**BRAIN-CONTROLLED CAR FOR DISABLED USING ARTIFICIAL INTELLIGENCE**

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**(ST/CS/ND/20/160)**

**A SEMINAR REPRESENTED TO THE DEPARTMENT OF COMPUTER SCIENCE, SCHOOL OF SCIENCE AND TECHNOLOGY, FEDERAL POLYTECHNIC MUBI, ADAMAWA STATE, NIGERIA**

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**Abstract**

*Brain-Controlled Vehicle (BCV) is an already established technology usually designed for disabled patients. This review focuses on the most relevant topics on brain-controlled vehicles, with a special reference to the terrestrial BCV (e.g., the mobile car, car simulator, real car, graphical and gaming car) and the aerial BCV, also called BCAV (e.g., real quadcopters, drones, fixed wings, graphical helicopter, and aircraft) controlled by using bio-signals, such as electroencephalogram (EEG), Electrooculogram (EOG), and Electromyogram (EMG). For instance, EEG-based algorithms detect patterns from the motor imaginary cortex area of the brain for intention detection, patterns like event-related desynchronization/event-related synchronization, steady-state visually evoked potentials, P300, and generated local evoked potential patterns. We have identified that the reported best-performing approaches employ machine learning and artificial intelligence optimization methods, namely support vector machine, neural network, linear discriminant analysis, k-nearest neighbor, k-means, water drop optimization, and chaotic tug of war. We considered the following metrics to analyze the efficiency of the different methods: type and combination of bio-signals, time response, and accuracy values with statistical analysis. The present work provides an extensive literature review of the key findings of the past ten years, indicating future perspectives in the field.*

**Keywords:** Artificial, intelligence, Application, Control system, Brain computer interface.

**Introduction**

A brain computer interface (BCI), sometimes called a direct neural interface or a brain-machine interface – is a direct communication pathway between a human or animal brain (or brain cell culture) and an external device. In one-way BCIs, computers either accept commands from the brain or send signals to it (for example, to restore vision) but not both. Two-way BCIs would allow brains and external devices to exchange information in both directions but have yet to be successfully implanted in animals or humans (Wu et al., 2022).

In this definition, the word brain means the brain or nervous system of an organic life form rather than the mind. Computer means any processing or computational device from simple circuits to silicon chips (including hypothetical future technologies such as quantum computing) (Katayzyna et al., 2022).

Once the driver (disabled) nears the car. The security system of the car is activated. Images, as well as thermographic results of the driver, are previously fed into the database of the computer. If the video images match with the database entries then the security system advances to the next stage. Here the thermographic image verification is done with the database. Once the driver passes this stage the door slides to the sides and a ramp is lowered from its floor. The ramp has flip actuators in its lower end. Once the driver enters the ramp, the flip actuates the ramp to be lifted horizontally. Then robotic arms assist the driver to his seat. As soon as the driver is seated the EEG (electroencephalogram) helmet, attached to the top of the seat, is lowered and suitably placed on the drivers head. A wide screen of the computer is placed at an angle aesthetically suitable to the driver. Each program can be controlled either directly by a mouse or by a shortcut. For starting the car, the start button is clicked. Accordingly, the computer switches ON the circuit from the battery to the A.C. Series Induction motors (Nehad et al., 2022)..

**Literature Review**

The recent research in neuroscience supported by the development of high-precision sensors and artificial intelligence methods has significantly increased our knowledge about how the human brain works. In particular, human body movements activate neurons in the sensorimotor cortex area. The activated neurons generate action potentials for different actions, which have different patterns with specific properties. Several studies have been conducted to explore patterns in electroencephalogram (EEG) signals. The patterns would be related to voluntary movements or the human body reaction based on the condition, such as stress that our recent review paper on stress detection for drivers and heavy equipment operators considered this phenomenon comprehensively. Subsequently, automatic methods of identifying and predicting these patterns specifically at the onset of a voluntary movement have been introduced (Atefe et al., 2022).

The Brain Computer Interface (BCI) science uses the patterns in EEG signals for the control of applications, such as bionic hands, ankle foot orthosis, mobile robots, vehicles, and wheelchair. These applications are useful for disabled people, who could potentially enjoy a more convenient life. Among the vast variety of BCI applications, this review focuses on the Brain-Controlled Vehicle (BCV) and the Brain-Controlled Aerial Vehicle (BCAV), mainly designed for non-disabled people and in particular for those not having suffered a brain stroke. The benefits of BCV and BCAV applications for skilled workers are for instance easier and faster execution of various tasks, relatively low costs of missions, precision in hazardous missions, remote access to remote locations and research targets, such as safety checks of large areas, burned areas, provision of first-aid equipment in accidents in remote locations, and acquisition of weather information from areas that are difficult to access (mountains, pole areas, or volcanoes) (Atefe et al., 2022).

At present, some of the initial BCV EEG-based questions and limitations have been solved; for instance, the area of the cortex for recording the EEG related to specific tasks such as hand movement, the frequency range of neuron activities, and the specific patterns related to the applied stimulation, and how to develop algorithms for automatically finding the patterns. The unsolved problems are mathematical algorithms for noise rejection and automatic identification of specific patterns with a high precision. In particular, development of effective algorithms for feature extraction and classification for automatic pattern identification are challenging tasks. Further questions associated with neuron connectivity are, for instance: which neurons are connected in a specific task, and how neurons communicate after the stimulation (Katarzyna et al., 2022).

Other challenges are related to the mathematical approaches for prediction of patterns, design of real-time algorithms, and speeding up the processing of time-consuming methods, such as wavelet-based methods. The key problems in the BCV applications based on the EEG are (i) the nonlinearity of the brain, generating patterns of different varieties for individual participants; (ii) the denoising of the EEG signals affected by white noise (which is highly nonlinear, and is similar to the EEG); (iii) hardware limitations (distance and speed) of communication for portable and wireless devices (irrespective of Bluetooth and Wi-Fi) in real-time applications.

In the initial generation of key series studies, Atefe *et al.* (2022), implemented an EBC system for BCV applications by using EEG and EMG signals in a graphical racing car task in the real-time mode. In the algorithm, the areas under the ERP patterns relative to the emergency brakes were computed and categorized using the RLDA classifier, and the efficiency was considered by accuracy and response time (reaction) parameters. The cons of the method are the low number of features, the limited ERP patterns for feature extraction, and the use of the linear classification RLDA. Therefore, different types and a larger number of ERPs for training of a nonlinear classifier for such a complicated signal (EEG) are highly recommended. It is noted that the ERPs vary over time in various situations.

In the study by Katarzyna *et al.* (2022), the objective was to overcome the limitations of previous studies by increasing the number of states for identification (soft and sharp braking) based on the driver’s intentions. Each state has different task scenarios; soft braking refers to normal driving conditions, and sharp braking to a scenario with an obstacle on the road. In order to overcome the disadvantages mentioned earlier, features were extracted from three different patterns, such as RPs (time interval from 300 ms before the stimulation to 600 ms after the stimulation), the IM (ERD/ERS obtained by filtering EEG data between 5 and 35 Hz) and the ERP (obtained by Hilbert transformation). The results showed a higher accuracy to “… compared to the previous study. In addition, the authors reported that the area of the cortex which produce the ERP patterns relative to the emergency cases were determined. The limitation in the study of was the low rate of robustness and the use of the binary RLDA classifier for categorizing more than two classes. The RLDA principle is based on the LDA algorithm, which is a linear classifier designed for binary identification. The LDA maximizes between-group scattering over within-group scattering. In other words, the algorithm searches for the projections by optimizing the feature space coordination, which reduces the inter-class variance whilst increases the distance between classes. By regularizing the LDA (RLDA), scattering of the inter-class features is regularized and enables a nonsingular matrix, which has the capability of employing a large number of features for the classification. The main limitations of the RLDA are the linearity of the algorithm and confinement to two state identifications (Amin et al., 2022).

To solve the low robustness in the real-time experiment, Atefe *et al.* (2022), extracted new features from the auditory signals in a vehicle-following graphical task for training of a RLDA classifier. The new trained algorithm was tested for the EBC in a real-world traffic case. The results did not report the accuracy and robustness of the algorithm. Overall, the presented series of studies aimed to extend the results by using patterns from EEG, EMG, and auditory signals. The significant advantages are variations of ERP patterns generated in different situations by using scenario tasks. The main drawback of the studies is that a larger number of subjects was not employed when using different classifiers.

**Artificial Intelligence**

Affective computing is the study and development of systems that can recognize, interpret, process, and simulate human affects. It is an interdisciplinary field spanning computer sciences, psychology, and cognitive science. While the origins of the field may be traced as far back as the early philosophical inquiries into emotion the more modern branch of computer science originated with Rosalind Picard’s1995 paper on "affective computing". A motivation for the research is the ability to simulate empathy, where the machine would be able to interpret human emotions and adapts its behavior to give an appropriate response to those emotions (Nehad et al., 2022).

**Applications of Artificial Intelligence**

One main factor that influences the ability for a driver-less automobile to function is mapping. In general, the vehicle would be pre-programmed with a map of the area being driven. This map would include data on the approximations of street light and curb heights in order for the vehicle to be aware of its surroundings. However, Google has been working on an algorithm with the purpose of eliminating the need for pre-programmed maps and instead, creating a device that would be able to adjust to a variety of new surroundings. Some self-driving cars are not equipped with steering wheels or brakes, so there has also been research focused on creating an algorithm that is capable of maintaining a safe environment for the passengers in the vehicle through awareness of speed and driving conditions (Wu et al., 2022).

Another factor that is influencing the ability for a driver-less automobile is the safety of the passenger. To make a driver-less automobile, engineers must program it to handle high risk situations. These situations could include a head on collision with pedestrians. The car's main goal should be to make a decision that would avoid hitting the pedestrians and saving the passengers in the car. But there is a possibility the car would need to make a decision that would put someone in danger. In other words, the car would need to decide to save the pedestrians or the passengers. The programing of the car in these situations is crucial to a successful driver-less automobile.

#### Biocontrol System

The biocontrol system integrates signals from various other systems and compares them with originals in the database. It comprises of the following systems:

1. Brain-computer interface
2. Automatic security system
3. Automatic navigation
4. system

##### Brain Computer Interface

Brain-computer interfaces will increase acceptance by offering customized, intelligent help and training, especially for the non-expert user. Development of such a flexible interface paradigm raises several challenges in the areas of machine perception and automatic explanation. The teams doing research in this field have developed a single-position, brain-controlled switch that responds to specific patterns detected in spatiotemporal electroencephalograms (EEG) measured from the human scalp. We refer to this initial design as the Low Frequency.

The EEG is then filtered and run through a fast Fourier transform before being displayed as a three-dimensional graphic. The data can then be piped into MIDI compatible music programs. Furthermore, MIDI can be adjusted to control other external processes, such as robotics. The experimental control system is configured for the particular task being used in the evaluation. Real Time Workshop generates all the control programs from Simulink models and C/C++ using MS Visual C++ 6.0. Analysis of data is mostly done within Mat lab environment.

**Automatic Security System**

The EEG of the driver is monitored continually. When it drops less than 4 Hz then the driver is in an unstable state. A message is given to the driver for confirmation and waits for some time, to continue the drive. A confirmed reply activates the program for automatic drive .If the driver is doesn’t give reply then the computer prompts the driver for the destination before the drive.

##### Automatic Navigation System

As the computer is based on artificial intelligence it automatically monitors every route the car travels and stores it in its map database for future use. The map database is analyzed and the shortest route to the destination is chosen. With traffic monitoring system provided by satellite radio the computer drives the car automatically. Video and anti-collision sensors mainly assist this drive by providing continuous live feed of the environment up to 180 m, which is sufficient for the purpose.

##### Electroencephalography

In conventional scalp EEG, the recording is obtained by placing [electrodes o](https://en.wikipedia.org/wiki/Electrode)n the scalp with a conductive gel or paste, usually after preparing the scalp area by light [abrasion t](https://en.wikipedia.org/wiki/Abrasion_(medical))o reduce [impedance d](https://en.wikipedia.org/wiki/Electrical_impedance)ue to dead skin cells. Many systems typically use electrodes, each of which is attached to an individual wire. Some systems use caps or nets into which electrodes are embedded; this is particularly common when high-density arrays of electrodes are needed.

Electrode locations and names are specified by the [International 10–20 system f](https://en.wikipedia.org/wiki/10-20_system_(EEG))or most clinical and research applications (except when high-density arrays are used). This system ensures that the naming of electrodes is consistent across laboratories. In most clinical applications, 19 recording electrodes (plus ground and system reference) are used.[[38] A](https://en.wikipedia.org/wiki/Electroencephalography#cite_note-38) smaller number of electrodes are typically used when recording EEG from [neonates.](https://en.wikipedia.org/wiki/Infant) Additional electrodes can be added to the standard set-up when a clinical or research application demands increased spatial resolution for a particular area of the brain. High-density arrays (typically via cap or net) can contain up to 256 electrodes more-or-less evenly spaced around the scalp. The EEG signals can be captured with opensource hardware such as [OpenBCI a](https://en.wikipedia.org/wiki/OpenBCI)nd the signal can be processed by freely available EEG software such as [EEGLAB o](https://en.wikipedia.org/wiki/EEGLAB)r the [Neurophysiological Biomarker Toolbox (Wu et al., 2022).](https://en.wikipedia.org/wiki/Neurophysiological_Biomarker_Toolbox)

As part of an evaluation for epilepsy surgery, it may be necessary to insert electrodes near the surface of the brain, under the surface of the [dura mater.](https://en.wikipedia.org/wiki/Dura_mater) This is accomplished via burr hole or [craniotomy.](https://en.wikipedia.org/wiki/Craniotomy) This is referred to variously as ["electrocorticography (ECoG)",](https://en.wikipedia.org/wiki/Electrocorticography) "intracranial EEG (I-EEG)" or "subdural EEG (SD-EEG)". Depth electrodes may also be placed into brain structures, such as the [amygdala o](https://en.wikipedia.org/wiki/Amygdala)r [hippocampus,](https://en.wikipedia.org/wiki/Hippocampus) structures, which are common epileptic foci and may not be "seen" clearly by scalp EEG. The electrocorticographic signal is processed in the same manner as digital scalp EEG (above), with a couple of caveats. ECoG is typically recorded at higher sampling rates than scalp EEG because of the requirements of [Nyquist theorem](https://en.wikipedia.org/wiki/Nyquist%E2%80%93Shannon_sampling_theorem) [t](https://en.wikipedia.org/wiki/Nyquist%E2%80%93Shannon_sampling_theorem)he subdural signal is composed of a higher predominance of higher frequency components.

Since an EEG voltage signal represents a difference between the voltages at two electrodes, the display of the EEG for the reading encephalographer may be set up in one of several ways. The representation of the EEG channels is referred to as a montage.

###### Sequential montage

Each channel (i.e., waveform) represents the difference between two adjacent electrodes. The entire montage consists of a series of these channels. For example, the channel "Fp1-F3" represents the difference in voltage between the Fp1 electrode and the F3 electrode. The next channel in the montage, "F3-C3", represents the voltage difference between F3 and C3, and so on through the entire array of electrodes.

###### Referential montage

Each channel represents the difference between a certain electrode and a designated reference electrode. There is no standard position for this reference; it is, however, at a different position than the "recording" electrodes. Midline positions are often used because they do not amplify the signal in one hemisphere vs. the other. Another popular reference is "linked ears", which is a physical or mathematical average of electrodes attached to both earlobes or [mastoids*.*](https://en.wikipedia.org/wiki/Mastoid_process)

###### Average reference montage

The outputs of all of the amplifiers are summed and averaged, and this averaged signal is used as the common reference for each channel.

###### Laplacian montage

Each channel represents the difference between an electrode and a weighted average of the surrounding electrodes.

#### Conclusion

This is an era of technology and artificial intelligence is going to conquer the globe in the years to come. With a few modifications to the existing system and a unanimous support from the government and the society, this system can be used to serve the disabled in greater ways and bring about a revolutionary change in the society. Thus, the integration of bioelectronics with the automatic system is going to be the hour of the need for all futuristic vehicles.

**Recommendations**

Therefore, this paper recommends that, an accurate alerting system is required to analyze the feeling of the user during work such as alpha waves monitoring, eye tracker and/or video processing to inform how is the user situation and how the user should proceed the work.

It also recommends that an air traffic system for control of drones how and where to move to prevent crashes be developed.

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