Project Specifications & Requirements

ENG5325 Robotics TDP

# Project Description

The project focuses on designing and developing robotic soccer teams using humanoid robots inspired by the RoboCup Kid-size Humanoid Soccer League. The project aims to replicate real soccer actions, such as kicking the ball, dribbling, passing, running, and intercepting, using a team of four humanoid robots per side. The robots must follow specific behavioral characteristics based on their role within the team, which includes Striker, Defender, and Goalkeeper.

# Project Phases

## Simulation Development:

The first phase of the project is to simulate a digital twin of the playing environment as well as the players. The simulated environment will be based on the 9m x 6m real life pitch. The players will be fully autonomous - meaning that no human intervention will occur during the play. Therefore, behavioral algorithms need to be developed to enable players to effectively play the game.

## Hardware Implementation and Testing:

Once the simulation has been completed and approved by a supervisor, the behavior models can be loaded to the hardware and real-world testing can take place. NAO6 humanoid robots are the units chosen for use in this project.

# Operational Cost

The predicted man hours to be invested into this project is 6 hours a week per group member over the course of the project term which is 27 weeks. This would total to 972 working hours from the group.

The cost also accounts for the expected use of the lab to test the team’s software on the physical hardware. 40 lab hours have been estimated per group member bringing the total working hours to 1212. 40 hours for the use of the lab facilities were estimated and 10% of the total time has also been estimated to be accompanied by expert help, both totaling approximately 160 hours. The final spread for cost is 1212 hours at £100/hour and 160 at £1000/hour. This project is estimated to cost £281,200 for 1332 hours of work.

# Project Requirements and Specifications:

## Robot Team Specifications:

The expected outcome for this project will be for the team to design and implement software for a fully autonomous 4v4 football match. This will be done using NAO6 humanoid robots following the RoboCup kid-size league guidelines. The three positions of striker, defender, and keeper will need to be developed with each having special goals and characteristics so the robots can work as a cohesive unit. The visual sensors of the NAO6 robot will be utilized to identify the target, their direction of play, and differentiate their teammates from their opponents. The robots’ actuators will be programmed so the robots move fluidly around the pitch, kick the ball, and stand up if knocked over. Before implementing software to the hardware, the team will need to create a simulated environment of the playing field as well as a digital twin of the players so the code can be tested and verified before being applied to the hardware. The project will finish with a formal report to recap it, a presentation presented by all group members, and a demonstration of the working robotic football team.

The playing environment will be a 9m x 6m pitch with standard markings for goalie box and penalties areas. A ball with similar dimensions to a FIFA size 1 ball will be used. It will be approximately 45cm in circumference (14.3cm in diameter) and have a leather outer covering.

## Project Management:

The project management structure that has been agreed upon by the team will be the V model. Using the V model approach will offer the team more flexibility when there’s a need to revisit software design and implementation phases from the hardware portion of the project.

* ~~The project management approach follows the V Model, consisting of various stages, including specification, requirements, modelling, control and behaviour, software design of robot soccer teams, implementation, system test, field test, operation, and final reporting.~~
* ~~A Waterfall Diagram is used to detail the stages, which include specification, requirements, modelling, control and guidance, algorithm development, environment development, and operation. (Delta might be practiced through the first semeter)~~
* ~~The progress and resource allocation will be monitored through Time Allocation Records (TARs).~~
* **~~We have chosen to utilize the V model~~**

# Final Reporting and Deliverables:

The project will conclude with a formal report to recap the team's learnings, and a presentation presented by all group members. The report should include peer/personal assessments of the team's collaboration, estimated vs actual cost of the project, as well as performance metrics on how the final robotic team performed.

# Design Review:

A Design Review will be conducted in January 2024 to assess project progress and determine whether the project can proceed to the hardware implementation stage. The project will not be able to move on from software to hardware implementation without a sign off from the project supervisor.

# Timeline:

The timeline this project is expected to be completed in is within the time frame of semester 1 and 2. The submission date for the report is April 15, 2024, and group presentations will take place during the week of April 15.

Software Tools:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Simulation/ System Modeling | Visualization & 3D Modeling | Project Management & Planning | Development Environments | Collaboration Tools |
| Matlab | Gazebo | Jira | VS Code | One Drive |
| Simulink | RVizz | MS. Excel | Pycharm |  |
| Stateflow | RQT |  | Spyder |  |
| ROS2 |  |  |  |  |

### ~~Simulation and Modeling Tools:~~

* ~~MATLAB: For mathematical modelling and simulation development.~~
* ~~Simulink: A tool for modelling, simulating, and analysing multi-domain dynamic systems.~~
* ~~Stateflow: Used for modelling and simulation of control logic.~~

### ~~Robot Operating System (ROS):~~

* ~~ROS is a framework for developing robot software and managing robot hardware.~~

### ~~Visualisation and 3D Modeling Tools:~~

* ~~3D Modelling Software: To create a virtual playing environment and visualise the robot players, field, and ball.~~

### ~~Project Management and Planning Tools:~~

* ~~Project Management Software: To create Gantt charts, track project progress, and manage project milestones.~~

~~Jira~~

### ~~Development Environments:~~

* ~~Code editors and IDEs for programming robots and developing control algorithms.~~

~~VSCode, Spyder, PyCharm,...~~

### ~~Collaboration Tools:~~

* ~~Tools for sharing documents and collaborating within the team.~~

~~One Drive~~

Hardware Tools:

### NAO6 Humanoid Robots:

* Four NAO6 humanoid robots per team, mimicking real soccer players.
* Sensors and actuators for perceiving and interacting with the environment and the ball.

### Computing Hardware:

* Computers or workstations for running simulations, control algorithms, and software development.

### Physical Soccer Field Setup:

* A physical playing field with specified dimensions (9m x 6m) and markings as per the project requirements.

### Robotic Soccer Balls:

* Soccer balls resembling FIFA Ball Size 1 for use in simulations and tests.

### Robot Control and Guidance Equipment:

* Equipment and systems for controlling and guiding the humanoid robots during testing and field trials.

### Camera Systems (if necessary):

* Cameras for monitoring and capturing robot soccer matches and their behavior.