# A Review Paper on Electrified Vehicles and BCI Technology Integration

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**Abstract:- In our daily life, we generally witness disabled people travelling from one location to another on a variety of tricycles and triwheeled vehicles. Nevertheless, for those who suffer from ALS, cerebral palsy, or autism (all related to brain development, causing problems in locomotion, unable to move the muscles of body). For them, using or operating standard cars designed for disabled people is difficult, or perhaps better put, impossible. We'll use BCI (brain-computer interface) technology to make it simple for these people with disabilities to operate vehicles. By using solely their brain signals, BCI enables a person to communicate with a machine (EEG-Electroencephalogram). By utilising a brain-computer interface, we will improve how these disadvantaged people engage with these electric vehicles in this study. Through fictitious movement, this BCI technology can enable impaired people to operate electric automobiles.**

***Keywords:*** *Brain-Computer Interface; Electric Cars; EEG.*

## I. INTRODUCTION

People with impairments can benefit from EEG-based brain computer interface (BCI) systems to improve their quality of life. The restoration of movement, communication, and environmental control are all applications of BCI systems. The most difficult aspect of these applications is to EEG is used to operate automobiles. A few studies have been done on how to construct an information chain from. The BCI system connects the brain to automobiles. Nankai University's DuanFengand his research team implement. The gadget can control the car via communicating with the auto control system and EEG signals (Humans' thoughts).

Although substantial progress has been achieved in this field, there are still at least two main barriers to overcome before BCI technology may be used commercially. To begin with, most BCI systems were developed in a lab setting, resulting in a lack of flexibility, scalability, and availability. Second, complete. The BCI system's technology was both sophisticated and expensive, and the applications that went with it were equally so. Promotion is challenging. Researchers who are striving to solve the problems listed above encounter significant hurdles. With the rise in popularity of electric cars in recent years, an increasing number of individuals have chosen to use them as transportation. It also offers the advantages of being simple to use, energy efficient, and environmentally friendly.Because of the brain-machine interface technology utilized in electric car drive control systems, it will be easier for people with disabilities to travel alone. The purpose of this research is to develop a framework for real-time BCI control of electric vehicles. This involves physiological signal acquisition, EEG transmission, and the usage of mobile devices. EEG is analyzed and processed before cars are controlled.

## II. EXISTING WORK

Hans Berger discovered the electrical signals of brain and the creation of electroencephalography (EEG), where the history of brain and computer interfaces begins. Berger is considered the first to man who uses an EEG to capture human brain activity(1924). By examining EEG traces, Berger was capable of recognising oscillatory activity, like Berger's wave or generally called as the alpha wave (8–13 Hz). Berger's original recording system was quite basic. His patients had silver wires placed beneath their scalps. Later, rubber bandages were used to secure silver foils to the patient's skull in their place. With poor results, Berger said that these sensors were like the Lippmann’s capillary electrometer. After the invention of “Siemens double-coil recording galvanometer”, which was able to exhibited electric voltages as tiny as one ten thousandth of a volt, is one of the more complex measurement instruments? Berger looked into the relationships between differences in his EEG waveform diagrams and different neurological conditions. EEGs opened up completely new fields of inquiry into the functioning of the human brain.

The term "brain computer interface" (BCI) refers to a new method of interacting with computers that involves collecting relevant EEG signals using EEG acquisition equipment, extracting features from those signals, classifying various brain functions and emotions (such as mouse movements up and down, etc.), and then establishing link in between the brain of humans and the external devices like computers, lights, wheelchairs, cell phones, vehicles, etc.

JR Wolpaw and DJ McFarland started utilising EEG in 1991 to research the brain computer interface system; at the time, this technology was mostly used to control cursor movement in 1D.

A brain independent thinking control cursor movement experiment was first presented by Pfurtscheller et al. in the year 2000. E Donchin developed a character input mechanism for the P300. Additionally, some individuals implement the screen menu selection utilising steady-state visual evoked potential (SSVEP). The experimental system for telephone dialling by SSVEP was created by Professor Gao SHANGKAI and colleagues at Tsinghua University in

2002. It was implemented in 2003 employing BCI control of devices including lights, TVs, phones, and other interior environments.Tsinghua University utilised EEG to effectively manage a football-playing dog in 2006.

The so-called brain machine interface (BCI) uses the brain's natural communication pathways through the usage of muscles and peripheral nerves. Most notably for those with damaged nerves and muscles, people hope that this new communication technology can be used as an auxiliary control of vehicles, weapons, and other systems, giving them another way to communicate with the outside world since patients with disabilities are unable to use conventional means of communication.

## III. SYSTEM DESIGN

### *A. Structure of the System*

The architecture schematic of the BCI shows the EEG cap, a signal gathering and amplification unit, a signal processing module, and a controller system (Fig. 1). The driver and the four components make up the entire data chain.

This data cycle has four stages.

- Cortical potentials will shift as a result of human thought activity. This shift can be recorded with an EEG cap equipped with a high-sensitivity electrode.
- The data wire from the EEG cap is used to transmit this signal to the signal collection and amplification device. The system can accept 8 analogue input channels that are digitalized at a resolution of 16 bits and sampled at a constant sampling rate of 256 Hz.
- The original signal is converted to formated data in the form of a sizable data matrix by the signal acquisition and amplification unit.
- This device's primary job is the conversion of pretreatment EEG signals into control signals, such as turning left or right, go ahead or backward, stop, etc. The movement of the automobile will provide input to the driver.

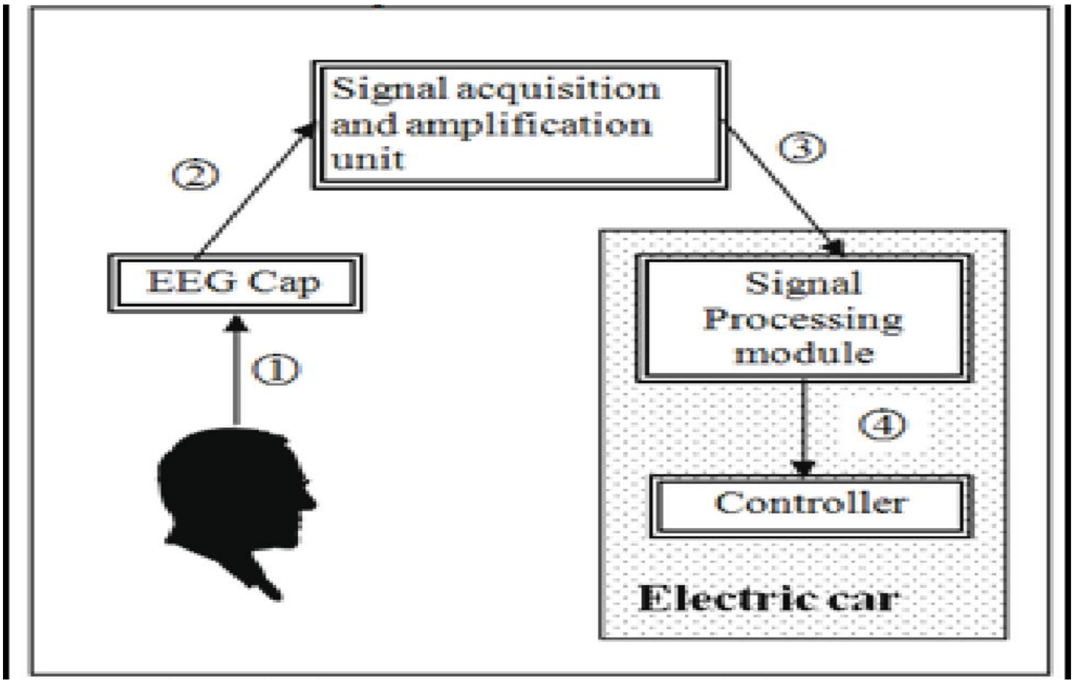


Fig. 1: BCI system architecture for electric vehicles

Prior to designing software, one of the first things we must do is analyse the requirements. UML, a popular modelling tool, has a wide variety of diagram forms. Use case diagrams are among the mainutilising UML diagrams. The diagram used for the BCI system for electric cars is shown in figure 2 below:

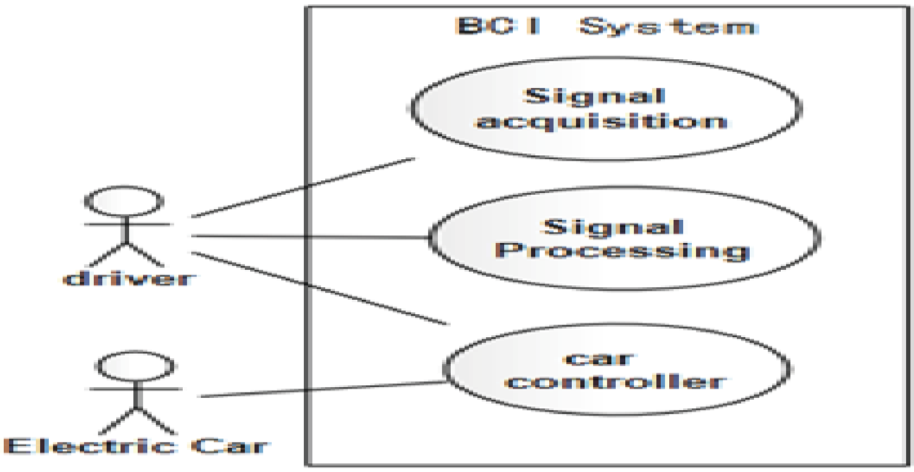

Fig. 2: BCI system use case diagram for an electric vehicle

The main three key use cases are: signal collection, signal processing, and automobile controller, as shown in figure 2. The use case for signal acquisition is in charge of reading EEG data packs from an EEG collecting device through a Bluetooth connection and sending them to the signal processing module after collecting them. The use case for signal processing is in charge of analysing and processing EEG data from the given signal analysis modules, with the final findings being delivered to the controller of the vehicle. The electric car's movement direction and speed are finally controlled by control signals produced by the car controller. The driver and electric automobile play the two roles in the illustration. Two activity diagrams for the use cases of signal acquisition and signal processing are shown in figures 3 and 4.

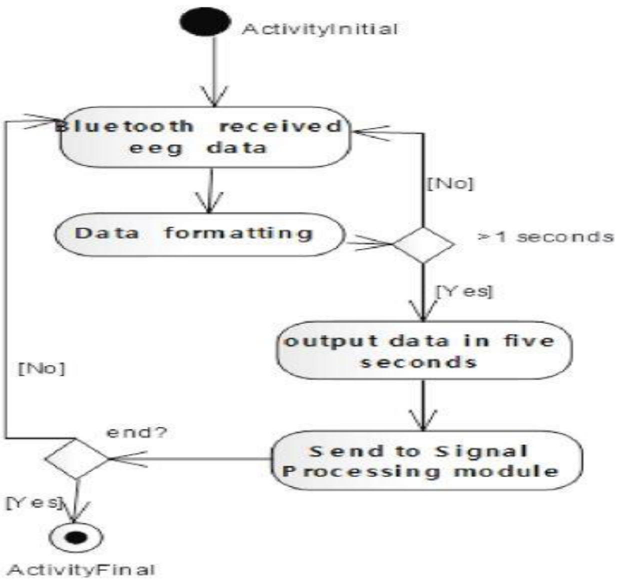

Fig. 3: A flowchart of signal acquisition activity

Figure 3 illustrates how the system first receives the EEG data through the Bluetooth port, stores it after formatting, and then checks to see if there has been a delay of more than one-half of a second. If so, it outputs the EEG data that was collected in few seconds before sending it to the signal processing module.

Figure 4 illustrates how the structured EEG data delivered from the acquisition module will be received by the system. Following that, the system goes through four stages: signal pre-processing, feature extraction, feature selection, and classification. The system will transfer data to the controller unit or give the result and go on to the next data analysis if specific classification results were achieved.

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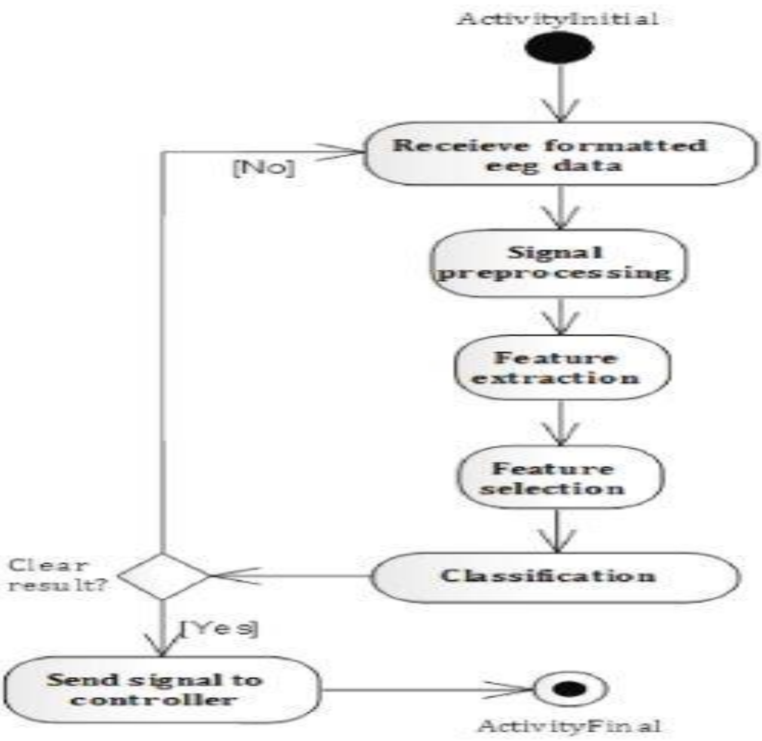


Fig. 4: A flowchart of signal processing activity

This is a sequence diagram of the primary operation flow of this system, as shown in figure 5. Participate in the role graph of drivers, which includes electric cars, EEG acquisition devices, and its class participation in Analysis and Controller.

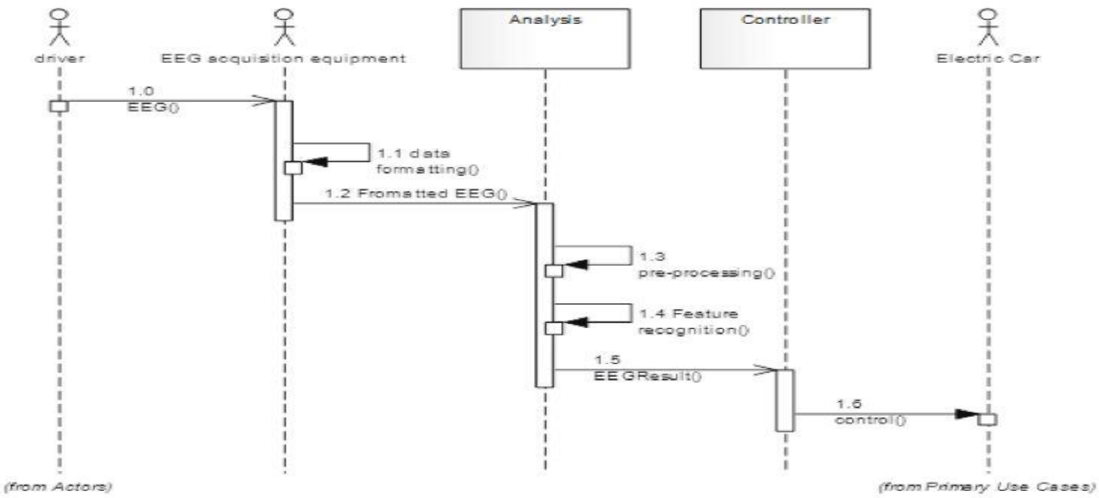


Fig. 5: Diagram showing the primary activity's sequence

*B. Structure Architecture*

We must stick to a straightforward class structure while creating the software architecture for the interaction framework. The Classes, including Active and Parameterized Classes, and other components of the model are depicted in the Class Diagram, which illustrates the logical structure of the system. It is a static model that describes what already existing and the characteristics and behaviors it possesses, as opposed to how something is carried out. The best way to show the connections between Classes and Interfaces is through a class diagram. Fig. 6 depicts the class structure of the BCI system for electric cars. EEGStream, EEMatrix, and EEGResult are three of the data entity types represented in the illustration.The standard format for EEG data is represented as an electrical matrix, which is stored and managed by the EEGStream class. The EEGResult class is in charge of storing "non-standard matrix data" formats for analyzing of all different kinds of pre results, as well as final results. The Bluetooth class is in charge of managing Bluetooth port communication, the Analysis class is in charge of managing method calls and processing all types of signal analysis, and the Controller class is in charge of converting the results collected fromprocessing unit into a control data that is forwarded to the electric car. The Controller class further contains two subclasses, the Direction Controller class and the Speed Controller class, respectively. Manager class will oversee the management of all operational processes.

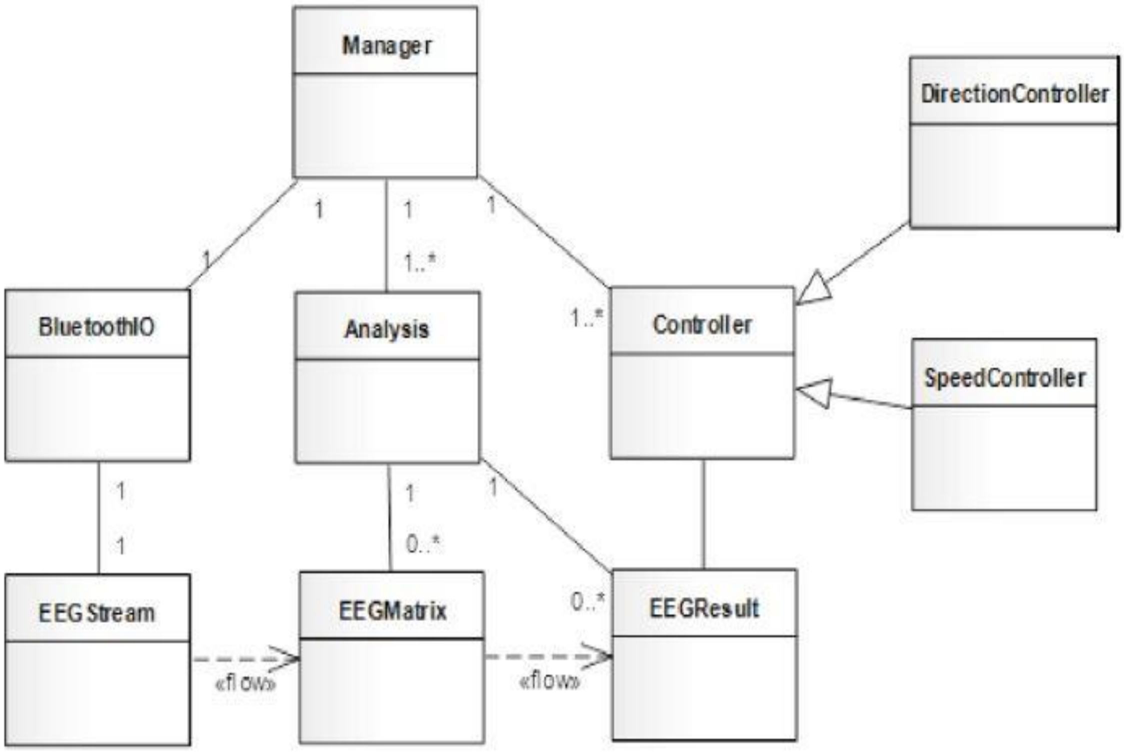


Fig. 6: BCI system architecture for electric vehicles

*C. Limitations*

The parameters used in this investigation are straightforward and well controlled. It does not seek to identify challenges that could occur in the usage of the suggested solutions in a commercial or non-academic context, instead concentrating on the examination of appropriate control mechanisms. In particular, this study does not look into or offer remedies for potential signal inferences in a moving vehicle. On the other hand, investigations have shown that abrupt motions brought on by vehicle motion can result in inaccurate EEG headset readings. One of the biggest difficulties preventing the use of the apparatus used here in the real life is the impact of motion.

*D. Equipment constraints*

Outside of the context of experiments, neither the EEG reading headgear nor the eye tracking apparatus have much use. The "Pupil Labs eye tracker" is often used in 2-dimensional estimate mode, which restricts its capacity to deliver accurate readings during the change of the user's location. Throughout each test, the participants are instructed to maintain complete stillness. A more advanced gadget made of numerous cameras that can predict the user's stance and offer accurate values might take the place of the eye tracker in order to solve this issue. The EEG headset being utilised is a tool for research and testing; comfort and setup time are not being considered.

The fundamental physics of the interface itself are one of the main problems that brain-computer interface researchers are now tackling. The electroencephalograph (EEG), a collection of electrodes that can read brain activity, is the simplest and least intrusive approach. The electrodes of an EEG instrument specifically monitor the voltage changes brought on by the passage of current within the brain's neurons. The skull, however, obstructs much of the electrical transmission and distorts what does.

*E. Safety issues*

When talking about a wheelchair situation, it's critical to remember that such a system would need to meet a very high standard of safety in order to be approved for the transportation of a disabled person. However, a car equippedwith theBCI system with the intention of identifying and responding to unexpected emergency circumstances may run into much more difficulties. While safety systems that rely on a vehicle's sensors would be able to see a hazard in some circumstances, systems that depend on human response, such emergency braking assistance, would be useless if the user was not paying attention and didn't intend to be driving. Therefore, the application of the described control system to a vehicle in a typical driving situation should only be seen as a help. Increased safety can be achieved in this application by using the EEG signals to previously identify the operator's action to stop up to 420 ms quicker than observable circumstances. As previously mentioned, inaccurate readings brought on by outside influences might jeopardize the passenger's safety. The EEG headgear should need to be consistently kept from moving during unexpected changes in the car's motion in order to be utilised in such a situation without experiencing a system failure. Furthermore, if alternative channels are available, the P300 values should never be favored due to their excessive latency.

### *F. Ethical issues*

Adding interfaces that handicapped people may utilise to move around and perform everyday tasks has its own special obstacles. The autonomous components of the steering steps need to be thoroughly and fully investigated to safeguard since paralysed and quadriplegic individuals with restricted bodily functions are particularly vulnerable.

## IV. CONCLUSION

This given study looked at a brain and computer interface for impaired people to drive and presented a brand-new target-following-based steering technique. An examination of the study questions has been conducted, along with a discussion of the issues raised by participants and recommendations for enhancements. So, there are four key elements that may be used to summarize the study's findings.

The proposed techniques and anticipated future work related to such interfaces have been realized in a testing unit. By removing the operator from the vehicle, the technology creates a secure setting for testing real-world driving. Most of the subjects were capable to complete the driving tasks despite technological issues that arose throughout several of the studies. Finally, elements of the proposed method might be evaluated in a real-world automobile environment. Despite major challenges brought on by a changing surroundings and light intensity levels, the simpler version of the system managed to maintain a certain degree of functionality. The system's shortcomings have been noted, and potential changes for future development have been put forth.

## V. FUTURE IMPROVEMENT

The results of this investigation are generally encouraging. Without any training, the participants should be able to utilize the system, while in certain circumstances; the achievement of the suggested technique performs far better than alternatives now available. But some of the participants were unable to operate the vehicle due to technical difficulties. Several important elements that need improvement have been identified based on the replies gathered. Therefore, more research on the goal-oriented control as well as the using of the P300 signal to voluntarysubjectchoosing should be conducted on the basis of modified circumstances. The results of this above study can potentially be utilised to examine other uses for brain-computer interfaces.

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