IMPERIAL NEUROTECH SOCIETY

PROPOSER: ANISH KOCHHAR

# MIND-CONTROLLED WHEELCHAIR PROJECT

***CORE TEAMS***

DATA COLLECTION

SIGNAL PROCESSING

MACHINE LEARNING

SOFTWARE DEVELOPMENT

HARDWARE

# THE PROJECT BRIEF

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We will be modifying a motorised wheelchair to change its driving direction based the output of a ***machine learning*** model trained to decode user thoughts

We will implement the entire data handling pipeline, from ***i)*** collecting raw EEG signals → ***ii)*** cleaning and removing noise →***iii)*** training an ML model with labelled intention data

# THE TEAMS

DATA COLLECTION

SIGNAL PROCESSING

MACHINE LEARNING

SOFTWARE DEVELOPMENT

HARDWARE

**DATA COLLECTION**
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} TEAM

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# DATA COLLECTION TEAM

## CORE RESPONSIBLITIES

- Design and test electrode montage placements, optimising for quality and comfort
- Manage participant recruitment: draft protocols, consent forms, and eligibility criteria
- Set up EEG recording trials, ensuring data consistency across sessions
- Conduct data labelling for motor imagery or specific cognitive commands

## POTENTIAL ROADBLOCKS

1. **Participant recruitment issues**: Delays in finding volunteers may shift timelines
2. **Inconsistent data quality**: Noise from movement and placement variability could necessitate retesting
3. **Electrode optimisation**: Initial placements may need refining to ensure stable, low-noise signals, potentially requiring changes to the signal processing workflow

DATA COLLECTION
**SIGNAL PROCESSING**
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# SIGNAL PROCESSING TEAM

## CORE RESPONSIBLITIES

- Implement noise-reduction filters (e.g., bandpass filters, adaptive filtering)
- Address artefacts from movement or environmental interference (e.g., muscle activity)
- Optimise filtering for real-time response and low-latency processing.
- Develop segmentation and pre-processing scripts to pass data to ML team in a clean, usable format

## POTENTIAL ROADBLOCKS

1. **Artefact removal challenges:** Manual fine-tuning for various artifact types may require iterative approaches
2. **Data inconsistencies:** Variability in EEG signals due to electrode positioning might require close collaboration with Data Collection to develop reliable protocols

DATA COLLECTION
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# MACHINE LEARNING TEAM

## CORE RESPONSIBLITIES

- Research and compare machine learning models (e.g., SVM, CNN, RNN) for optimal accuracy and speed
- Develop, train, and optimise models to recognise distinct motor imagery commands
- Validate models through cross-validation, fine-tune hyperparameters, and address overfitting
- Implement continuous training strategies with new data for better adaptive responses

## POTENTIAL ROADBLOCKS

1. **Data volume and variability:** Small, varied datasets can impact accuracy; alternative data augmentation or synthetic data generation may be necessary
2. **Real-time constraints:** Model complexity may hinder response time; lighter models or hardware accelerations could be required
3. **Model generalisation:** Difficulty in generalising commands across users could necessitate personalised model adjustments

DATA COLLECTION
SIGNAL PROCESSING
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# SOFTWARE DEVELOPMENT TEAM

## CORE RESPONSIBLITIES

- Develop the real-time data pipeline from EEG device to wheelchair
- Build internal-facing UI for real-time data monitoring for data collection and testing
- Design user-facing UI for prediction display and wheelchair control
- Implement autonomy features (e.g. computer vision, SLAM)
- Coordinate inter-device communication and ensure synchronisation with the wheelchair

## POTENTIAL ROADBLOCKS

1. **Real-time data handling:** Latency or dropped data issues may require optimisations in data transmission
2. **Autonomy feature complexity:** Adding computer vision or SLAM may impact timelines if hardware is limited
3. **Inter-device communication:** Compatibility issues or interference between multiple devices could need troubleshooting

DATA COLLECTION
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# HARDWARE TEAM

## CORE RESPONSIBLITIES

- Design and modify the wheelchair for electronic integration
- Install and calibrate motor controls, ensuring safe operational limits
- Install additional sensors, such as LIDAR, for potential autonomous navigation
- Design power management for reliable, sustainable use

## POTENTIAL ROADBLOCKS

1. **Motor calibration challenges:** Achieving accurate motor responses may need additional fine-tuning
2. **Sensor integration:** Compatibility or installation challenges may arise with LIDAR or other sensors
3. **Battery management:** Power issues, such as battery life or overheating, may require redesigns

# ROUGH TIMELINE

| | November | December | January | February | March | April | May |
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| DATA COLLECTION | RECRUIT PARTICIPANTS, FINALISE PROTOCOLS, AND CONDUCT INITIAL EEG RECORDINGS WITH TESTING OF ELECTRODE PLACEMENTS | | CONTINUE EEG TRIALS, FOCUS ON REFINING DATA QUALITY BASED ON SIGNAL PROCESSING FEEDBACK, AND INCREASE PARTICIPANT VOLUME | | COLLABORATE WITH ML AND SOFTWARE TEAMS FOR VALIDATION TRIALS; ASSIST IN FINAL DATA COLLECTION IF NEEDED | | |

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| SIGNAL PROCESSING | BEGIN DEVELOPING BASIC FILTERING AND NOISE REDUCTION TECHNIQUES WITH TEST DATA | | DEVELOP AND TEST REAL-TIME PRE-PROCESSING TECHNIQUES ON COLLECTED DATA, INCLUDING ARTEFACT REMOVAL | | OPTIMISE REAL-TIME FILTERING FOR LATENCY, PASS FINAL PRE-PROCESSING SCRIPTS TO SOFTWARE AND ML TEAMS | | |

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## MACHINE LEARNING

- CONDUCT RESEARCH INTO MODEL ARCHITECTURES AND START WORKING ON A BASELINE MODEL USING OPEN-SOURCE EEG DATASET
- TEST MODEL OUTPUTS WITH REAL-TIME DATA FROM SOFTWARE AND SIGNAL PROCESSING PIPELINE, ITERATE ON MODELS BASED ON FEEDBACK
- FINALIZE MODEL TRAINING, CONDUCT EXTENSIVE TESTING, AND REFINE BASED ON RESULTS

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## SOFTWARE DEVELOPMENT

- ESTABLISH THE FOUNDATIONAL DATA PIPELINE FROM EEG DEVICE TO A STORAGE SOLUTION, ENABLING EARLY DATA ACCESS FOR SIGNAL PROCESSING AND ML TEAMS
- BEGIN DEVELOPING INTERNAL UI FOR DATA MONITORING AND AN INTERFACE FOR PREDICTED OUTPUTS FOR VALIDATION WITH ML TEAM
- IMPLEMENT BASIC CONTROL INTERFACE FOR WHEELCHAIR COMMANDS, ALLOWING FOR MODEL INTEGRATION AND CONTROL TESTING
- FINALISE INTER-DEVICE COMMUNICATION, ENSURE SMOOTH REAL-TIME DATA FLOW, AND CONNECT WITH HARDWARE TEAM FOR CONTROL COMMANDS

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## HARDWARE

- ASSESS WHEELCHAIR FOR MODIFICATIONS, FINALISE REQUIREMENTS FOR MOTOR CONTROL, AND TEST POWER SYSTEMS
- INSTALL MOTORS, RUN BASIC MOVEMENT TESTS, AND ENSURE MOTOR CONTROL IS RELIABLE FOR AUTONOMOUS INTEGRATION
- FINALISE SENSOR INTEGRATION, INCLUDING LIDAR, AND RUN INITIAL NAVIGATION TESTS
- PERFORM SAFETY TESTING, ADDRESS ANY HARDWARE FAULTS, AND PREPARE SYSTEM FOR DEMONSTRATION

# WHAT WE'RE LOOKING FOR

## 01
## TEAM LEADS

- Some prior knowledge of their respective sub-field (note, this could be from this week!)
- Previous project experience
- Strong organisation and team-management skills

Estimated time commitment: **5 hours a week**

## 02
## TEAM MEMBERS

- No prior neurotech experience needed
- Strong willingness to learn / interest in the field
- Previous group project experience
- Strong organisation and time management skills

Estimated time commitment: **4 hours a week**

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- ENTHUSIASM
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- ENTHUSIASM
- PRIOR KNOWLEDGE

After that (roughly 1 week), we will recruit for each team, and let everyone know by **NOVEMBER 18TH** at the latest!

We will then start with the **RESEARCH** phase

# THE ICL NEUROTECH PROJECT PATHWAY*

## RESEARCH

DURING THE RESEARCH PHASE, STUDENTS WILL BE PROVIDED WITH A VARIETY OF RESOURCES—RANGING FROM PODCASTS AND MOVIES TO JOURNALS AND ARTICLES—BOTH DIRECTLY AND INDIRECTLY RELATED TO YOUR SPECIFIC PROJECT, DESIGNED TO INSPIRE AND MOTIVATE. PARTICIPANTS ARE EXPOSED TO DIVERSE PERSPECTIVES AND CREATIVE RESOURCES, ENCOURAGING OUT-OF-THE-BOX THINKING AND A DEEPER UNDERSTANDING OF THE PROJECT'S CONTEXT.

## TECHNICAL DEVELOPMENT

THE TECHNICAL DEVELOPMENT PHASE EQUIPS MEMBERS WITH THE SPECIFIC SKILLS AND TOOLS NEEDED TO BRING THEIR IDEAS TO LIFE. BY ORGANISING RELEVANT TALKS AND PROVIDING ACCESS TO SPECIALISED RESOURCES, THIS PHASE EMPOWERS INDIVIDUALS TO OVERCOME TECHNICAL CHALLENGES, BRIDGING THE GAP BETWEEN THEORY AND PRACTICE.

## CREATION

FINALLY, THE CREATION PHASE INTEGRATES THE KNOWLEDGE FROM RESEARCH AND THE SKILLS FROM TECHNICAL DEVELOPMENT, CULMINATING IN THE PRACTICAL REALISATION OF PROJECTS. THIS STRUCTURE ENSURES THAT IDEAS ARE NOT ONLY INNOVATIVE BUT ALSO TECHNICALLY FEASIBLE AND WELL-EXECUTED, ALLOWING FOR A COMPREHENSIVE, WELL-ROUNDED DEVELOPMENT PROCESS FROM CONCEPTION TO COMPLETION.

# THANK YOU

ANY
QUESTIONS?

FILL OUT THE GOOGLE FORM

JOIN OUR WHATSAPP

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