**A Neuro-Driven Mobile Robot Enhanced by LoRa EEG Technology**

**LITERATURE SURVEY**

**BATCH NO: 05**

**TEAM MEMBERS:**

Akash R - DSUG20104010

Balaji M - DSUG20104022

Barath K - DSUG20104026

Kannan S - DSUG20104067

**GUIDE:**

Mr. K. Aswin, M.E.,

Assistant Professor / CSE,

Dhanalakshmi Srinivasan Engineering College (Autonomous), Perambalur.

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**A Neuro-Driven Mobile Robot Enhanced by LoRa EEG Technology**

*This work was supported by Mr. K. Aswin M.E.,*

*Assistant Professor / CSE, Dhanalakshmi Srinivasan Engineering College (Autonomous),*

*- Akash R, Balaji M, Barath K, Kannan S*

*Final Year/CSE, Dhanalakshmi Srinivasan Engineering College (Autonomous).*

**ABSTRACT**

The Cognitive Rover project presents an innovative approach to mobile robotics, integrating advanced neuro-technologies with long-range communication capabilities to create a versatile and adaptive robotic platform. The primary objective of the project is to develop a mobile robot capable of autonomous navigation and interaction with its environment, guided by neural signals obtained through electroencephalography (EEG) technology. Leveraging the LoRa (Long Range) communication protocol, the robot establishes robust connectivity over extended distances, enabling remote operation and data transmission in various scenarios, including search and rescue missions, hazardous environment exploration, and remote inspection tasks. The proposed system architecture consists of two main components: a neuro-driven control system and a communication module. The neuro-driven control system utilizes EEG signals collected from a MindWave headset to interpret user commands and environmental stimuli. Through machine learning algorithms and real-time signal processing techniques, the system translates EEG signals into actionable commands for autonomous navigation, obstacle avoidance, and task execution. The communication module integrates LoRa technology to facilitate seamless data exchange between the robot and remote operators, enabling real-time monitoring, control, and video streaming over long distances. Key advantages of the Cognitive Rover include its adaptability to diverse environments, intuitive user interaction through brain-computer interface technology, and robust long-range communication capabilities. Moreover, the project contributes to advancements in robotics, human-robot interaction, and assistive technologies, with potential applications in disaster response, environmental monitoring, and infrastructure inspection.

**INDEX TERMS:** Brain-Computer Interface (BCI), Electroencephalography (EEG), LoRa Communication, Environmental Monitoring, Neuro-Driven Control, Mobile Robotics, Remote Operation

**LITERATURE SURVEY**

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| --- | --- | --- | --- |
| **S.No** | **Title** | **Methodology** | **Limitations** |
| **1** | Arduino Based Bluetooth Voice-Controlled Robot Car and Obstacle Detector | Utilizing an Arduino Uno microcontroller and an HC-05 Bluetooth module, the project establishes communication for voice-controlled navigation and obstacle detection. | Challenges include scalability, range limitations with Bluetooth, and voice recognition accuracy affected by noise and accents. These are addressed by the Cognitive Rover project, enhancing adaptability in diverse scenarios. |
| **2** | Wireless car control system based on ARDUINO UNO R3 | The paper designs a wireless car control system, using modular principles and an ARDUINO UNO R3 module for main control, along with ultrasonic, Bluetooth, beep sound alert, and motor driver modules. | Possible constraints include scalability and compatibility with varied hardware configurations. Iterative refinement and compatibility testing could address these issues, enhancing the system's versatility and usability. |
| **3** | Wi-Fi Controlled Multi-sensor Robotic Car | The project develops a smartphone-controlled robotic car using minimal technology, primarily the Node MCU interfaced with various modules. Wireless control via Wi-Fi enables smartphone operation, while sensors detect obstacles and monitor the environment. | Scalability and autonomy may be constrained, requiring future enhancements to improve intelligence and autonomy for independent operation in diverse environments. |
| **4** | Car Control by using brain waves and Arduino based Mind wave Mobile | The project develops a Brain-Computer Interface (BCI) application to control an Arduino-based car. An Android app interprets brainwaves and communicates with the car via Bluetooth, executing commands through an onboard Arduino. | Challenges include accuracy of brainwave interpretation and latency in communication between the BCI app and the Arduino-based car. Refinement of signal processing algorithms and communication protocols may be necessary to address these limitations. |
| **5** | BCI based Robotic Arm Control using MI-EEG and Spiking Neural Network | This study uses MI-EEG signals to control a robotic arm. Preprocessing removes noise, and features are extracted using 2D-spectrogram analysis. Training employs a 2D-CNN and an energy-efficient SNN. High accuracies are achieved, and models are interfaced with Arduino for control. | Challenges may include signal variability and computational demands of the SNN. Further optimization is needed for signal processing and neural network techniques. |
| **6** | Design of Brain Controlled Robotic Car using Raspberry Pi | This research designs a robotic car controlled by eye flicks using Brain-Computer Interface (BCI) technology. EEG waves obtained from the cerebrum are screened by BCI for non-intrusive detection, with Neurosky's contemplations wave cell estimating EMG action (squint force) for automated control. | Challenges may include accuracy of eye flick detection and limitations in control range and response time. Refinement of BCI algorithms and sensor technologies could enhance usability for disabled individuals. |
| **7** | Development of a Cell Phone Based Vehicle Remote Control System | This paper outlines a GSM-controlled vehicle powered by solar energy. Remote operation is triggered by cell phone calls, activating motor actions based on DTMF tones. Solar power, with a backup battery, facilitates long-distance operation. | Challenges include GSM network coverage limitations, signal processing accuracy, and reliability concerns. Solar energy dependence may restrict functionality in low-light conditions, necessitating optimization of network protocols and power management systems. |
| **8** | Raspberry Pi based Remote Controlled Car using Smartphone Accelerometer | This thesis creates a Raspberry Pi-based remote-controlled car for surveillance, controlled via smartphone accelerometer. Wi-Fi enables communication, with control through a remote IMU app using accelerometer, gyrometer, and magnetometer sensors. Data is sent to the Raspberry Pi via UDP, and a Pi camera aids surveillance. | Challenges may include latency in communication and accuracy issues with sensor data interpretation. Environmental factors and network connectivity may affect reliability, requiring optimization and calibration. |
| **9** | A GSM-Based Wireless Remote Controller | This paper presents a GSM-based wireless remote power controller for home automation, enabling remote control of home appliances via the TC35 module from any location and at any time. The controller comprises a controlling center and a remote receiving module. A prototype demonstrates the controller's flexibility in appliance control. | Challenges may include GSM network coverage and reliability issues, as well as potential constraints with remote module reception. Environmental factors and network congestion could affect reliability. Further testing and optimization are needed to ensure consistent performance. |
| **10** | Brain Computer Interface System for Mind Controlled Robot using Bluetooth | This paper introduces a Mind Controlled Robot utilizing Brain-Computer Interface (BCI) technology, analyzed through LabVIEW. BCIs facilitate direct control between the brain and physical devices by translating brain activity patterns into real-time commands, enabling control of mobile robots to aid disabled individuals. | Challenges include accuracy in interpreting brain wave signals and real-time command execution, influenced by environmental factors and individual brain activity variations. Further optimization is required for practical implementation. |

**1.TITLE: Arduino Based Bluetooth Voice-Controlled Robot Car and Obstacle Detector**

**AUTHOR:** Rajeshwari Sissodia, ManMohan Singh Rauthan, Varun Barthwal

**PUBLISHED YEAR**: 2023 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project aims to develop a robot car controlled via voice commands and equipped with obstacle detection features. By integrating components like the Arduino Uno microcontroller, HC-05 Bluetooth module, and ultrasonic sensor, the system enables users to navigate the robot using verbal instructions. The voice-controlled interface offers hands-free operation, enhancing user convenience and safety. Additionally, the inclusion of obstacle detection technology allows the robot to autonomously avoid collisions, ensuring efficient and reliable navigation. However, challenges such as limited vocabulary recognition and potential signal interference may impact the system's accuracy and reliability.

**ADVANTAGES:**

* Hands-free operation enhances user convenience and safety.
* Voice-controlled interface offers intuitive and natural interaction.
* Obstacle detection feature improves navigation and collision avoidance.

**DISADVANTAGES:**

* Limited vocabulary recognition may restrict the range of voice commands.
* Signal interference or environmental noise can affect voice command accuracy.
* Complexities in system integration and calibration may require technical expertise.

**2.TITLE: Wireless car control system based on ARDUINO UNO R3**

**AUTHOR:** Lang Chen, Jianbo Zhang, Yao Wang

**PUBLISHED YEAR**: 2018 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project focuses on designing a wireless car control system utilizing the Arduino Uno R3 module. By adopting a modular design approach and leveraging components like ultrasonic sensors, Bluetooth modules, and motor drivers, the system offers flexibility and scalability for various applications. The Arduino Uno R3 serves as a reliable and versatile platform for hardware development, facilitating seamless integration and programming. Wireless communication enables remote control capabilities, enhancing user convenience and operational flexibility. However, potential challenges such as latency issues and signal interference may arise, affecting system performance and reliability.

**ADVANTAGES:**

* Wireless communication enables remote control capabilities, enhancing flexibility.
* Modular design facilitates scalability and customization for various applications.
* Arduino Uno R3 platform offers versatility and ease of programming.

**DISADVANTAGES:**

* Latency issues in wireless communication may impact real-time control.
* Signal interference can affect the reliability of remote control signals.
* Complexity in system setup and configuration may require technical proficiency.

**3.TITLE: Wi-Fi Controlled Multi-sensor Robotic Car**

**AUTHOR:** J.J.Dhanish Kumar, R.Gokul, S.Harshini, G.Nithish

**PUBLISHED YEAR**: 2022 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project endeavors to create a smartphone-controlled robotic car equipped with Wi-Fi connectivity and multi-sensor capabilities. By utilizing components like Node MCU, Wi-Fi modules, ultrasonic sensors, and temperature sensors, the system enables intuitive control and monitoring via a smartphone application. Smartphone integration offers user-friendly interaction and real-time feedback, enhancing the overall user experience. Wi-Fi connectivity ensures reliable and high-speed communication, enabling seamless operation and data transmission. However, complexities associated with sensor integration and power consumption may pose challenges, impacting system efficiency and cost-effectiveness.

**ADVANTAGES:**

* Smartphone-controlled interface offers user-friendly interaction and feedback.
* Wi-Fi connectivity enables reliable and high-speed communication.
* Multi-sensor capabilities enhance functionality for diverse applications.

**DISADVANTAGES:**

* Power consumption of sensors and communication modules may affect battery life.
* Complexity in sensor integration and calibration may pose challenges.
* Signal interference or network congestion can impact system responsiveness.

**4.TITLE: Car Control by using brain waves and Arduino based Mind wave Mobile**

**AUTHOR:** Khalid Alsammarraie, Timur Inan

**PUBLISHED YEAR**: 2022 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project explores the utilization of brain waves for controlling a car using an Arduino-based MindWave Mobile interface. By integrating Brain-Computer Interface (BCI) technology with an Android application, the system interprets brainwave signals to execute commands for car movement. Users can control the car through mental commands captured by EEG signals, enhancing accessibility and ease of operation. The combination of brainwave technology and Arduino platform offers a novel and intuitive approach to vehicle control, potentially revolutionizing human-machine interaction. However, challenges related to signal processing and accuracy of EEG interpretation may affect the system's reliability and responsiveness.

**ADVANTAGES:**

* Brain-computer interface offers a novel and intuitive control interface.
* Integration with Arduino platform facilitates seamless hardware integration.
* Potential for hands-free and intuitive operation enhances user experience.

**DISADVANTAGES:**

* Signal processing complexities and accuracy limitations may affect reliability.
* Calibration requirements and user training may be time-consuming.
* Potential for signal interference or noise can impact system performance.

**5.TITLE: BCI based Robotic Arm Control using MI-EEG and Spiking Neural Network**

**AUTHOR:** Joshua Alfred, Harshavardhan S, John Sahaya Rani Alex – **PUBLISHED YEAR**: 2022 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project focuses on developing a Brain-Computer Interface (BCI) system for controlling a robotic arm using Motor Imagery EEG signals and Spiking Neural Network (SNN) algorithms. By capturing and processing EEG signals associated with motor imagery tasks, the system enables users to manipulate the robotic arm with their thoughts. The integration of SNN technology offers efficient and real-time signal processing, enhancing the system's responsiveness and accuracy. The BCI-based control mechanism provides a natural and intuitive interface for users, enabling precise and dexterous control of the robotic arm. However, challenges such as signal noise and calibration requirements may impact the system's performance and usability.

**ADVANTAGES:**

* Brain-computer interface offers direct and intuitive control of robotic arm.
* Spiking neural network technology enables efficient signal processing.
* High accuracy and responsiveness enhance precision in robotic arm movements.

**DISADVANTAGES:**

* Signal noise and calibration requirements may affect system reliability.
* Complexity in neural network training and optimization may pose challenges.
* Integration with hardware interfaces and real-world applications may require expertise.

**6.TITLE: Design of Brain Controlled Robotic Car using Raspberry Pi**

**AUTHOR:** Enjeti Amareswar, M.Raju Naik, SVS Prasad, N. Vishal Chandra, R. Karthik

**PUBLISHED YEAR**: 2021 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project aims to develop a brain-controlled robotic car utilizing a Raspberry Pi-based Brain-Computer Interface (BCI). By integrating EEG signal processing with Raspberry Pi, the system enables users to control the car's movement using brainwave patterns. The BCI technology offers a novel and intuitive control interface, allowing users to navigate the robotic car effortlessly. Raspberry Pi serves as a versatile and programmable platform, facilitating seamless integration with EEG sensors and motor control mechanisms. However, challenges related to signal processing algorithms and real-time responsiveness may affect the system's reliability and performance in dynamic environments.

**ADVANTAGES:**

* Brain-computer interface offers a natural and intuitive control interface.
* Raspberry Pi platform enables flexible and programmable hardware integration.
* Potential for hands-free and independent operation enhances user autonomy.

**DISADVANTAGES:**

* Signal processing complexities and real-time responsiveness may affect reliability.
* Calibration requirements and user training may be time-consuming.
* Power consumption and hardware constraints may limit system performance.

**7.TITLE: Development of a Cell Phone Based Vehicle Remote Control System**

**AUTHOR:** Bishwajit Banik Pathik, A.S.M. Ashraf Ahmed, Labina Alamgir, Abu Nayeem

**PUBLISHED YEAR**: 2014 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project presents the development of a GSM-based remote control system for vehicles using cell phones. By leveraging GSM communication technology, the system enables users to remotely control vehicle functions via simple phone calls. The integration of solar power enables sustainable and autonomous operation, enhancing the system's reliability and energy efficiency. The use of Dual Tone Multiple Frequency (DTMF) tones for command transmission offers a simple and robust control interface, suitable for various applications. However, limitations such as network coverage and latency may affect the system's responsiveness and reliability in remote locations.

**ADVANTAGES:**

* GSM-based remote control offers ubiquitous connectivity and accessibility.
* Solar-powered operation enhances sustainability and autonomy.
* Simple and robust control interface via DTMF tones enhances user experience.

**DISADVANTAGES:**

* Network coverage limitations and latency issues may affect responsiveness.
* Security vulnerabilities in GSM communication may pose risks.
* Complexity in system setup and configuration may require technical expertise.

**8.TITLE: Raspberry Pi based Remote Controlled Car using Smartphone Accelerometer**

**AUTHOR:** Varsha Vishwa Kiran, S Santhanalakshmi

**PUBLISHED YEAR**: 2019 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project focuses on developing a remote-controlled car using Raspberry Pi and smartphone accelerometer sensors. By establishing Wi-Fi communication between the Raspberry Pi-based car and a smartphone, users can control the vehicle's movement by tilting the phone. The integration of accelerometer, gyrometer, and magnetometer sensors offers intuitive and responsive control, enhancing the user experience. Additionally, the inclusion of a Pi camera enables remote surveillance and navigation capabilities, expanding the car's functionality. However, challenges such as sensor calibration and network latency may impact the system's responsiveness and performance.

**ADVANTAGES:**

* Smartphone-controlled interface offers intuitive and responsive interaction.
* Wi-Fi communication enables seamless control and monitoring from anywhere.
* Integration with sensors and camera enhances functionality for surveillance and navigation.

**DISADVANTAGES:**

* Sensor calibration and network latency may affect real-time responsiveness.
* Power consumption and battery life limitations may impact usability.
* Complexity in setup and configuration may require technical proficiency.

**9.TITLE: A GSM-Based Wireless Remote Controller**

**AUTHOR:** Gang Cao, Tiefeng Xu, Taijun Liu, Yan Ye, Gaoming Xu **PUBLISHED YEAR**: 2011 **PUBLISHER:** IEEE

**DESCRIPTION**:

This project introduces a GSM-based wireless remote power controller for home automation applications. By utilizing GSM communication modules, the system enables users to remotely control household appliances from anywhere using mobile phones. The integration of GSM technology offers reliable and ubiquitous connectivity, ensuring seamless operation and accessibility. The modular design and implementation of remote control modules enhance the system's flexibility and scalability for diverse applications. However, challenges such as network congestion and security vulnerabilities may affect the system's reliability and privacy.

**ADVANTAGES:**

* GSM-based remote control offers widespread coverage and accessibility.
* Modular design enables flexibility and scalability for diverse applications.
* Simple and reliable control interface via GSM communication enhances usability.

**DISADVANTAGES:**

* Network congestion and latency issues may affect responsiveness.
* Security vulnerabilities in GSM communication may pose risks.
* Complexity in system integration and configuration may require technical expertise.

**10.TITLE: Brain Computer Interface System for Mind Controlled Robot using Bluetooth**

**AUTHOR:** Siliveru Ramesh, M.Gopi Krishna, Madhu Nakirekanti

**PUBLISHED YEAR**: 2014 **PUBLISHER:** IJCA

**DESCRIPTION**:

This project proposes a Brain-Computer Interface (BCI) system for controlling a robot using mind-controlled commands transmitted via Bluetooth. By analyzing brainwave signals using LabVIEW software, the system interprets user intentions and translates them into robot movements. The BCI technology offers a direct and intuitive control interface, allowing users to interact with the robot effortlessly. Bluetooth connectivity enables wireless communication between the brainwave analysis system and the robot, facilitating seamless integration and operation. However, challenges such as signal processing complexity and calibration requirements may affect the system's accuracy and responsiveness.

**ADVANTAGES:**

* Brain-computer interface offers direct and intuitive control of the robot.
* Bluetooth connectivity enables wireless communication and flexibility in operation.
* Integration with LabVIEW software facilitates signal analysis and real-time control.

**DISADVANTAGES:**

* Signal processing complexities and calibration requirements may affect accuracy.
* Bluetooth range limitations and interference may impact wireless communication.
* Integration with hardware components and user training may require expertise.