PDE3823 – Project Proposal - Formal Form

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Program of study	Robotics and Mechatronics BEng
Assigned Supervisor	Michael Margolis
Working title **Development of Control and Interface Systems for a Flight Simulation Experience**	

Problem Definition/Research Question(s)

The core problem this project aims to address is connecting a virtual flight simulator with a mechanical chair, enabling the simulator to fully immerse the user in the flight experience. The mechanical chair being used is a variation of the MDX rollercoaster ride chair modified for wheelchair access.

In the context of Robotics and Mechatronics, this is an important issue to tackle because there are no readily available software tools that allow for seamless integration between a flight simulator and the chair. Additionally, since the ride is intended to be used by another organization (Royal Aeronautical Society), there is a significant emphasis on creating software that is not only functional but also accessible to individuals other than the engineers who developed it. Therefore, UI and UX design will play a crucial role in this project.

Another key focus of this project is implementing safety measures for the ride operator. These measures will allow the operator to halt the ride or control it safely in the event of motion sickness or a malfunction during the simulation.

Justification and context

A reason this project is relevant is because it integrates my built up knowledge about python, Unity, Blender, C# and Robotics into a collaborative project with the Royal Aeronautical Society which if done well, it will be used regularly by them in outreach events. This is a project which carries a lot of inherent learning value and opportunities to reach out to people outside of my university.

Moreover the final result can either potentially motivate young people to pursue the field of aeronautics ~~as well as be used by trainee pilots to better prepare for flight assessments and getting their license.~~

Among the relevant research, I found that X-Plane supports python communication for sending airplane telemetry (position and rotation data) via UDP protocol. I also found a rough pre-written code repos and examples of people getting telemetry data from X-Plane which can easily be implemented. ???

Commented [MM1]: Not correct

Commented [MM2]: For disabled people

Commented [MM3]: More important is the collaboration with third party developers

Moving down to the chair, I also made research on the inverse kinematics of the chair platform as well as how the actual chair controls muscle distance by varying pressure to each one of the 6 muscles. This involves using a lookup table to convert the desired distances per muscle to a given pressure according to a given person weight. Changing person weight will be yet another feature the final software needs to include.

The inverse kinematics are worked out automatically by the python program according to the chair's physical configuration so that:
target_pose=>target_muscle_distances=>target_muscle_pressures.

The PLC controlling the chair communicates with the python program likewise by UDP protocol.

The prior work on the MDX rollercoaster involved a custom unity game sending Rolle coater telemetry data to the chair the same way. As previously described.

Project Aims and Objectives

Main objective: The final ride is designed to be a highly immersive experience, allowing the user to feel as though they are truly piloting an airplane. The chair moves in sync with the plane's motions, and the user can observe their surroundings through a VR headset, interacting with them as if they were inside the airplane.

The sub-objectives that lead to main objective are:
- Software is able to move mechanical chair in real time with the flight simulation. ~~The ride should not cause motion sickness after at least 2 repeated uses.~~
- Software comes with a user interface that allows operator to easily control the ride.
- Software provides fail safe measures to shut off the ride in case of emergency.
- User interfaces allows operator to manually control the chair's pose and see a side by side simulation of it.
- Software is able to modularly connect to other flight sims aside from X-Plane. ???
- Software allows connectivity to other platforms aside from the MDX rollercoaster chair.NO
- Software allows connectivity to a custom Unity game anyone can make from scratch. NO
Software simulates as close as possible the elastic action of the muscles

Research Methodology

One of the main methods for research during this project will be team collaboration with people who did previous work on the platform. This is merely taking advantage of other's people's knowledge on the rollercoaster chair which in turn allows me to focus on adding further functionality for the software to perform more complex tasks than previously.
Not so much more complex, but much more tailored to the specific requirements detailed above.

Another research methodology will be qualitative feedback tests from inexperienced users on the software's user experience (UX). This will be a crucial tool to better enhance my project because insight on other users allows me to see problems with the UX I wouldn't otherwise notice.

An agile methodology will be implemented to design the software. The idea is to write

the software in small manageable steps such as "Get telemetry working between sim and python client" then "Get python to communicate with chair PLC via UDP" whilst continuously getting feedback on each step. There will be a focus on flexibility too as features and requirements may pop-up as the project advances.
I suggest best way to do this is to design a framework that can use many of the existing low level modules to get a skeletal system running as soon as possible. The low level modules can be modifed if necessary but focos on the high level and new functionality.

The development of the flight simulator chair does not involve direct interaction with sensitive human subject data, medical research, or activities that could harm individuals. Therefore there do not seem to be any ethical considerations or approvals to take into account at the moment.

Project Scope and Feasibility

In terms of boundaries, this project has plenty of achievable milestones with some room for further improvement after the final prototype is made. The project milestones over the weeks are as follows:

Week 1-2:Proposal write up and Pre-liminal research
Week 2 agree high level functional spec
Week 3 propose high level framework and system design
~~Week 3: Getting python client to communicate with X-Plane (and other sims if possible)~~
Week 4: Developing initial prototype for Unity GUI application that communicates with python client
-Week 5: Getting python client to communicate with the mechanical chair and move it as intended
-Week 6: Beginning work on implementing mechanical chair fail-safes
-Week 7: Working on improving operator user experience with Unity GUI by acquiring user feedback
-Week 8: Polishing UI and UX as well as allowing extra features such as operator manual control
-Week 9: Polishing software into one final product
-Week 10-12: Work on extra "ideal" features such as support for more flight-sims and mechanical platforms/chairs

Required Resources

Most required resources are already met by the university although here is a brief summary of the key components:
-Motion platform (such as the one from the MDX rollercoaster)
-X-Plane full license (for better simulation variety)
~~-VR headset~~
~~-Gaming PC capable enough to smoothly run sim and extra motion platform software~~
-Extra screen for operator to quickly operate the chair itself
-Flight control peripherals
-Access to MDX basement where platforms are kept
-Ancilliarry components such as air pressure tank for the motion platform or 3D printed parts will likewise be needed

Intended Deliverables

The main deliverable is a ride is designed to be a highly immersive experience, allowing the user to feel as though they are truly piloting an airplane. The chair moves in sync with the plane's motions, and the user can observe their surroundings through ~~a VR headset,~~ interacting with them as if they were inside the airplane. The ride should be as safe as possible including several fail-safes the operator, software or user can easily trigger if anything goes wrong. The UI and UX for the operator must be easy enough to require minimal training and previous context to operate including manual platform control for trouble shooting. Final documents for the project are also expected including: report, vlog, presentation, video vlogs, etc.. The final project is intended to be a complete ride experience that can be handed off to the Royal Aeronautics Society for their use in outreach event. This requires the final project to be as robust and least prone to failure as possible.
Initial Bibliography/Reference List
Motion platform github page: https://github.com/michaelmargolis/MdxMotionPlatformV3/tree/master …TO BE FILLED
Risk Assessment
Some foreseeable assessment risks could likewise come from struggling to make the GUI app (intended to be made in Unity at the moment) connect with python as well as the overall difficulty of working with software packages I'm not too familiar with yet. The best way I have to mitigate this issue are tutors and colleagues which worked with the MDX rollercoaster before of which I am able to consult in case I encounter any issues. Failing that, I plan to ensure I make the most of time by focusing research on issues as early as possible to avoid running out of time.

Supervisor approval	

Signed
(digitally)……Date……

EXPLANATION OF TYPICAL TERMS USED IN RESEARCH PROPOSALS

Working title
Write a title which briefly describes the research problem and your approach to it.

Problem Definition/Research Question(s)
- Describe the core research question or problem your project seeks to address.

- Why is this an important problem or question within the context of your field?

Justification and context
Project Justification: Explain why this project is relevant and valuable to the field. Include any industry insights, trends, or societal needs that underscore its importance.
Background/Literature Review: Summarize relevant research or prior work related to your project.

Project Aims and Objectives
Primary Aim: What is the overarching goal of your project?
Objectives: Break down the aim into specific objectives. These should be measurable milestones that support the main aim.

Research Methodology
Approach: Describe the main research methods and technical approaches you will use. (e.g., experimental testing, simulations, design prototyping, field studies)
Data Collection & Analysis Techniques: Outline how you will collect, manage, and analyze data.
Ethical Considerations: Describe any ethical considerations or approvals required for the project.

Project Scope and Feasibility
Scope Definition: Define the boundaries of your project—what is included and what is not. This helps in managing expectations and staying focused.
Timeline/Project Phases: A brief outline of the stages of your project, including key deadlines for milestones (e.g., completion of research, initial prototype, final testing, etc.)

Required Resources
Equipment and Materials: List the tools, equipment, and materials necessary for your project.
Software and Technical Needs: Specify any software, licenses, or digital tools that will support your research and development.
Specialist Support:
Indicate if additional expertise (e.g., lab technicians, domain experts) is required for your project's success

Intended Deliverables
Define the tangible outputs you plan to deliver. These might include a final prototype, design documents, performance data, technical reports, etc.
Expected Impact: Explain how these deliverables address the research question and their potential applications in industry or further research.
Initial Bibliography/Reference List
References: List initial references and sources that form the foundation of your research. This should include academic papers, textbooks, industry reports, and relevant websites.

Risk Assessment
Potential Challenges: Identify foreseeable challenges or risks that may impact your project (e.g., resource constraints, technical limitations).

Mitigation Strategies: Outline how you plan to address these challenges if they arise.

Supervisor approval
Is the Proposal Acceptable?