stimuli.

Gesture control is an important aspect of non-verbal communication that enables interaction with machines, especially in the realm of robotics. This form of control relies on recognizing gestures such as hand movements, often with the help of technologies like accelerometers. In particular, the accelerometer in smartphones has proven effective in detecting these movements, which can then be processed to guide a robot's motion via Bluetooth communication with a microcontroller. This method offers an intuitive and cost-efficient way to control robots, allowing them to imitate the user's hand gestures with minimal hardware requirements [1]. Robots are increasingly being used in various applications such as manufacturing, healthcare, and entertainment. The development of intelligent robots capable of performing tasks autonomously has created new opportunities for increasing productivity and efficiency while reducing the need for human intervention. However, traditional robot control systems, such as remote control, have limitations in terms of usability and interaction [2]. The development of hands-free robotic interfaces has opened new possibilities for people with disabilities, especially through systems that use head movements to control robotic limbs. Such systems map head angles, including pitch, roll, and yaw, to corresponding movements of a robot arm. This method, which employs an inertial measurement unit (IMU), provides efficient control through non-invasive means. The research underscores the potential of head gestures as a viable and efficient approach to managing robotic interfaces, thereby improving accessibility for individuals with physical limitations [3][4]. The importance of gesture control in robotics continues to grow, especially as it eliminates the need for traditional input devices like keyboards and mice. Accelerometer sensors have reduced the need for bulkier technologies such as data gloves in gesture-controlled robots. These sensors detect and translate hand movements into commands that a microcontroller can use to operate devices, including wheelchairs for those with physical disabilities.

1.2. LITERATURE REVIEW

In [1] This research investigates a hand gesture-based concept for portable robot control. Hand signals that transmit control signals can cause portable robots to move. Motion recognition is achieved through picture handling, picture counter handling, and other techniques. A portable

robot's control is based on regarding identified and decoded data.

In [2] This paper describes a method of using the Arduino Uno Lilypad to operate an automata with hand signals. To regulate the anticipated show, a movement device attached to the gloves is used. The main goal of this technique is to manipulate the robot's hand gesture for exploitation.

In [3] A hand-gesture based control interface for manipulating a car-robot is presented in this work. The user's hand movements are recorded using a three-axis accelerometer. A microcontroller can receive information wirelessly from any frame of association. At that stage, the received signals are converted into one of six orders for car-robot navigational control.

In [4] The main goal of this extension is to use an accelerometer/gyroscope-based gesture controller to control the automated arm's movement. This method is far more useful than using a joystick or console. The primary goal of this paper is to enhance an uncomplicated and strong structure for the protest place on the robot's live demonstration. To survey the suggested question discovery computation and gesture controller, exploratory results are employed.

In [5] This study describes the use of hand gestures to control a robot. They demonstrated a modern client hand discovery strategy in addition to a hand signal finding method that uses the robot's camera to recognize the hand in progressive outlines. They succeeded in making the robot follow the hand that was identified. In the future study participants, the hand's rate of detection will increase.

2. Methodology

2.1 Block diagram of System:

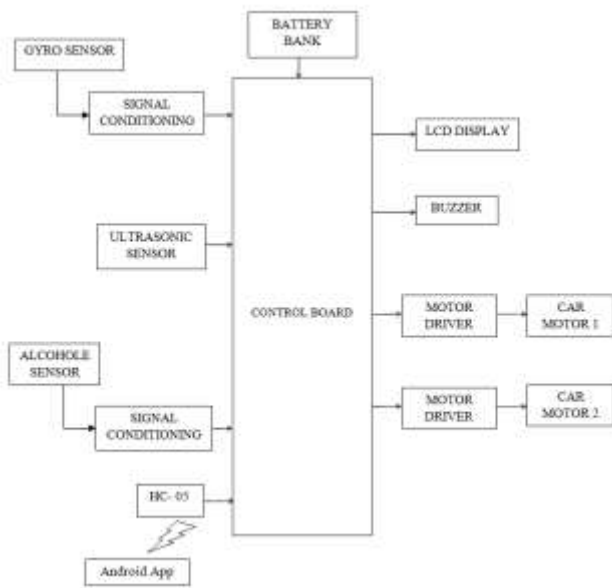


Fig -1: Block Diagram

The car will rely only on what the individual is thinking they will hence not require any physical movement on the part of the individual. It captures EEG (electroencephalogram) signals from the driver's brain using Neuro EEG head set which contains three electrodes. The captured signals are send to the Bluetooth module (HC05).It is connected with Arduino (ATMEGA 328) in which the instructions for the movement are programmed. The signals from the brain are compared with the instructions which we already stored. It comes with sensors to covert these signals into commands to drive the car. According to Reuters, the driver needs to wear brain signal-reading equipment following which one can control the car to go forward, backwards, come to a stop, lock and unlock vehicles without actually moving their hands or feet. The driving instruction from the brain will be displayed on a LED screen. The output from the Arduino is connected with driver motor (L293D) to which the vehicle is associated. If above requirements are satisfied the car can become the future of driving and a great help for the disabled in every manner in the field of transportation.

The system allows a robotic car to be **controlled using head movements and muscle (EMG) signals** in real time. It integrates **bio-signal sensing, motion detection, and embedded control** to drive motors based on user intent.

2.3 ATmega 2560:

This is an Official Arduino Mega 2560 ATmega2560 MCU Rev3 A000067 The Official Arduino Mega 2560 is a Rev3 development board based on the ATmega2560 microcontroller. The board has 54 digital input/output pins (of which 14 can be used as PWM outputs), **16 analog inputs, 4 UARTs** (hardware serial ports), a **16MHz crystal oscillator**, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with an AC to DC adaptor or battery to get started.

The Mega is compatible with most shields designed for the Arduino Uno, Duemilanove, or Diecimila. The Arduino Mega can be powered via a USB connection or with an external power supply. The power source is selected automatically. The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers.

Features:

1. ATmega16U2 instead 8U2 as USB to serial converter
2. 1.0 pinout
3. Stronger RESET circuit
4. 5V operating voltage
5. Input voltage (recommended) range from 7V to 12V
6. Input voltage (limit) range from 6V to 20V
7. 40mA DC current per I/O pin
8. 256KB flash memory of which 8KB used by the bootloader
9. 8KB SRAM
10. 4KB EEPROM



Fig -2: ATmega 2560

2.4 ADXL335 5V 3-axis Accelerometer

Precision Motion Sensing: 7Semi ADXL335 5V 3-Axis Accelerometer

Empower your projects with the 7Semi ADXL335 3-Axis Accelerometer Breakout Analog Out, the perfect solution for accurate motion sensing across three dimensions (X, Y, and Z). This versatile module is engineered for seamless integration, offering a compact 21x16mm footprint ideal for space-constrained applications.

Key Features & Benefits

- **3-Axis Sensing:** Capture acceleration data in all directions for comprehensive motion analysis.
- **Robust Performance:** Withstands up to 10,000g of shock, ensuring reliable operation in demanding environments.
- **Energy Efficient:** Low power consumption (350uA typical) extends battery life and reduces overall project power needs.
- **Convenient 5V Supply:** Simplify your power connections with the standard 5V operating voltage.
- **Compact Design:** The 21x16mm form factor saves valuable space on your PCB.
- **Built-In Self-Test & Adjustable Sensitivity:** Streamline sensor calibration for quick setup and optimal accuracy.



Fig -3: ADXL335

2.5 Alcohol Sensor:

Even This MQ-3 Alcohol Detector Gas Sensor Module is simple to use. MQ-3 Alcohol Detector Module which can sense the presence of Alcohol in the air. The module uses our MQ-3 sensor. It simplifies the interface to the

odd pin spacing of the sensor and provides an interface through standard 4 x 0.1. header pins. It provides an analog output corresponding to the concentration of the gas in the air and an easy-to-use digital output. The onboard potentiometer can be used to set the maximum gas concentration beyond which the digital output gets triggered. Perfect sensing alcohol concentration on your breath just likes a common breathalyzer. Just power the module with 5V set the threshold and you can start getting the gas concentration of the air around the sensor! An onboard LED signals the presence of any gas. The digital output can be easily interfaced to microcontrollers and other circuits. The analog output can be hooked up to an ADC of a microcontroller to get a wide range of sensor readings.



Fig -4: Alcohol Sensor

3.2 HC05 Bluetooth Module:

HC-05 6 Pin Wireless Serial Bluetooth Module is a Bluetooth module for use with any microcontroller. It uses the UART protocol to make it easy to send and receive data wirelessly.

The HC-06 module is a slave only device. This means that it can connect to most phones and computers with Bluetooth but it cannot connect to another slave-only device such as keyboards and other HC-06 modules. To connect with other slave devices a master module would be necessary such as the HC-05 version which can do both master and slave.



Fig -5: HC05 Bluetooth Module

CONCLUSION

The project “**Real-Time Robotic Car Control using Brainwaves and Head Movements**” successfully demonstrates how **bio-signals** and **motion sensors** can be integrated to achieve intuitive, hands-free robotic control. By utilizing the **gyrosensor** for position signal detection and the **MPU6050 sensor** for head movement tracking, the system effectively interprets human gestures into robotic motion commands through the **ATmega2560 microcontroller**.

This approach provides an affordable and practical solution for **assistive technologies**, especially for individuals with limited mobility. The system operates in real time, offering smooth and responsive control with relatively simple hardware and programming.

Although calibration and signal noise remain challenges, the results show that **bio-signal-based control systems** have significant potential for use in **rehabilitation, prosthetic devices, assistive robots, and human-machine interaction**.

Overall, the project contributes to advancing accessible robotics, demonstrating that low-cost embedded technology can enable meaningful human-robot collaboration and independence for differently-abled users.

Future Work:

Brain-controlled robotic car leveraging mind waves would encompass several key features. Firstly, it would integrate sophisticated sensors capable of detecting and interpreting brain signals, enabling users to control the vehicle's navigation, steering, acceleration, and braking through their thoughts. Safety would be paramount, with the inclusion of collision detection and avoidance systems to mitigate potential accidents. The system would also incorporate adaptive learning algorithms to personalize control settings based on individual users' brainwave patterns, ensuring optimal performance and user experience. A user-friendly interface would facilitate calibration and customization, while providing feedback on the car's actions based on the user's brain signals. Moreover, accessibility would be a priority, with design considerations to accommodate users with diverse physical abilities. Seamless integration with other devices and technologies would further enhance

the car's usability and utility in various contexts, promising a transformative and empowering experience for users.

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