OBSTACLE AVOIDING ROBOT WITH BRAIN INTERFACE

PROJECT PHASE-I REPORT
Submitted by

SREERAG V (ASI20CS110)
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Under the guidance of

PROF. SUMESH C RAMAN

To

APJ Abdul Kalam Technological University
In partial fulfilment of the requirements for the award of the Degree
of
Bachelor of Technology in Computer Science and Engineering

Department of Computer Science and Engineering

(NBA Accredited Program)
ADI SHANKARA INSTITUTE OF ENGINEERING AND
TECHNOLOGY KALADY

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ADI SHANKARA INSTITUTE OF ENGINEERING AND TECHNOLOGY, KALADY

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

Certified that this is a bonafide record of the seminar entitled

"OBSTACLE AVOIDING ROBOT WITH BRAIN INTERFACE"

Submitted by

SREERAG V (ASI20CS110)
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during the year 2023-24 in partial fulfillment of the requirement for

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Project Guide | Project Coordinator | Head of the Department

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VISION AND MISSION OF THE DEPARTMENT

VISION

Nurturing globally competent Computer Science and Engineering graduates capable of taking challenges in the industry and Research; Development activities.

MISSION

- Imparting quality education to meet the needs of industry, and to achieve excellence in teaching and learning.
- Inculcating value-based, socially committed professionalism for development of society.
- Providing support to promote quality research.

CONTENTS

CHAPTER 1

INTRODUCTION

OARBi, or Obstacle Avoiding Robot with Brain Interface is not just a small scaled robot that can avoid obstacles and be controlled with our minds. It is a robot that will pave the way to future generations where humanity can control things with their mind with the additional security of the "thing" being able to automatically navigate through a determined path, if needed. The whole system, be it mind controlling or obstacle avoiding, is integrated onto a single robotic vehicle to demonstrate its capability of being controlled by the human mind and avoiding obstacles on its own. Although OARBi started off as a simple obstacle avoiding robot, a breakthrough in BCI or brain computer interface made the development of controlling via the brain and thus adding that to the already existing obstacle avoiding robot. The aforementioned breakthrough in the BCI space was a BCI device, or EEG device to be exact, that could be used to read data from the visual cortex part of the human brain and then process that data with machine learning and further continue to transport it to the digital computers so that it can be mapped to the onboard processor (which in this case, is an Arduino board) and in turn control the motoring functions of the robotic vehicle. Basically, OARBi has 2 integrated functions. OARBi can be controlled via our minds and OARBi can move on it's own. The additional feature is that both of these can be integrated together. As in, OARBi can be controlled via the mind and then even so, it can help avoid obstacles and even plan new routes and take appropriate measures to go through the appropriate route.

The primary objective of OARBi extends beyond creating a robot solely controlled by the human mind. Instead, OARBi functions as a demonstrative platform with the potential for integration into practical applications. While OARBi may have limited standalone utility tailored to specific human needs, it stands as a compelling showcase of possibilities emerging from recent advancements in both the BCI and robotics realms.

CHAPTER 2

LITERATURE SURVEY

[1] Keerthi Kumar M, Chaitra Rai, Manisha R, Priyanka C B, Syeda Saniya Anis

EEG Controlled Smart Wheelchair for Disabled People (2019) - The paper presents an intelligent control method for controlling an electric wheelchair for several disabled persons.The proposed system aims to resolve the problem of providing a reliable and accurate method of controlling a wheelchair for people with disabilities who cannot use conventional methods of controlling a wheelchair, such as a joystick or keyboard. The proposed system can be implemented by process of :

1.Data Acquisition
2.Preprocessing
3.Feature extraction and classifications

[2] O-Yeon Kwon ,Min-Ho Lee ,Cuntai Guan and Seong-Whan Lee

Subject Independent Brain ComputerInterfaces Based on Deep Convolutional Neural Networks (2020) - Is based on Deep Convolutional Neural Networks" involves constructing a large motor imagery-based EEG database and proposing a subject-independent framework based on deep convolutional neural networks The study aims to build a calibration-free or subject-independent BCI system that does not require a calibration procedure for each individual user before using the BCI. The discriminative feature representation is formulated as a combination of spectral-spatial input embedding the diversity of the EEG signals and a feature representation learned from the CNN through a fusion technique that integrates a variety of discriminative brain signal patterns.

[3] Jin Woo Choi ,Junyong Park ,Sejoon Huh , and Sungho Jo

AsynchronousMotor Imagery BCI and LiDAR-Based Shared Control System for Intuitive Wheelchair Navigation (2023) - The research paper “Asynchronous Motor Imagery BCI and LiDAR-Based Shared Control” proposes a brain-controlled mobility system that uses real-time neural signals from motor imagery. The system includes shared control capabilities that consider continuously updated environmental information along with EEGsignals to improve navigation performance. A comparative study was conducted using a wheelchair equipped with LiDAR and IMU sensors, where participants drove the wheelchair using either the brain-controlled system or a keyboard. The results showed that the shared control approach enabled participants who failed with the asynchronous BCI-based system to successfully complete the task.

[4] Rui Zhang, QihongWang, Kai Li,Shenghong He, Si Qin, Zhenghui Feng,Yang Chen, PingxiaSong,Tingyan Yang,Yuandong Zhang,Zhuliang Yu,Yaohua Hu, MingShao*, Yuanqing Li

A BCI-BasedEnvironmental Control System for Patients With Severe Spinal Cord Injuries (2017) - The research paper “A BCI-Based Environmental Control System for Patients With Severe Spinal Cord Injuries” proposes an event-related potential (ERP) brain-computer interface (BCI)-based environmental control system1. This system integrates household electrical appliances, a nursing bed, and an intelligent wheelchair to assist paralyzed patients with severe spinal cord injuries (SCIs). The system uses an asynchronous mode to switch the environmental control system on or off or to select a device for achieving self-paced control. Two experiments involving six SCI patients were conducted separately in a nursing bed and a wheelchair, and the patients were instructed to control the nursing bed, the wheelchair, and household electrical appliances.

[5] Rui Zhang,Yuanqing Li,Member, Yongyong Yan, Hao Zhang,Shaoyu Wu,Tianyou Yu, and Zhenghui Gu,

Control of a Wheelchair in an Indoor Environment Based on a Brain–Computer Interface and Automated Navigation (2016) - The research paper “Control of a Wheelchair in an Indoor Environment Based on a Brain–Computer Interface and Automated Navigation” presents a brain-controlled intelligent wheelchair with the capability of automatic navigation. The system uses an autonomous navigation system to automatically generate candidate destinations and waypoints based on the existing environment. The user selects a destination using a motor imagery (MI)-based or P300-based BCI. According to the determined destination, the navigation system plans a short and safe path and navigates the wheelchair to the destination

[6] Dr.E.V.Krishna Rao, N.Yaswanth Kumar Reddy,B.V.S.S.Greeshma, Y.S.S.Vardhan Reddy

EEG Based Smart Wheelchair For Disabled Persons Using Non-Invasive BCI (2022) - The IEEE research paper "EEG Based Smart Wheelchair For Disabled Persons Using Non-Invasive BCI" proposes a smart wheelchair system that integrates a non-invasive brain-computer interface (BCI) with automated navigation techniques to control the wheelchair in an indoor environment. The methodology of the research paper is not explicitly mentioned in the search results. However, the paper likely includes a description of the experimental setup, data collection, and analysis methods used to evaluate the performance of the proposed system. The paper may also include a discussion of the limitations and future directions of the research.

CHAPTER 3

PROPOSED SYSTEM

3.1 Objective

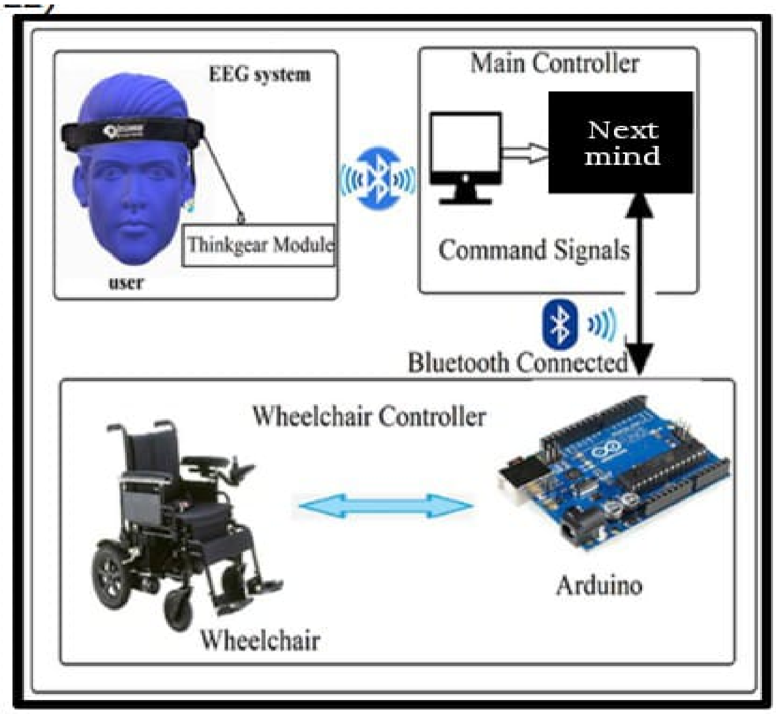
The OARBi project integrates two key objectives :

- Mind-controlled operation: OARBi can be controlled via the user's mind, utilizing EEG sensors to capture brain signals and translate them into input signals for the robotic vehicle.
- Autonomous navigation: OARBi is capable of moving on its own, using integrated sensors and algorithms to detect obstacles, plan new routes, and take appropriate measures to navigate through the environment.

Integration of mind control and autonomous features: OARBi can seamlessly integrate mind-controlled operation with autonomous navigation, allowing the user to control the vehicle with their mind while enabling the system to independently avoid obstacles and adjust its route as needed for user safety and convenience.

3.2 Methodology

3.2.1 System Architecture



Methodology system consists of :

1. Brain Signal Acquisition

Use EEG(Electroencephalography) - NextMind: This is the actual sensor used to get input from the visual cortex part of the brain. The sensor has 9 electrodes in total and is positioned in the back side of the head in order for optimal contact points. The sensor then starts to collect the various signals produced inside the brain using the electrodes. It is then up to the various machine learning algorithms to determine the noise from the actual signals that is needed for processing. Sub components are mainly a NeuroTag which is basically a pattern that is recognized by the brain and the NeuroManager which processes the NeuroTag. When the brain senses the NeuroTag present in the display, it sends out a signal which is captured and realized by NextMind which in turn feeds it to the processors. The data is then transferred to the onboard computers via Bluetooth.

2. Signal Processing

Arduino and the Bluetooth Module- Arduino is the onboard computer located in the actual build of OARBI. The Arduino receives the data from the sensor via the Bluetooth module. The Arduino is pre-programmed via the user to perform various actions according to the data received. The Arduino then transfers control to the motor driver.

3. Signal Feature Extraction

The motor driver- The motor driver receives the data from the Arduino and passes electronic signals to each individual motor.

4. Robot Hardware Integration

The ultrasonic distance sensor – The ultrasonic distance sensor is a special kind of sensor used to measure distance between OARBI and the obstacles in front of it by transmitting ultrasonic waves. The distance is measured by taking in account the time that is taken for the ultrasonic wave to be transferred and received by the sensor. If the distance is less than the specified distance in the program, OARBI stops on its own and plans a different course of route. This process continues in a repeated manner.

3.2.2 Functional Requirements

- **Signal Acquisition**

Utilizes EEG to capture signals from the Visual Cortex of the brain using the sensor with 9 electrodes positioned at the back of the head for optimal contact points. If the attempt fails to sense the surroundings, the signals won't be transferred to Nextmind.

- **Signal Processing**

After the signal is being processed and the unwanted noise will be avoided, The signal will be transferred to the arduino via bluetooth module. The arduino will then pass the control over to the Motor Driver. If it fails, Signal processing will continue with the unwanted noises, and the further transferring of the signals will get interrupted.

- **Movements of Wheels**

Use motors to move the wheels to propel and direct robot movement. If arduino fails to pass the signals to the motor driver. The robot will not be able to move further (It Stops).

- **Obstacle Avoidance**

Using ultrasonic distance sensors, the distance between robot and the obstacle is calculated and further movement will be estimated. If the UV distance sensor fails, the sensor won't be able to calculate the distance between the obstacle and the robot. Therefore the robot will process the signal again to decide and finalize the direction.

3.2.3 Non - Functional Requirement

While functional requirements define what a system should do, non-functional requirements (NFRs) describe how it should do it. Think of them as the "quality standards" for the system, defining its operation and characteristics, such as performance, reliability, security, usability, and maintainability. These "how" aspects are crucial for building a successful system that meets user needs and expectations.

- In the domain of EEG-based robotic control, a critical non-functional requirement is the implementation of robust cybersecurity measures to safeguard the Brain-Computer Interface (BCI) system, ensuring the confidentiality and integrity of sensitive neural data

3.2.4 Hardware Requirements

The hardware required for the development of this project includes :

- EEG Sensor designed to take inputs from the visual cortex part of the brain.
- Motors, Motor driver, Arduino, Bluetooth module, Ultrasonic Distance Sensor.
- x86, x64 architecture with SSE2 instruction set support. 5GB Storage.
- Display

3.2.5 Software Requirements

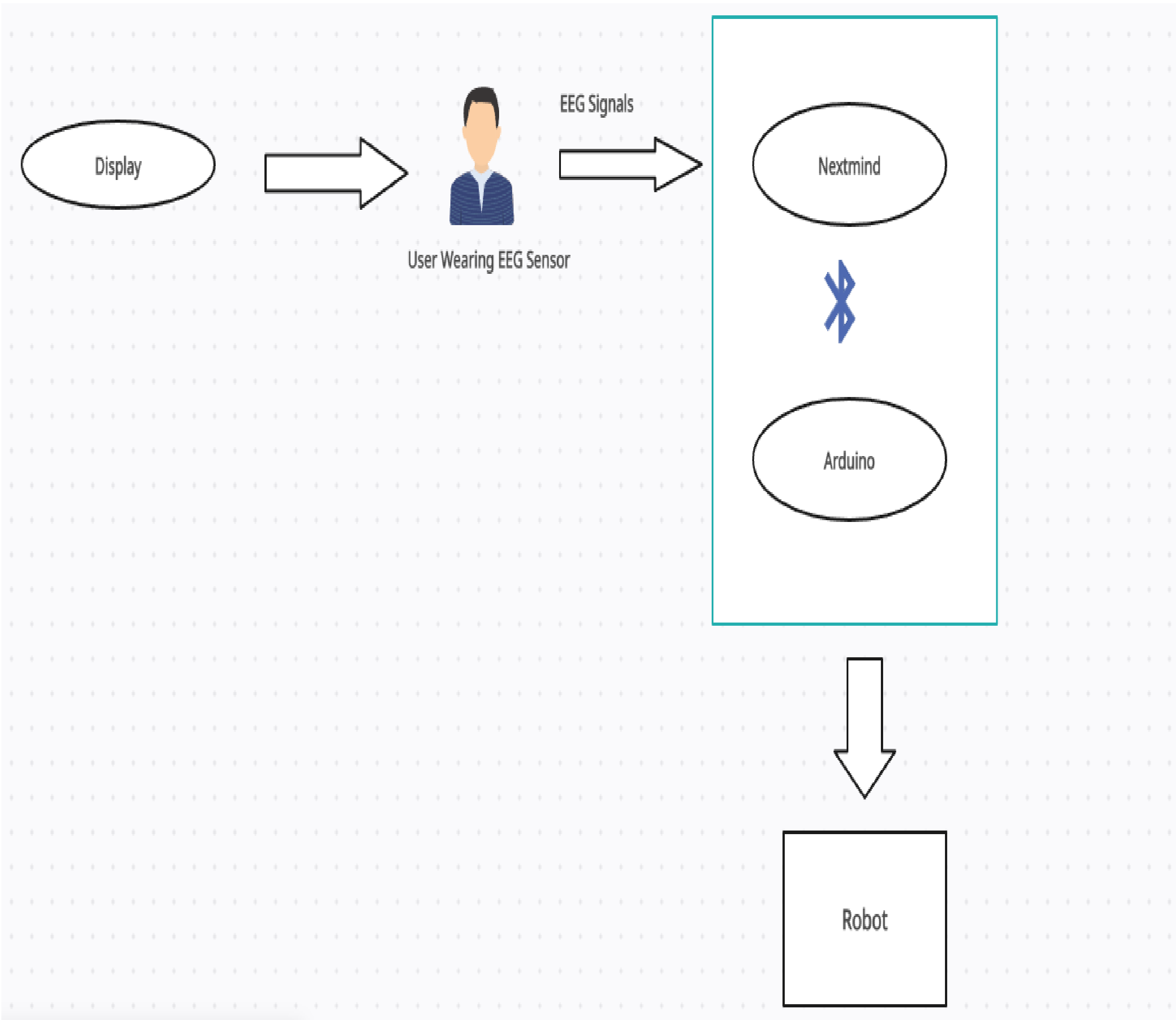
The Software required for the development of this project includes :

- Windows 7 (SP1+) and Windows 10, 64-bit versions only.
- Unity.
- Arduino IDE.
- DirectX.

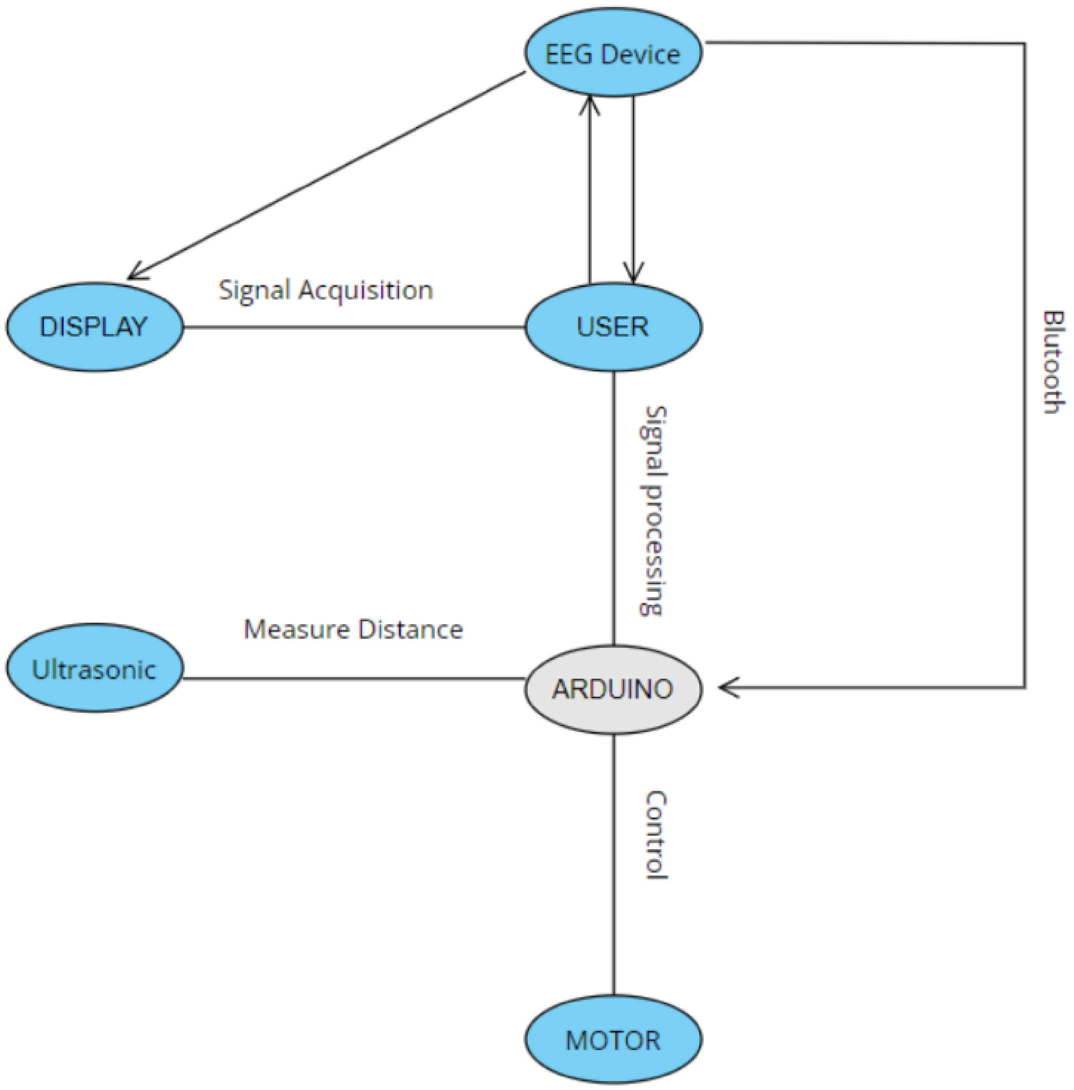
CHAPTER 4

DESIGN DIAGRAM

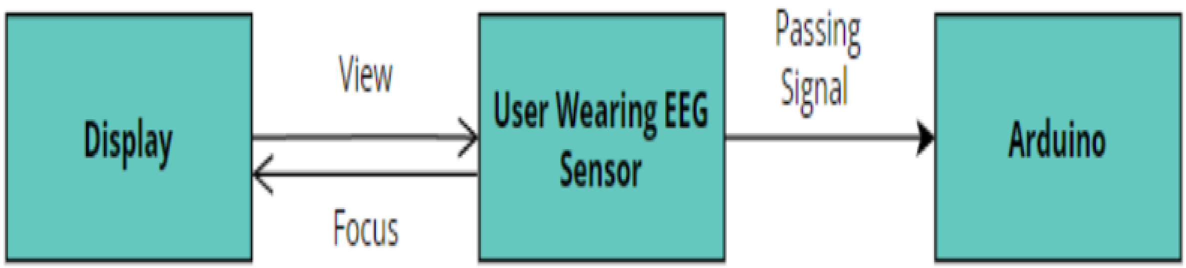
4.1 Use Case Diagram



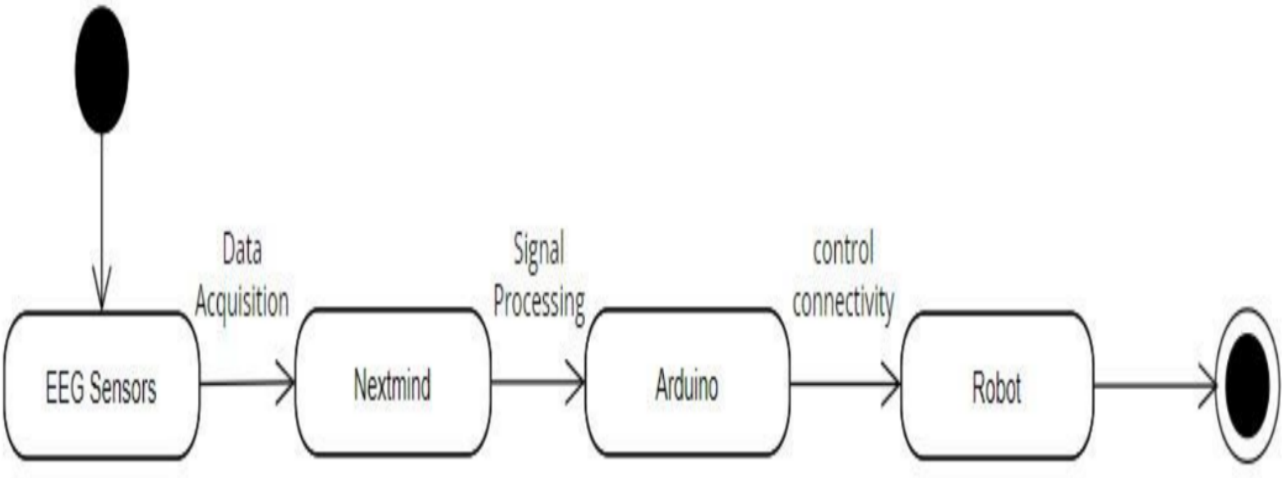
4.2 Class Diagram



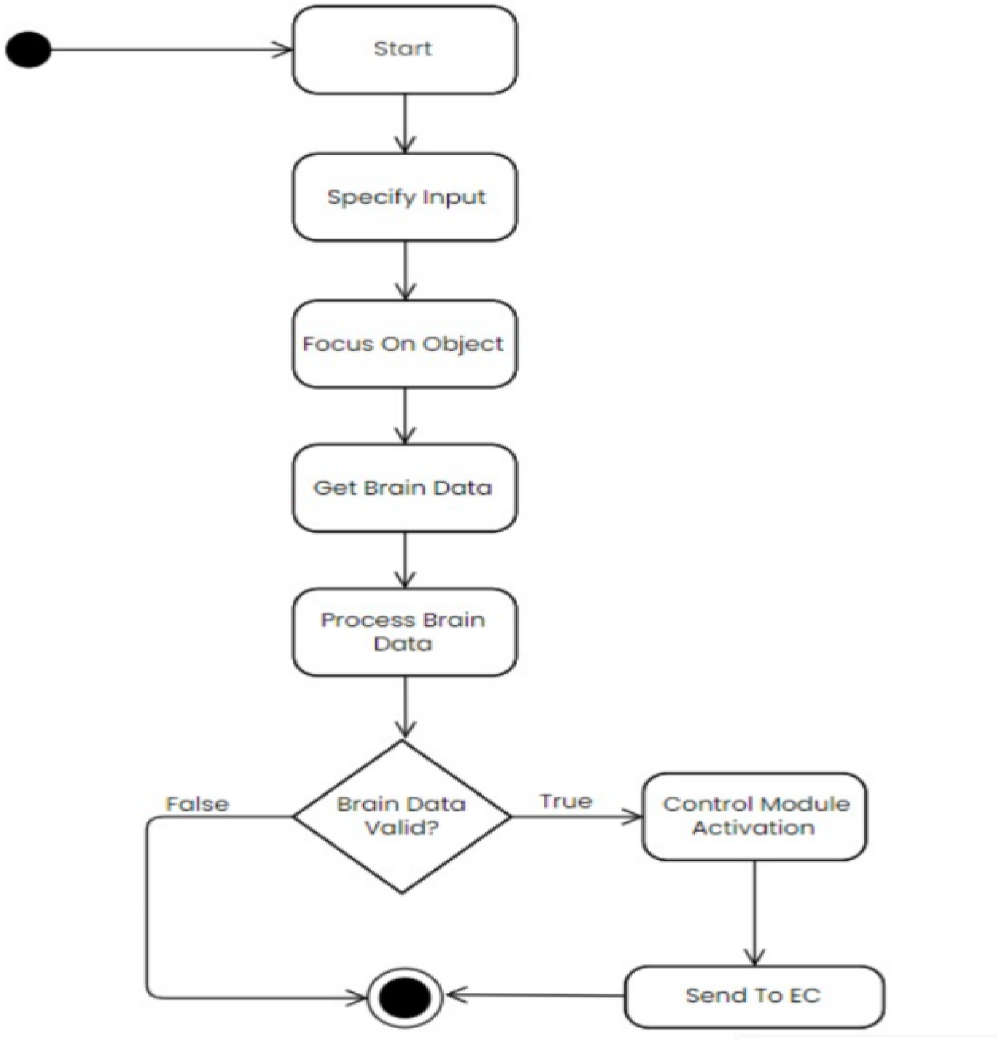
4.3 Deployment Diagram



4.4 State Chart Diagram



4.5 Activity Diagram



Chapter 5
PROJECT SCHEDULE

GOAL 1: Project Planning and Literature Survey

OBJECTIVES	TIMELINE	RESOURCES	TEAM RESPONSIBILITIES	STRATEGY
Literature survey Project Planning	9 - 11 - 23 to 23- 11 - 23	IEEE papers Science direct papers	Member 1: Literature survey Member 1: Literature survey Member 1: Literature survey	Distribution of work among the teams Brainstorming ideas on selection of techniques

GOAL 2: Design Phase

OBJECTIVES	TIMELINE	RESOURCES	TEAM RESPONSIBILITIES	STRATEGY
Architecture design Hardware components Software Developing	5 - 1 - 24 to 4 - 2 - 24		Member 1: Gather Hardware Components Member 2: Architecture Design Member 3: Software specification and development	Researching the specific hardware components Preparing architectural and design diagrams Starting early development

GOAL 3: Implementation stage

OBJECTIVES	TIMELINE	RESOURCES	TEAM RESPONSIBILITIES	STRATEGY
Building the model for image processing Software testing Unit testing	10 - 02 - 24 to 3 - 04 - 24	Github,C,C#, UNITY,DirectX Selenium NUnit	Member 1: model creation for image processing using UNITYand DirectX Member 2: Software Testing Member 3:Unit Testing	Implement image processing tool Testing of the existing software Testing the developed devices

GOAL 4: Testing

OBJECTIVES	TIMELINE	RESOURCES	TEAM RESPONSIBILITIES	STRATEGY
Test Methods: Integration testing Validation testing Output testing User acceptance testing White box and Black box testing Performance Testing	26 - 4 - 24 to 7 - 6 - 24	Testpad Wireshark BlazeMeter	Member 1: Functional testing Member 2: White box and Black box testing Member 3:Performance testing	Functional testing of the robot Causes the control structure of the procedural design to drive test cases. Performance testing of the robot as a whole

Chapter 6
CONCLUSION

OARBi, the Obstacle Avoiding Robot with Brain Interface, is more than just a robotic vehicle. It is a culmination of cutting-edge technology and innovative design, poised to revolutionize the way we interact with our environment. With its user-friendly interface, intuitive controls, and advanced obstacle avoidance capabilities, OARBi promises to be a valuable tool for a diverse range of users. OARBi is driven by the power of your mind. Through a specially designed Unity-based interface, users can easily feed data into the brain, generating signals that OARBi seamlessly interprets and translates into movement. This intuitive approach eliminates the need for complex controllers or cumbersome programming, making OARBi accessible to users of all ages and skill levels.

OARBi doesn't just follow your every command. Its onboard sensors constantly scan the environment, detecting and avoiding obstacles in real-time. This proactive safety feature ensures smooth and safe navigation, even if you unintentionally make a mistake or encounter unexpected hurdles. This intelligent decision-making allows you to rely on OARBi, knowing it will navigate its surroundings with precision and care. The true power of OARBi lies in its ability to combine mind-controlled and autonomous movement. This unique fusion allows for a dynamic and adaptable experience, catering to your specific needs and the demands of the situation. You can choose to guide OARBi with your thoughts, allowing it to handle any obstacles it encounters on its own. Alternatively, you can let OARBi operate independently, setting its own course while remaining vigilant of its surroundings.

OARBi isn't just for tech enthusiasts or those with specialized skills. Its simple setup and user-friendly interface make it accessible to a wide range of individuals. Whether you're looking for a fun and engaging way to interact with technology, a helpful tool for everyday tasks, or a source of assistance for those with physical limitations, OARBi has the potential to make a positive impact on your life. With its advanced capabilities, user-friendly design, and broad range of applications, OARBi is more than just a robot. It is a gateway to a future where technology seamlessly integrates with our lives, enhancing our capabilities and expanding our horizons.

Chapter 7
REFERENCE

[1] Jobin Jose, "Development of EOG Based Human Machine Interface Control System for Motorized Wheelchair," Master of Technology, Department of Biotechnology and Medical Engineering, National Institute of Technology Rourkela, Odisha, 769 008, India, June 2013.

[2] Arvind Prasad, Snehal Shah, Priyanka Ruparelia, Ashish Sawant, "Powered Wheelchairs," International Journal Of Scientific & Technology Research, Vol. 2, Issue 11, pp. 162-165, November 2013.

[3] Nirmal T M, "Wheelchair for Physically and Mentally Disabled Persons," International Journal of Electrical and Electronics Research, Vol. 2, Issue 2, pp. 112-118, April - June 2014.

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[5] Jobby K. Chacko, Deepu Oommen, Kevin K. Mathew, Noble Sunny, N. Babu, "Microcontroller Based EOG Guided Wheelchair," International Journal of Medical, Health, Biomedical, Bioengineering, and Pharmaceutical Engineering, Vol. 7(11), pp. 423-426, 2013.

[6] Imran Ali Mirza, Amiya Tripathy, "Mind-Controlled Wheelchair using an EEG Headset and Arduino Microcontroller," 2015 International Conference on Technologies for Sustainable Development (ICTSD-2015), Feb. 04 – 06, 2015, Mumbai, India, 2015.

[7] Atanasios Vourvopoulos, Fotis Liarokapis, "Brain controlled NXT Robot: Tele Operating a robot through brain electrical activity," IEEE Conference on Games and Virtual Worlds, 2016.

[8] Jobby K. Chacko, Deepu Oommen, Kevin K. Mathew, Noble Sunny, N. Babu, "Microcontroller-Based EOG Guided Wheelchair," International Journal of Medical, Health, Biomedical, and Pharmaceutical Engineering.