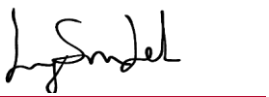
MSc Computer Science
London

Est. 1841 | YORK ST JOHN UNIVERSITY

Dissertation Proposal Form

Date of Submission:

Name	KEHINDE JOHN, ONI
Student Id	230149939
Module Code	COM7040M
Project Title	ADVANCED AI -BASED INTEGRATED BATTERY MANAGEMENT SYSTEM FOR 2/3-WHEELER ELECTRIC VEHICLES
Supervisor Name	DR. SOONLEH LING
Supervisor Approval	YES
Supervisor Signature	

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Section 1: Academic

This section helps Academic staff assess the viability of your project. It also helps identify the most appropriate supervisor for your proposed research. This proposal will be referred to as a point of discussion by your supervisor in seminar sessions.

NAME: KEHINDE JOHN, ONI	STUDENT NUMBER: 230149939
PROPOSED TITLE OF PROJECT: ADVANCED AI -BASED INTEGRATED BATTERY MANAGEMENT SYSTEM AND FOR 2/3-WHEELER ELECTRIC VEHICLES	

BRIEFLY DESCRIBE YOUR FIELD OF STUDY:

Project Overview

The purpose of the advanced AI-based battery management system "BMS" is to: The two-wheel and three-wheel electric vehicle project is to use cutting-edge AI technology to improve the performance, lifespan, and efficiency of electric vehicle batteries.

Completing this project will require integrating complex artificial intelligence algorithms with real-time data collection from sensors embedded in electric vehicle batteries.

AI systems evaluate this data to predict and optimize battery operation, improving battery life, increasing charging efficiency, and ensuring safer and more sustainable operation of electric vehicles.

Successful development, implementation, and optimization of advanced AI-based BMS for two-wheel and three-wheel electric vehicles requires interdisciplinary understanding and collaboration across different disciplines

~~**The main components of the project are:**~~

~~i. **AI Integration:**~~

~~Uses AI algorithms to predict and maximize battery performance through continuous monitoring and analysis of battery data.~~

~~ii. **Data-Driven Insights:**~~

~~Collecting real-time data from sensors enables proactive management and maintenance through critical insights into battery activity.~~

~~iii. **Improving Efficiency**: To improve the lifespan and reliability of batteries used in electric vehicles, research aims to optimize overall battery performance and charging efficiency.~~

~~Issues such as protecting data privacy, addressing moral dilemmas associated with AI decision-making, and integrating AI-driven technology into two- and three-wheeled electric vehicles require careful consideration.~~

The ~~f~~Fields of ~~s~~Study for~~of~~ this project are:

1. **Artificial Intelligence (AI) and Machine Learning (ML):**
   The fields of artificial intelligence (AI) and machine learning are important for developing algorithms that can predict and analyze battery behavior and maximizing charging and discharging schedules for batteries used in electric vehicles.
2. D**ata Science and Analytics:**
   To gain insights and make data-driven decisions about battery management, you need to be familiar with managing and evaluating real-time data from sensors.
3. **Vehicle Technology**:
   Knowledge of the special requirements and functional characteristics of electric vehicles is essential for the smooth integration of the BMS into the vehicle design.
4. **Energy Storage and Battery Technology:**
   Understanding the intricacies of battery operation and performance requires a comprehensive understanding of battery chemistry, energy storage concepts, and technological breakthroughs.
5. **Cybersecurity and data protection**:
   Cybersecurity and data protection expertise are essential to maintaining the integrity of user information and systems, especially regarding sensitive data collected by electric vehicles.
6. **Electrical Engineering**:
   BMS hardware development and sensor integration into electric vehicles requires a

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comprehensive understanding of battery systems, electronics, and electrical components.

7. **Programming**:

Almost every aspect of this project requires programming knowledge, to fit the needs of the project. All of those require the use of programming. For this project, it is likely to use multiple languages and frameworks

~~Successful development, implementation, and optimization of advanced AI-based BMS for two-wheel and three-wheel electric vehicles requires interdisciplinary understanding and collaboration across different disciplines~~

WHAT QUESTION DOES YOUR PROJECT SEEK TO ANSWER?

Throughout the project life-cycle, we aim to seek answers to the following questions:

i. **How can AI be effectively integrated into battery management systems for 2/3-wheel EVs**?

- Our initiative is primarily driven by the need to meet a compelling business need, find creative solutions to overcome technological obstacles, and take advantage of a sizable market potential in the 2 and 3-wheeler electric vehicle (EV) sector.
- Hardware and Software Integration: To enable real-time monitoring, defect detection, state-of-charge (SoC) estimation, and cell balancing, integrate hardware components (sensors, controllers, etc.) with AI-powered software.
- Evaluate how the created AI-based BMS will improve battery performance.

ii. **What are the ideal battery performance parameters and control schemes**?

- Examine vital battery characteristics and create AI-driven control algorithms to optimize battery longevity, safety, and efficiency in 2/3-wheeler EVs.

~~ii. **How does the AI-based BMS contribute to the overall performance and longevity of 2/3-Wheeler EV batteries**?~~

- ~~Evaluate how the created AI-based IBMS will improve battery performance, deal with degradation, optimize charging and discharging, and guarantee safe operation.~~

~~ii. **What are the implications of integrating AI-driven battery management in terms of cost-effectiveness and sustainability**?~~

- ~~Examine the financial viability and environmental effects of installing an AI-based IBMS in 2/3-wheeler EVs, taking into account things like lower maintenance costs and longer battery life.~~

~~ii. **How does the AI-integrated BMS improve the user experience and confidence in electric vehicle technology**?~~

- ~~Examine how the AI-integrated BMS improves user experience, offers insightful feedback, and inspires confidence in EV technology by looking into its usability and user interface features.~~

WHAT HYPOTHESIS ARE YOU SEEKING TO TEST?

This hypothesis seeks to demonstrate that the battery management system specially created for 2- and 3-wheel EVs will experience quantifiable benefits in a number of areas upon the incorporation of cutting-edge AI algorithms:

H0~~1~~. **Enhanced Performance of Batteries**:
Range, acceleration, and overall vehicle economy will all be enhanced by the AI-driven Battery Management System's efficient regulation and optimization of charging, discharging, and energy flow.

H1~~2~~. **Extended Life of Batteries**:
By using AI algorithms to enable continuous monitoring and predictive analytics, the system will reduce the causes that lead to battery degradation. This will extend the battery's useful life and ensure that its capacity is maintained over time.

~~H3. **Increased Productivity**:~~
~~Artificial Intelligence (AI) and real-time data processing will optimize the electric propulsion system by minimizing energy losses and improving energy usage.~~

WHAT ARE THE PROBABLE PROJECT OUTCOMES?

The project is expected to generate the following outcomes:

1. AI Algorithms that could lead to b~~B~~**etter p~~P~~erformance from the Battery**~~:~~
   By more effectively controlling the cycles of charging and discharging, the installation of an AI-based BMS is anticipated to maximize battery performance. This could allay one of the main worries of EV customers by improving the vehicle's acceleration, range, and overall efficiency.
2. **Extended Battery Lifespan**:
   It is expected that the AI-integrated BMS will reduce factors that cause battery degradation through control techniques and predictive analytics. This may result in extending the battery's life, keeping it charged for a longer amount of time, and lowering the frequency of battery replacements or problems linked to degradation for the car and its occupants.
3. **Increased Dependability and Safety**:
   AI systems that enable real-time monitoring and failure prediction may make battery operation safer and more dependable. Early identification of irregularities or possible defects could avert dangerous situations and guarantee the general safety of the car and its occupants.
4. **Optimal Energy Use**:
   It is anticipated that the BMS powered by AI would optimize energy use in the car's electrical system. This may lead to lower energy losses, more effective use of the battery's capacity overall, and an improvement in the efficiency of converting stored energy to propulsion.
5. **Enhanced User Experience**:
   A well-thought-out AI-integrated BMS may provide better feedback systems and user interfaces. Improved battery health, charging status, and alarm visibility may help users feel more comfortable and knowledgeable about electric car technology.

~~5. **Technological Innovation and Progress**:~~
~~The successful deployment of an AI-based BMS designed for 2- and 3-Wheeler EVs may lead to innovations in the realm of technology. It might open the door to more advancements in battery management systems, which would have an impact on EV technology going forward.~~

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PLEASE PROVIDE A BRIEF BIBLIOGRPAHY OF 2-4 KEY TEXTS FOR YOUR STUDY (USE HARVARD REFERENCESTYLE)

1. Akhavan-Rezai, E., Shaaban, M.F., El-Saadany, E.F. and Karray, F. (2015) 'Demand response through interactive incorporation of plug-in electric vehicles', *Power & Energy Society General Meeting*, IEEE, July, pp.1–5.

2. Amjad, S., Neelakrishnan, S. and Rudramoorthy, R. (2010) 'Review of design considerations and technological challenges for successful development and deployment of plug-in hybrid electric vehicles's *Renewable and Sustainable Energy Reviews*, Vol. 14, pp.1104–1110.

3. Arora, S., Shen, W. and Kapoor, A. (2016) 'Review of mechanical design and strategic placement technique of a robust battery pack for electric vehicles', *Renewable and Sustainable Energy Reviews*, Vol. 60, pp.1319–1331.

4. Chan, C.C. and Chau, K.T. (2001) *Modern Electric Vehicle Technology*, Oxford University Press, Oxford.

5. Chau, K.T. (2009) 'Electric motor drives for battery, hybrid and fuel cell vehicles', in Raines, G.B. (Ed.): *Electric Vehicles: Technology, Research and Development, Nova Science*, New York, pp.1–40.

6. Kim, S., Lee, J., & Park, S. (2021). AI-Based Control Algorithm for Efficient Power Electronics in Electric Vehicles. IEEE Transactions on Industrial Electronics, 68(2), 1250-1260.

7. Predictive analytics for battery management systems of electric vehicles using deep learning. IEEE Transactions on Transportation Electrification, 5(3), 813-823.

8. Smith, R., & Johnson, L. (2022). Advancements in AI-Driven Battery Management Systems for Electric Vehicles. Journal of Advanced Automotive Technologies, 12(4), 567-580.

9. Johnson, A., & Brown, K. (2020). AI-Integrated Power Electronics for Enhanced Performance in Electric Vehicles. International Journal of Electric Vehicle Technology, 8(2), 189-201.

10. García, F. H., & Yang, D. C. (Eds.). (2019). Electric Vehicles - Modelling and Simulations. IntechOpen.

~~5.~~11.

PLEASE NAME ANY MEMBER OF THE ACADEMIC TEAM YOU HAVE DISCUSSED THIS POTENTIAL PROJECT:
DR. SOONLEH Ling

(staff use only) Project Approved by Academic Team?	YES		NO	

Any other Academic Staff comments
~~Note that this project is also part of SaaR project from YSJ.~~

Student can proceed with the project based on the current status of RP but the following comments need to be considered:

1. ***More classification on research questions will be required in order to understand what performance metrics could be used to evaluate the proposed system.***
2. ***Clarity on the project outputs should be further improved to ensure the student delivers the right project outputs.***
3. ***Further elaboration of project / development tools will be required to explain how those tools can be used to carry out the project.***

4. Project timeline including milestones should be included in the RP.

5. More technical description of BMS system required to demonstrate understanding of project

Student needs to take all the above into consideration when executing the project.

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Section 2: Technical

This section is designed to help the technical team ensure the appropriate equipment to support each project has been ordered. It also exists to help you fully ascertain the technical requirements of your proposed project. In filling out this section please note that we do not 'buy' major items of equipment for student projects. However, if a piece of equipment has a use to the department beyond the scope of a single project, we will consider purchasing it. Though purchasing equipment through the university is often is a slow process.

PLEASE DESCRIBE YOUR PROJECT IN TECHNICAL TERMS:

The advanced artificial intelligence (AI)-based battery management system (BMS) ~~for two- and three-wheeler electric vehicles~~2/3-wheel EVs is a sophisticated combination of software and hardware components intended to maximize battery efficiency and performance through the use of AI algorithms.

The system is based on a number of sensors that gather data in real time from the vehicle's batteries, including voltage, current, temperature, and state-of-charge (SoC). After preprocessing, this data is used to feed AI/ML models such as neural networks or regression models that are designed to comprehend and forecast battery behavior.

With the use of AI models, charging, discharging, and thermal management may be regulated to improve battery longevity and overall vehicle performance. Additionally, defect prediction and optimization tactics are made possible. In order to guarantee effective energy use, extend battery life, and give users real-time insights through user-friendly interfaces, the predictive analytics strengthen the system's decision-making processes. This helps to make ~~electric vehicle~~EV -operations safer, more ~~dependable~~reliable, and environmentally friendly.

The main components of the project are:

i. **AI Integration**:
Uses AI algorithms to predict and maximize battery performance through continuous monitoring and analysis of battery data.

ii. **Data-Driven Insights**:
Collecting real-time data from sensors enables proactive management and maintenance through critical insights into battery activity.

iii. **Improving Efficiency**: To improve the lifespan and reliability of batteries used in electric vehicles, research aims to optimize overall battery performance and charging efficiency.

Issues such as protecting data privacy, addressing moral dilemmas associated with AI decision-making, and integrating AI-driven technology into two- and three-wheeled electric vehicles require careful consideration.

System Architecture and Technologies.

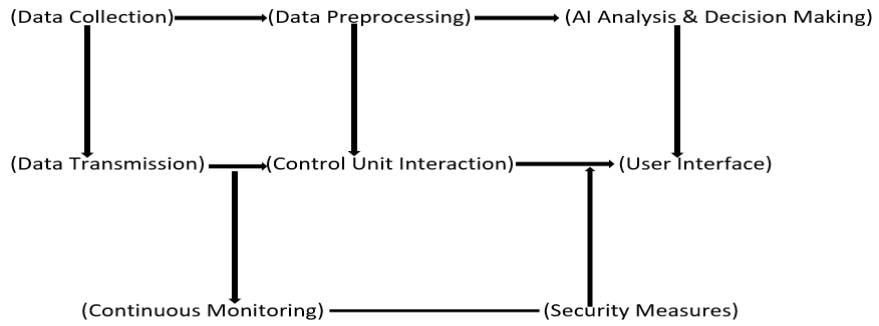
1. **Software for Battery Management**: Creating unique software to monitor battery condition, enhance charging techniques, and give the car's management systems real-time input.

2. **Human Machine Interface (HMI)**: introducing a user-friendly interface that allows users to track battery life, receive alarms, and communicate with the BMS through the dashboard or mobile app.
3. **Cybersecurity Measures**: Incorporating strong security protocols, encryption techniques, and authentication procedures is essential to protecting sensitive information and ensuring system integrity.
4. **Hardware**: AI acceleration is achieved through the use of effective microcontrollers, processors, memory modules, and specialized hardware to speed up data processing and decision-making.
5. **Data collection and preprocessing**: Before the sensor data is sent to the central processing unit, data collection and preparation is performed using a microcontroller or edge device.
6. **Central Processing Unit (CPU)**: Use of powerful computer systems with AI/ML algorithms for data analysis, predictive modeling, and decision-making. This system can be edge-based or cloud-based.
7. **AI/ML Frameworks**: Build and use machine learning models for predictive battery analysis and optimization using AI/ML frameworks such as TensorFlow, and scikit-learn.
8. **Communication protocols**: To ensure a smooth connection between In BMS components and vehicle systems, communication protocols such as CAN bus, Ethernet, or wireless technologies (Bluetooth, Wi-Fi, etc.) can be used.
9. **Sensor Integration**: Integrate temperature voltage, current, and SoC sensors into your car's battery system to set up a sensor array and record data in real-time.

~~Project~~ How AI is used in BMS System, Data Flow diagram~~.~~

1. Data collection using battery-powered sensors.
2. Pre-collect and prepare data for analysis.
3. Transfer to an AI system for testing and assessment.
4. Artificial intelligence communicates with the battery control unit.
5. Submit comments through the user interface.
6. Continuous learning, adapting, and monitoring of the system.
7. We implement strict security measures at every step.

~~7.~~



The Chart Above shows the flow of Advanced AI Based BMS Project.

[explain and elaborate the flow]

[BMS System architecture diagram] and explain here

For the research, testing, and integration stages of an Advanced AI-Based BMS project for 2- and 3-wheeler Electric Vehicles, certain lab supplies and equipment are necessary. They guarantee precise data gathering, analysis, and application of AI-driven battery management techniques.

1. **Equipment for testing batteries**: This category include battery testers, impedance analyzers, and cyclers for assessing the properties, health, and performance of batteries.
2. **Sensor Arrays**: A variety of sensors, including temperature, voltage, current, and SoC sensors, are essential for gathering data from batteries in real time.
3. Systems for gathering and processing data from sensors and battery testing apparatus are known as data acquisition systems.
4. **Computing Infrastructure**: To run simulations, analyze data, and train AI/ML models, high-performance PCs or servers are needed.
5. **Electrical Testing Equipment**: For electrical testing and analysis, tools such as multimeters, power sources, oscilloscopes, and electronic loads are required.
6. **Development Kits and Prototyping Tools**: development kits for microcontrollers or microprocessors, prototyping platforms such as Arduino or Raspberry Pi, and related hardware components for integration and testing.
7. **AI/ML Software and Tools**: Python-based libraries like TensorFlow, or MATLAB are examples of software packages and tools for machine learning and data analysis.
8. **Simulation Software for modeling** battery behavior and testing AI algorithms before they are put into practice in the real world.
9. **Lab Safety Equipment**: To guarantee a safe working environment, wear safety gear such as gloves, goggles, lab coats, and fire safety equipment.
10. **Components of the Battery Management System**: Parts unique to the BMS include balance boards, communication modules for hardware integration, and battery controllers.

Prototyping Supplies: soldering stations, PCB fabrication tools, and prototyping supplies for creating and evaluating hardware components.

The project may face several challenges:

1. **Accountability and Transparency**: AI systems may be intricate and challenging to understand, making it difficult to justify their choices or actions. Concerns over responsibility for mistakes or system breakdowns may arise from a lack of transparency.

i. **Security Concerns**: Potential safety risks or cyber threats could arise from the system's vulnerabilities being exploited. Strong cybersecurity defenses are essential to preventing unwanted access and BMS manipulation.

ii. **Bias in AI Algorithms**: Depending on the data used for training, AI models may display biases that result in unfair outcomes or unequal treatment. The BMS's handling of batteries and user interactions may be impacted by this bias.

iii. **Data privacy**: Sensitive information about user behavior, whereabouts, or usage habits may be collected and processed in real-time from automobiles. It is essential to safeguard this data against misuse or illegal access in order to preserve user privacy.

HOW TO MITIGATE THE CHALLENGES

i. **Algorithmic Fairness and Bias Mitigation**: To reduce biases, regularly verify that the training data is diverse and audit AI systems for biases. Throughout the development cycle, apply fairness-aware algorithms and carry out bias assessments.

ii. **Strict cybersecurity processes**, such as encryption, authentication, and ongoing monitoring, should be used to protect against potential cyber threats and unauthorized access.

iii. **The goal of explainable AI** is to create AI models that give consumers the ability to comprehend and analyze system decisions. Describe how to offer justifications for the recommendations or actions taken by the BMS.

iv. **Privacy by Design**: Assert stringent access controls, data encryption, and anonymization from the project's outset, and implement privacy-enhancing methods. Establish open policies for the gathering, using, and sharing of data

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[Need project timeline]

- **Literature review**

~~References~~

1. ~~Kim, S., Lee, J., & Park, S. (2021). AI-Based Control Algorithm for Efficient Power Electronics in Electric Vehicles. IEEE Transactions on Industrial Electronics, 68(2), 1250-1260.~~

For creating documents and reports, Microsoft word will be used, and all the documents will be uploaded to the Paragon teams' channel (cloud) as a risk mitigation plan. The supervisor acts as the administrator of the channeland can view the latest updates and get notified.

WHAT EXISTING LAB EQUIPMENT DO YOU NEED ACCESS TO UNDERTAKE YOUR PROPOSED PROJECT:

~~For the research, testing, and integration stages of an Advanced AI-Based BMS project for 2- and 3-wheeler Electric Vehicles, certain lab supplies and equipment are necessary. They guarantee precise data gathering, analysis, and application of AI-driven battery management techniques.~~

~~3. **Equipment for testing batteries**: This category include battery testers, impedance analyzers, and cyclers for assessing the properties, health, and performance of batteries.~~
~~4. **Sensor Arrays**: A variety of sensors, including temperature, voltage, current, and SoC sensors, are essential for gathering data from batteries in real-time.~~
~~5. Systems for gathering and processing data from sensors and battery testing apparatus are known as data acquisition systems.~~
~~6. **Computing Infrastructure**: To run simulations, analyze data, and train AI/ML models, high-performance PCs or servers are needed.~~
~~7. **Electrical Testing Equipment**: For electrical testing and analysis, tools such as multimeters, power sources, oscilloscopes, and electronic loads are required.~~
~~8. **Development Kits and Prototyping Tools**: development kits for microcontrollers or microprocessors, prototyping platforms such as Arduino or Raspberry Pi, and related hardware components for integration and testing.~~
~~9. **AI/ML Software and Tools**: Python-based libraries like TensorFlow, or MATLAB are examples of software packages and tools for machine learning and data analysis.~~
~~10. **Simulation Software for modeling** battery behavior and testing AI algorithms before they are put into practice in the real world.~~
~~11. **Lab Safety Equipment**: To guarantee a safe working environment, wear safety gear such as gloves, goggles, lab coats, and fire safety equipment.~~
~~12. **Components of the Battery Management System**: Parts unique to the BMS include balance boards, communication modules for hardware integration, and battery controllers.~~
11. ~~**Prototyping Supplies**: soldering stations, PCB fabrication tools, and prototyping supplies for creating and evaluating hardware components.~~
~~13.~~ N/A

PLEASE LIST ANY MINOR EQUIPMENT YOU MUST PURCHASE TO COMPLETE YOUR RESEARCH PROJECT: (e.g., switches, resistors, raspberry pi, Arduino etc)

1. **Connectors and Wiring**: An assortment of connectors, cables, and wiring accessories to link sensors, control units, and the battery management system.
2. **Data Logging Devices**: Compact recording or data loggers that are used to record particular battery characteristics or system performance during field testing.
3. **Power Management Units**: Equipment for controlling the distribution of power and guaranteeing a steady power supply to the BMS and related parts.
4. **Diagnostic Tools**: Portable diagnostic instruments or gadgets for immediate battery system examination and troubleshooting in the course of field testing or maintenance.
5. **Prototyping Materials**: Extra supplies for quick testing and iteration throughout the development stage, such as breadboards, connectors, and prototyping components.
~~6. **Safety Equipment**: To guarantee safety throughout the testing and integration stages, additional safety equipment, signage, and emergency shutdown systems are required.~~
~~7. **Mounting and Enclosures**: Hardware components are safely housed within the vehicle's~~

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~~architecture with mounting brackets, casings, and enclosures.~~

PLEASE LIST ANY MAJOR EQUIPMENT YOU REQUIRE TO COMPLETE YOUR RESEARCH PROJECT ALONG WITH LINKS TO WHERE IT MAY BE PURCHASED (e.g., a Drone, mobile phone etc).
N/A

HAVE YOU DISCUSSED THE FEESIBILITY OF YOUR PROJECT WITH A MEMBER OF THE TECHNICAL TEAM? IF SO WHO?

(staff use only) Project Approved by Technical Team?			NO	

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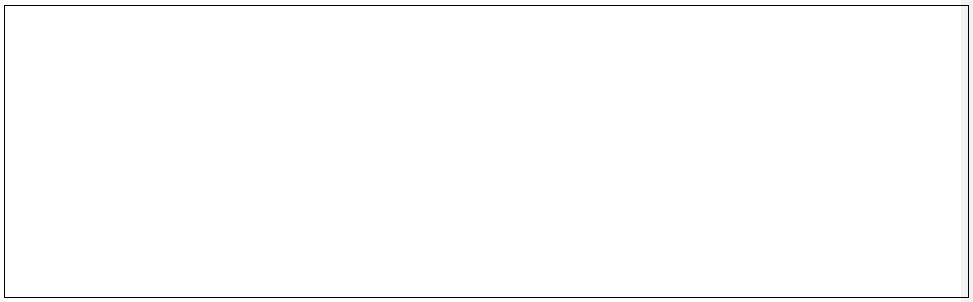

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Section 3: Ethics Approval

This section of the form will help ascertain if you need to complete and undergo the universities research ethics approval process. Please answer all questions honestly.

Question	Yes	No
Does your Research involve any of the following? Human participants / subjects, Human tissue, Documents		**No**
Will the research require the collection of primary source material that might be considered offensive or illegal to access or hold on a computer? (e.g., studies related to state security, pornography, abuse, illegal behaviour, or terrorism).		**No**
Does your research concern group which may be construed as terrorist or extremist?		**No**
Will the research involve visual/vocal methods where participants may be identified?		**No**
Will the research involve the use of genetic data (inherited/acquired genetic characteristics resulting from the analysis of a biological sample)?		**No**
Will the study require the co-operation of a gatekeeper to give access to, or to help recruit, participants? (e.g., headteacher or group leaders publicising your work)		**No**
Will it be necessary for participants to take part in the study without their knowledge or consent at the time?		**No**
Will the study involve recruitment of patients through the NHS (National Health Service)?		**No**
Will inducements be offered to participants? (e.g., the offer of being entered into a prize draw)		**No**
Does the study involve participants who are particularly vulnerable or unable to give informed consent? (e.g. participants under 18. Adults with learning disabilities, the frail elderly, or anyone who may be easily coerced due to lack of capacity)		**No**
Is there a possibility that the safety of the researcher may be in question?		**No**
Will the study require participants to commit extensive time to the study?		**No**
Are drugs, placebos, or any other substances to be administered to participants, or will the study involve invasive, intrusive, or potentially harmful procedures of any kind?		**No**
If there are experimental and control groups, will being in one group disadvantage participants?		**No**
Is an extensive degree of exercise or physical exertion involved?		**No**
Will blood or tissue samples be obtained from participants?		**No**
Could the study induce psychological stress or anxiety or cause harm or negative consequences beyond the risks encountered in normal life?		**No**

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*This part of Section 3 requires you to thoroughly **identify** and **mitigate** the ethical challenges of your research project. This is required to enable the computer Science ethics panel to properly consider if your proposed project requires you to submit a formal proposal to the university ethics panel.*

With your answers to the previous questions in mind, please describe the main ethical challenges of your research project and how you propose to mitigate them. Your discussion may include material not covered in the above questions. Please be as through as possible:

N/A

~~**ETHICAL CHALLENGES OF THE PROJECT**~~

~~i. **Accountability and Transparency**: AI systems may be intricate and challenging to understand, making it difficult to justify their choices or actions. Concerns over responsibility for mistakes or system breakdowns may arise from a lack of transparency.~~
~~ii. **Security Concerns**: Potential safety risks or cyber threats could arise from the system's vulnerabilities being exploited. Strong cybersecurity defenses are essential to preventing unwanted access and BMS manipulation.~~
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~~iv. **Data privacy**: Sensitive information about user behavior, whereabouts, or usage habits may be collected and processed in real-time from automobiles. It is essential to safeguard this data against misuse or illegal access in order to preserve user privacy.~~

~~**HOW TO MITIGATE THE CHALLENGES**~~

~~i. **Algorithmic Fairness and Bias Mitigation**: To reduce biases, regularly verify that the training data is diverse and audit AI systems for biases. Throughout the development cycle, apply fairness-aware algorithms and carry out bias assessments.~~
~~ii. **Strict cybersecurity processes**, such as encryption, authentication, and ongoing monitoring, should be used to protect against potential cyber threats and unauthorized access.~~
~~iii. **The goal of explainable AI** is to create AI models that give consumers the ability to comprehend and analyze system decisions. Describe how to offer justifications for the recommendations or actions taken by the BMS.~~
~~iv. **Privacy by Design**: Assert stringent access controls, data encryption, and anonymization from the project's outset, and implement privacy-enhancing methods. Establish open policies for the gathering, using, and sharing of data~~

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