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Brain-Controlled Robotic Assistance for Enhanced Mobility and Independence in People with Disabilities

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ABSTRACT
This paper examines a brain-controlled robot using BCI. Modern brain-computer interfaces (BCIs) allow the brain to operate physical equipment directly. They do this by translating brain activity into real-time commands instead of using muscles and ideas. These commands operate mobile robots. The project aims to create a robot that helps disabled people with daily duties. We analyze brain wave signals here. Human brains have millions of interconnected neurons. Neuronal connection conveys thoughts and emotions. This pattern changes with human intellect, generating electrical waves. Muscle contractions provide a specific electrical signal. The brain wave sensor detects electrical waves and converts them into Bluetooth data packets. The Level Analyzer Unit (LAU) will process brain wave data using MATLAB. Subsequently, the robot module will execute the control commands. This complete approach enables us to manipulate a humanoid robot using a muscle contraction triggered by blinking.

1. INTRODUCTION OVERVIEW

The worldwide healthcare community has recently shown a great amount of enthusiasm for rehabilitative robotic devices that have the potential to partially replace duties that are traditionally performed by caretakers. Additionally, this enthusiasm has been particularly evident in the previous twenty years. The dearth of trained personnel in a variety of healthcare disciplines is the root cause of the growing interest in the field of robots. Furthermore, there is an annual growth in the population of persons who are either elderly or have some kind of handicap. This study examined the viability of a brain-computer interface (BCI)-based robot that the user could control with their own mind. Brain-computer interfaces (BCIs) are technological advancements that provide direct brain-to-machine communication and control by translating various brain activity patterns into real-time commands. BCIs bypass conventional communication methods like muscles and thoughts. These codes enable the user to exert control over a mobile robot. The objective of the project is to develop a robot that can offer support to impaired persons in their daily activities and empower them to independently carry out specific tasks. It was observed that few EEG denoising techniques were implemented or they were not sufficiently validated. Various neural features and decoders were used for neural classification. Horizontal com parison was attempted by examining ITR and control
Efficiency [3]. The implemented shared control approach allowed each participant to complete a rather complex task in shorter times and with fewer commands independently of mental or manual control [4]. Through the utilization of a transmitter module and a receiver module, this project is able to achieve the many objectives that it has set for itself. When it comes to determining the frequency of the impulses that are being sent, the EEG sensor that is built into the transmitter is the one that is accountable for doing so. After the signals have been transmitted, the action that has been defined is triggered in a different module based on the frequencies that have been specified. This occurs after the transmission of the signals. Immediately following the transmission of the signals, this takes place. Due to the fact that it is a prototype module, the robot is able to perform the functions of a machine that is controlled by a collection of nerve impulses. This is because the robot is able to carry out these

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activities effectively. There is a high probability that the effective incorporation of brain-controlled robotic aid has the potential to totally revolutionize the area of assistive technology. Since brain pulses are very small, they must be amplified before digitization. Furthermore, raw EEG signals may con tain noise having different sources: electric or electro- magnetic fields [2]. Individuals who are afflicted with impairments would see a huge improvement in their lives as a consequence of this. The purpose of this introduction is to give a framework for evaluating the technological achievements, obstacles, and prospective advantages of this new technology. This framework will be provided in order to provide a framework at the end of this introduction. The importance of this strategy will be underlined because of its relevance in fostering self-sufficiency and improving the overall well-being of those who are unable to do certain physical tasks. This method's relevance will be emphasized throughout the course of the discussion.

2. LITERATURE SURVEY:

Towards Independence: A BCI Telepresence Robot for People With Severe Motor Disabilities

This study investigates the effects of shared control in a telepresence framework based on brain-computer interface (BCI). It explores how operating a mobile robot using a BCI can improve the quality of life for those with significant physical disabilities. A bidirectional audio/video link enables users of brain-computer interfaces (BCIs) to engage in active interaction with their loved ones who are located in various places. Controlling robots directly through unexpected routes such as Brain-Computer Interfaces (BCIs) is a difficult and hard task. The experimental findings demonstrate that shared control has the ability to streamline the functioning of brain-controlled telepresence robots. Through the use of shared control, individuals, regardless of their physical abilities, were able to successfully complete a challenging job in a realistic environment. This involved operating a robot amongst numerous objectives and obstacles, resulting in a reduction of both time and mental orders required. Shared control reduces the cognitive exertion of users. Shared control enables enhanced flexibility, enabling proficient users of brain-computer interfaces (BCIs) to generate a higher number of mental instructions compared to individuals who significantly relied on the technology. Participants with motor impairments successfully performed the identical exercises as the healthy participants.

Comprehensive review on brain-controlled mobile robots and robotic arms based on electroencephalography signals

Recent advancements have led to notable strides in brain-controlled robot systems, rendering them valuable for those with disabilities and various other applications. This paper provides a thorough examination of the EEG-based brain-controlled mobile robots and robotic arms systems that have been created. We initially provided a juxtaposition of SSVEP, P300, and ERD/ERS BCI systems, along with illustrations of their application in robotics. In this paper, the term mobile robot refers to a wheelchair, humanoid robot, simulated or virtual robot, or any robot that can be navigated in two dimensions. The main goal of brain-controlled robot design is to enable a subject to control a mobile robot to reach a target safely and accurately through brain signals [2]. Next, we introduced and examined the methods presently employed in these systems, encompassing signal gathering, preprocessing methods, feature extraction techniques, and machine learning algorithms for EEG classification. We also provided instances of their application in robots. In addition, we demonstrated and discussed current advancements in EEG-based brain-controlled mobile robots and robotic arms, utilizing techniques such as event-related desynchronization/synchronization (ERD/ERS), steady-state visually evoked potentials (SSVEP), P300, and hybrid systems. The output of the discussion included the analysis of the movements of both EEG-controlled mobile robots and robotic arm systems, as well as the examination of assessment concerns. Ultimately, we addressed and deliberated upon several obstacles encountered by developers of EEG-based brain-controlled mobile robots and robotic arm systems.

Self-adaptive shared control with brain state evaluation network for human-wheelchair cooperation

Our study specifically examines the all-time shared control scheme in BCI systems. In contrast to

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time-shared control schemes, all-time shared control systems must address the issue of allocating control weight between human control and robot autonomy in a rational manner. The shared control system has the capability to adaptively adjust the assistance level of robot autonomy for subjects with different control abilities [6]. The majority of shared control systems prioritize weight assignment based on environmental information, such as obstacle distance, and the similarity in control strategy between human and robot autonomy. However, individuals with varying levels of control abilities should be assigned varied levels of support from the robot. This is particularly important for individuals with weak control abilities, who should be provided with higher levels of autonomous aid. Furthermore, the brain state of an individual undergoes changes at many spatio-temporal scales. In order to assess the dynamic state of the brain, we utilize trial-and-error learning to train the BSE-NET. Subsequently, we employ the BSE-NET to generate the shared control signal in an online control experiment. The experimental findings indicate that the majority of the participants successfully completed the wheelchair navigation tasks. Additionally, the shared control system demonstrated the ability to dynamically adjust the level of robot autonomy to suit the individual needs of various participants.

Noninvasive Brain–Machine Interfaces for Robotic Devices

This study presents a comprehensive analysis of the latest advancements in noninvasive BMI-driven technologies. It focuses on 86 research published within the past 15 years, with particular attention given to the interactions between the user, the BMI system, and the robot. Our research revealed that Body-Machine Interfaces (BMIs) are primarily utilized for controlling navigation devices, such as telepresence mobile robots. These BMIs mainly rely on external stimulation and the majority of brain-controlled robots employ a discrete control approach[1]. Only a limited number of works have involved impaired individuals in the evaluation of a brain-controlled robot. The review emphasizes the primary problems in the field, including the integration of BMI and robotics, as well as the necessity for a user-centered design to enhance the translational impact of BMIs.

Brain–machine interfaces for controlling lower-limb powered robotic systems

A comprehensive literature review was performed analyzing studies that proposed the use of Body Mass Index (BMI) in the design of lower-limb robotic systems. Description of the devices, user population, inputs and outputs of the brain-machine interfaces (BMIs) and robots, and the neural properties, decoders and system performance were provided. Systematic review on the studies of the BMIs for controlling the lower-limb robotic systems available in literature [5]. The tasks often involved the classification of distinct state commands, such as walk, stop, and turn. They reported that these approaches are applied or validated poorly in existing EEG denoising studies. We used multiple neural features and decoders for neural identification. Horizontal comparison was tried by conducting ITR scales to compare the two parts

Brain Wave Controlled Robotic Arm for Paralytic and Physically Impaired Patients

The advanced robotic arm system has demonstrated encouraging outcomes and holds potential for assisting impaired individuals in effortlessly carrying out routine activities, so enabling them to lead autonomous and respectable lives. We effectively classified user data into three outputs using the Neurosky Mindwave headset system. Unfortunately, we were unable to control the arm with the accuracy necessary to complete all the different types of movement. In order to execute intricate movements, it may be necessary to improve the design of our system through rehabilitation. To improve the system, it would be beneficial to gather additional data and employ various optimization techniques to increase the differentiation between different ranges. In addition, augmenting the system with a few additional EEG sensors would improve the accuracy of the entire system and yield a superior overall output. In future endeavors, we want to conduct experiments utilizing these methodologies in order to augment the precision of this system, hence enabling its effective implementation in a wide range of real-world settings.

Brain Computer Interface based Arduino Home Automation System for Physically Challenged
Home automation has been built with Internet of Things (IoT) technology to control all devices by connecting them through an internet. With IoT technology all home appliances can be operated. But for physically challenged person, operating the appliances by using internet is remaining as a tough task. Brain Controlled Interface (BCI) technology supports the physically challenged population to communicate with home appliances. In the proposed design, the system will interpret the signals from human brain and convert them into actions. The signals will be further analysed by brain sense headset by placing the electrodes placing around the scalp. These signals are converted into the raw waveform and processed towards the Arduino controller by using Bluetooth module. The Arduino will further process the received signal and operate the appliances by using relay. The proposed system will be cost effective with more ease in the design. The system is specifically designed for paralyzed and disabled persons to help themselves in operating the appliances.

Sensitive Brain-Computer Interface to help manoeuvre a Miniature Wheelchair using Electroencephalography
A Brain-Computer Interface (BCI) serves as a conduit for communication between our brain and any external object. An emerging discipline with a wide array of uses spanning from biomedicine to many industries. The firm utilizes the NeuroSky MindWave Mobile headgear to collect and analyze brainwaves, also known as electroencephalographs (EEG), which measure Attention, Meditation, and Eye Blink Strength. EEGs are the initial non-invasive method capable of precisely capturing the diverse electrical impulses generated by individual neurons [8]. The utilization of EEG signals for the development of a Brain-Computer Interface (BCI) with a Mini-Wheelchair has yielded significant outcomes, including the successful implementation of an EEG-based BCI using an Arduino Microcontroller. This system was built up for less money, and its setup-time time is quite lower. The algorithms were developed using 3 different combinations of concentration, meditation and eye blink strength.

Electroencephalogram based Movable Electric Wheelchair for Differently Abled Person
The objective of this paper is to design a movable electric wheel chair for the Quadriplegia patients. Quadriplegia patients are those people who cannot move any of their appendages in the body underneath their necks. An EEG-based cerebrum-controlled wheelchair has been developed to utilize the Brain PC interface (BCI). The designed chair uses Neurosky mind wave EEG headset [10]. The Atmel Microcontroller is modified utilizing Arduino and MATLAB Programming language to send the BCI yield to perform forward in reverse and rotational developments in the wheelchair. This wheelchair will be a great help for the patients with mobility impairments.

Flexion and Extension Motion for Prosthetic Hand Controlled by Single-Channel EEG
Over the past few decades, many researchers have tried to connect the human brain to digital devices. Brain-Computer Interface (BCI) directly connects the human brain to digital computer devices and controls them by capturing electrical signals generated in the brain. One of the most commonly used devices on the BCI system is an electroencephalogram (EEG). This study applied the single-channel electroencephalogram (EEG) signal as the input signal for a prosthetic hand. A myoelectric hand was developed using 3D printer technology and incorporated motion feedback by coupling a potentiometer to finger linkage [7]. It is part of a non-invasive BCI, where the electrode must be placed outside the skull or on the scalp. However, signal processing for EEG is not easy, and it needs a complex computation method. This study applied the single-channel electroencephalogram (EEG) signal as the input signal for a prosthetic hand. A myoelectric hand was developed using 3D printer technology and incorporated motion feedback by coupling a potentiometer to finger linkage. Attention signal was transmitted from the EEG headset to the Arduino microcontroller using Bluetooth. On-off feedback control was applied as a control system for driving the finger flexion and

extension of the Anthropomorphic Prosthetic Hand. Based on the test result, the hand can be commended using single-channel EEG for flexion and extension motion on the prosthetic hand.

EXISTING SYSTEM VS PROPOSED SYSTEM

EXISTING SYSTEM

Firstly, the lack of remotecontrol operation restricts users from independently initiating or modifying commands from a distance, limiting their ability to fully control the system. This leads to the second issue: users often depend on others to operate these systems, which undermines the goal of achieving true autonomy and independence. Additionally, the absence of muscle contraction sensing further hampers the system's effectiveness, as it cannot provide the nuanced and responsive control necessary for intuitive and natural movement. These limitations underscore the need for significant advancements to enhance the functionality and user experience of brain-controlled robotic assistance.

PROPOSED SYSTEM

The suggested system comprises of two modules: a Transmitter module and a Receiver module. We have constructed a prototype of a mobile robotic apparatus. It is a well-established fact that the brain consistently produces messages, even during periods of rest or sleep. This is why we experience dreams, since the neural impulses continue to be formed subconsciously. We allocated certain activities to a specific range of frequencies or signals. The robotic module will function in accordance with the sensor values it receives from the other module.

This study involves the examination of EEG (electroencephalogram) data in order to control a robotic system with accurate commands. The device employs an EEG signal reader that converts the impulses into analog data. The setup initializes two serial communications: one for traditional serial communication and another for a software-based serial connection. Throughout the operational period, the system consistently measures and records the levels of EEG signals, and presents this data for the purpose of monitoring. The technique is designed to assess specific ranges of EEG signal levels in order to determine corresponding actions for the robot. When the EEG signal level falls between 550 and 700, a directive is transmitted to commence forward motion. When the level is between 400 and 549, the robot is directed to proceed in the other direction. indications with a magnitude between 200 and 300 indicate a right turn, whereas indications ranging from 300 to 400 indicate a left turn. Furthermore, whenever the EEG signal drops below 50, it sends a command to the robot to stop. The robot receives and carries out the correct action by transmitting each instruction over both serial ports. The system includes a time delay after each instruction to prevent rapid and consecutive instructions, therefore assuring smooth operation and accurate execution of tasks based on the recorded levels of the EEG signal. This technique harnesses neural signals to manipulate the movements of robots, aiming to achieve intuitive and immediate control.

The other module focuses on controlling a robot's movement by using accurate commands sent through serial connection. The configuration involves allocating four motor control pins to govern the movement of the left and right motors of the robot. The pins are configured as output to effectively control the motors. Throughout the operational period, the system diligently checks for incoming commands via a serial connection. After receiving a command, the robot analyzes and executes the required procedures to control its motion. Upon receiving an instruction to proceed, the system triggers the motors on both the left and right sides, propelling the robot forward and causing it to progress. During a right turn, the robot selectively engages just the left motor, resulting in a clockwise rotation. Conversely, during a left turn, just the right motor is activated, causing the robot to rotate towards the left. When a stop order is received, all motors are deactivated, resulting in the robot coming to a full stop. The reverse command directs the system to engage the motors in a manner that

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causes both sides of the robot to move in a backward direction, resulting in the robot moving in reverse. Each command is accompanied with a printed message for the purpose of monitoring, to check that the correct operations are being carried out in line with the received instructions. This technique allows for the robot to be manipulated in a natural and immediate way, providing a clear and direct method of guiding its motion and actions.

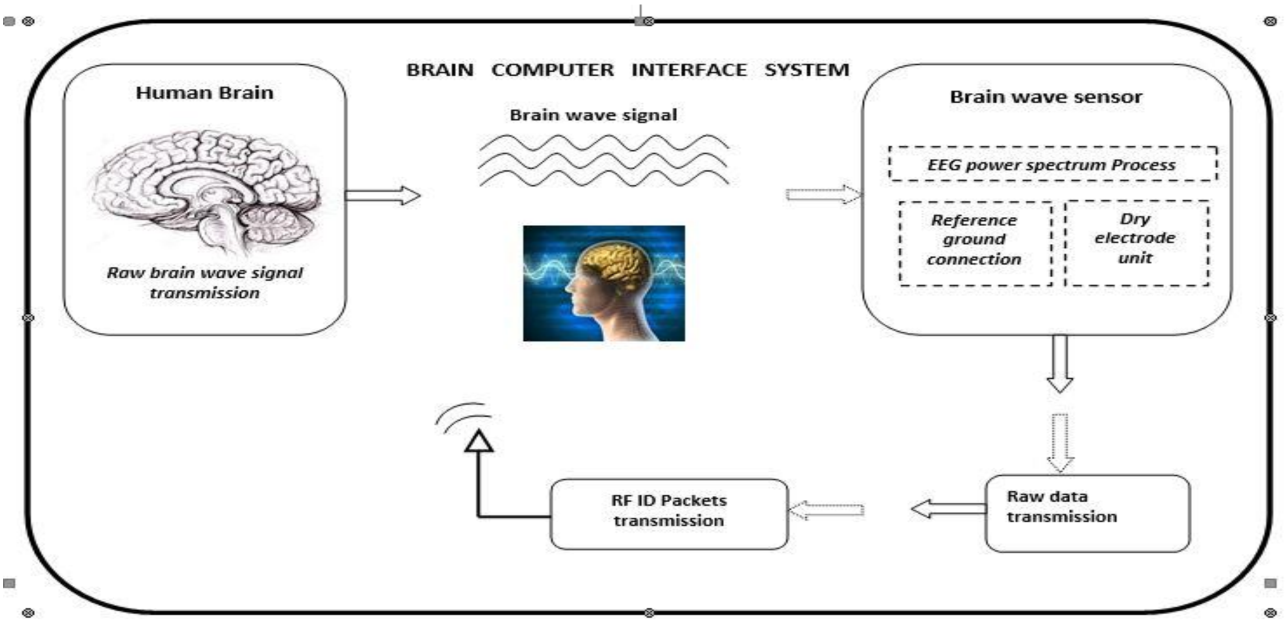

Fig. a

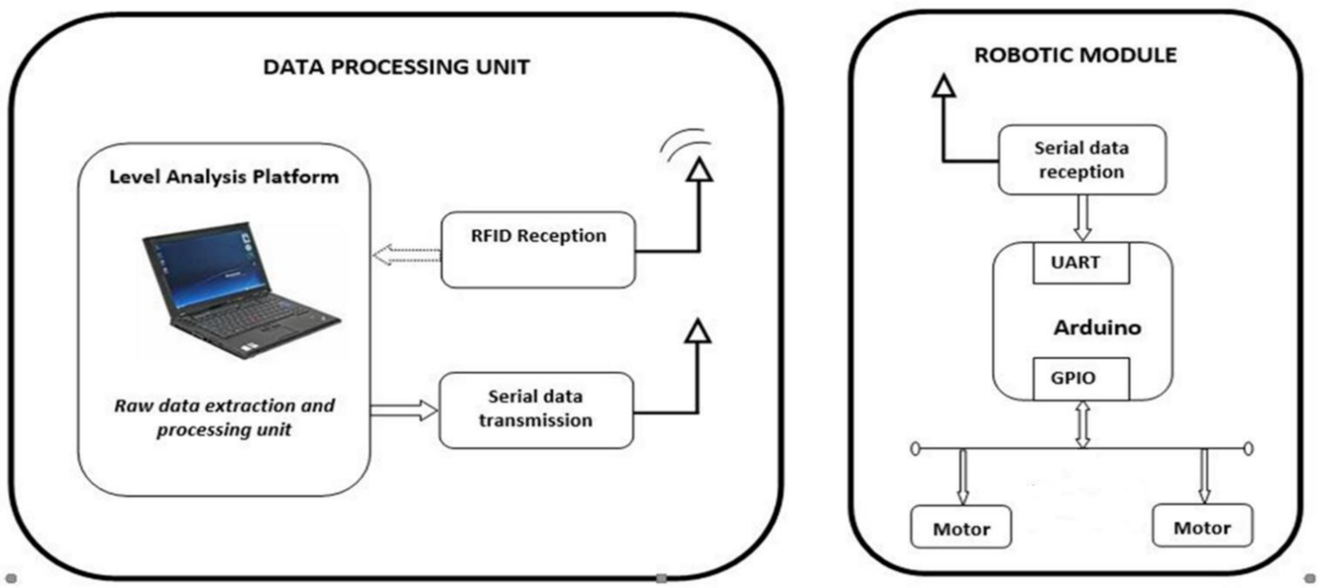

Fig. b

Figure a & b : depicts the block diagram of brain controlled robotic assistance for enhanced mobility and independence in people with disabilities. It starts with extracting EEG signals from the brain through the electrodes and through BCI system these signals are analyzed and translated into commands. This raw data is transmitted in the form of RFID packets and reaches data processing unit through RFID reception. Now the processed serial data is sent to programmed Arduino

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microcontroller which controls the movement of the four motors involved.

RESULTS

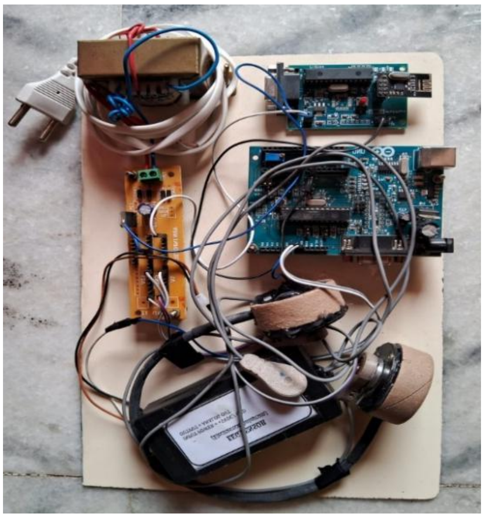

Fig.1

Figure 1: depicts the transmitting section that includes a wireless transmitter, power supply, Arduino microcontroller, stepdown transformer, EEG sensor. This part of the project captures the EEG signals from the brain through the electrodes placed on the scalp and transmits to the receiving section by classifying the captured signals based on the range specified in microcontroller.

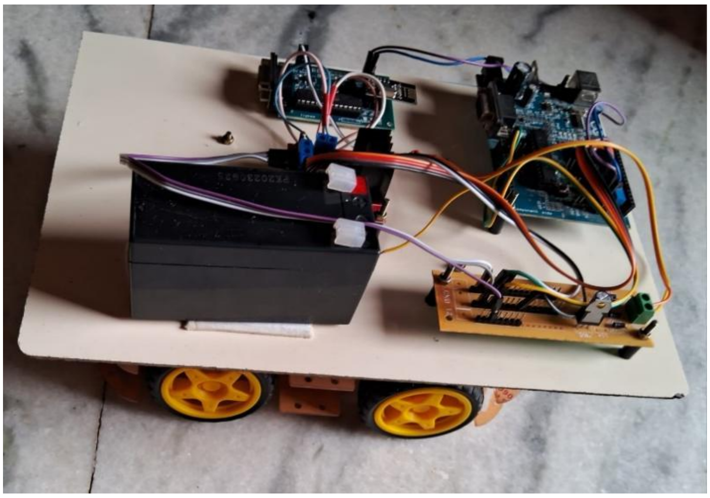

Fig.2

Figure 2: depicts a prototype model of a robotic wheelchair for disabled person that consists of wireless receiver, Arduino microcontroller, battery, power supply board and four motors. When the wireless receiver receives the signals from the transmitter module it invokes the function of Arduino microcontroller. As the microcontroller is programmed to perform the action, the Robot moves in the particular direction based on the range of signals.

CONCLUSIONS

In Conclusion, the combination of Brain-Computer Interface (BCI) technology with the Arduino

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microcontroller family offers an effective option for enabling smooth communication between the human brain and electrical devices. By utilizing the Arduino platform's adaptability and user-friendly nature, in conjunction with the capabilities of BCI systems, a diverse array of applications may be created, including assistive technology, interactive art works, and more. The connectivity solution has the potential to greatly improve accessibility and empowerment for those with impairments. BCI technology enables persons with motor impairments or disabilities to achieve enhanced autonomy by utilizing their brain impulses to operate electronic devices and interfaces. This presents possibilities for enhanced communication, mobility, and quality of life. Moreover, the open-source nature of the Arduino platform and the considerable support from its community empower developers to create and personalize BCI applications based on their individual requirements and preferences. This promotes a cooperative atmosphere where concepts may be exchanged, improved, and put into action quickly, resulting in ongoing progress in BCI technology. Moreover, the Arduino microcontrollers' cost-effectiveness and ease of use make them a perfect option for incorporating BCI technology into many projects and applications, even those with minimal resources or technical knowledge. The democratization of BCI technology facilitates its extensive adoption and implementation in several domains, including as healthcare, education, entertainment, and beyond. To summarize, the smooth incorporation of Brain-Computer Interface technology with the Arduino microcontroller family presents a hopeful approach for accessing new opportunities in human-computer interaction and enabling users to engage with the digital world in innovative and significant manners. The ever-advancing technology has limitless potential to revolutionize lives and enhance experiences through BCI applications.

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