**PDE3823 – Project Proposal - Formal Form**

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| Student Name | Omar Maaouane |
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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** | |
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| 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.  This project is part of the Royal Aeronautical Society’s (RAeS) Falcon 2 programme; a programme designed for STEM students to create, develop, and build a real-life mobile flight simulator. This simulator will travel to Special Educational Needs and Disability (SEND) schools and public events across the UK, introducing people from all backgrounds to the wonders of flight.  In the context of Robotics and Mechatronics, this is an important issue to tackle because there are no readily available software tools that currently meet the needs of the RAeS.  Additionally, since the ride is intended to be used by another organization there is a significant emphasis on creating user friendly software. Therefore, UI and UX design will play a crucial role in this project.  The final flight sim is intended to be usable by wheelchair users as well as abled users. This is a separate project another peer is undertaking. My project will focus on the software control interface between the virtual sim and the mechanical chair.  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 RAeS 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 will potentially inspire dozens of young people to pursue careers in the field of aeronautics, allowing the project to continue having a direct, positive, and lasting impact beyond just research.  Among the relevant research, I found that X-Plane supports python communication for sending airplane telemetry (position and rotation data) via UDP protocol. There’s a pre-written library called XPPython which precisely allows python to interface with the X-Plane flight sim and be able to get all the required airplane telemetry data as well as creating plugins and widgets within X-Plane to obtain further functionality.  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 Rollercoaster 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. An additional “wish” requirement is for the the user to be able observe their surroundings through a VR headset, interacting with them as if they were inside the airplane. In case that can’t be done normal or wide monitors can suffice.  The sub-objectives that lead to main objective are (objectives with “\*” are “wish” objectives):  - Software is able to move mechanical chair in real time with the flight simulation. Chair movement latency should be below 50ms.  - Software comes with a user interface that allows operator to easily control the ride.  -Software provides start/pause/stop button for the ride.  -\*User interfaces allows operator to manually control the chair’s pose and see a digital twin simulation of it. The simulation should ideally take into account the elastic action of the muscles and simulate it as close as possible. This can be useful to determine is the chair will collide or move too erratically for a given weight/gain setting.  -\*Software is designed in such a way that it can be adapted to other flight sims aside from X-Plane. | |
| 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 tailoring the final project 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 design a framework that can use many of the existing low-level modules to get a skeletal system running as soon as possible. This will likely entail not focusing on UI and just get a basic python framework that can get X-Plane plane telemetry and outputs it to the mechanical chair as soon as possible (ideally by end of Week 5).  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 on high-level functional spec  Week 3: Propose high-level framework and system design  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)  -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>  -XPPython plugin page: <https://xppython3.readthedocs.io/en/3.1.5/index.html>  -Python UDP socket documentation: <https://docs.python.org/3/library/socket.html> | |
| 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?