Initial Project Overview - SOC10101 Honours Project (40 Credits)

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Title of Project:

Investigating the use of Genetic Algorithms to optimise a path planning algorithm within the Context of a Formula Student Team

Overview of Project Content and Milestones:

The project will involve the development of a simple Simultaneous Localisation and Mapping (SLAM) algorithm[2] used to store and refine the locations of cones that conform to the current FSUK-AI 2025 rules[4], relative to a global reference frame based on the car's starting position. Then, using the output of the developed SLAM algorithm, we will investigate the use of genetic algorithms to optimise a path planning algorithm[1]′s output to facilitate the fastest possible lap time. In addition, we will also develop a simulation environment[3] to test the performance of the SLAM algorithm, path planning algorithms and genetic algorithm implementations.

The Main Deliverables:

- A Path Planning algorithm, suited to optimisation by genetic algorithm
- A SLAM algorithm
- A simulation environment
- A genetic algorithm to optimise the lap time of the car.

- A report detailing the development of the algorithms and environments.

The Target Audience for the Deliverable(s):

- Formula Student teams
- Researchers in the field of SLAM and genetic algorithms
- Students and academics in the field of robotics

The Work to be Undertaken:

- Researching the state-of-the-art in SLAM algorithms
- Research into genetic algorithms
- Research into path planning algorithms
- Research into simulation environments
- Developing a SLAM algorithm
- Developing a genetic algorithm
- Developing a path planning algorithm
- Developing a simulation environment
- Integrating the SLAM algorithm, the genetic algorithm, the path planning algorithm, and the simulation environment
- Baseline the performance of the path planning algorithm within the simulation environment:
  - Testing the performance of the standalone path planning algorithm
  - Testing the performance of the path planning algorithm with the SLAM algorithm
  - Testing the performance of the path planning algorithm with the SLAM algorithm and genetic algorithm
- Writing a report detailing the development of the SLAM algorithm, the genetic algorithm, the path planning algorithm, and the simulation environment

Additional Information / Knowledge Required:

- SLAM algorithms
- Path planning algorithms
- Genetic algorithms
- Robotics (ROS)
- Simulation environments (Compatible with ROS2)
- Formula Student
- Programming languages: Python, C++
- Git (For version control)
- Cuda (For GPU acceleration)

Information Sources that Provide a Context for the Project:

- Robotics research papers (Specifically SLAM algorithms, path planning algorithms, genetic algorithms and simulators compatible with ROS2)[2, 1, 3]
- Formula Student AI competition rules and regulations[4]
- Formula Student team reports and documentation

The Importance of the Project:

- It will contribute to the field of SLAM algorithms and genetic algorithms
- It will provide a valuable resource for Formula Student teams
- It will provide a valuable resource for researchers, students and academics in the field of robotics

The Key Challenge(s) to be Overcome:

- Developing a SLAM algorithm that is accurate and efficient
- Developing a genetic algorithm that is capable of optimising the path planning algorithm effectively.
- Developing a simulation environment that can accurately test the performance of the SLAM algorithm and the genetic algorithm
- Integrating the SLAM algorithm, the genetic algorithm, and the simulation environment
- Testing the performance of the SLAM algorithm and the genetic algorithm in the simulation environment
- Writing a report that clearly and concisely details the development of the SLAM algorithm, the genetic algorithm, and the simulation environment

References

[1] Daniel Harper. "Evolutionary Design Optimization for a Formula One Car and Track". PhD thesis. University of Georgia, 2024.

[2] Nick Le Large, Frank Bieder, and Martin Lauer. "Comparison of different SLAM approaches for a driverless race car". In: *tm - Technisches Messen* 88.4 (2021), pp. 227–236. DOI: doi:10.1515/teme-2021-0004. URL: https://doi.org/10.1515/teme-2021-0004.

[3] Jonathan Platt and Kenneth Ricks. "Comparative analysis of ros-unity3d and ros-gazebo for mobile ground robot simulation". In: *Journal of Intelligent & Robotic Systems* 106.4 (2022), p. 80.

[4] Formula Student UK. *Formula Student AI 2025 Rules*. Accessed 13/04/2025. URL: https://www.imeche.org/docs/default-source/1-oscar/formula-student/2025/rules/fs-ai-2025-rules---v1-0.pdf.