School of Computing 

COMP5200M Scoping and Planning Document

|  |  |
| --- | --- |
| **Student Name:**  Fanhui Meng | |
| **Programme of Study:**  Artificial Intelligence | |
| **Provisional Title of Project:**  Control Systems (AI) for Wrestling Robots | |
| **Name of External Company** (if any)**:**  N/A | |
| **Supervisor Name:**  Amy Lowe | |
| **Type of Project:**  Exploratory Software | |
| ***NOTE to student****: ensure you have discussed the content with the supervisor before submitting this document to Minerva. Submit an* ***electronic version*** *of this report in pdf via the appropriate link in Minerva; with filename of the format <surname><year>-SP ( e.g. SMITH15-SP.pdf).* | |
| **Signature of Student:** | **Date:** |

Contents

[1. Background Research for the project 1](#_Toc429570687)

[1.1 Context 1](#_Toc429570688)

[1.2 Problem statement 1](#_Toc429570689)

[1.3 Possible solution 1](#_Toc429570690)

[1.4 How to demonstrate the quality of the solution 1](#_Toc429570691)

[2. Scope for this project 1](#_Toc429570692)

[2.1 Aim 1](#_Toc429570693)

[2.2 Objectives 2](#_Toc429570694)

[2.3 Deliverables 2](#_Toc429570695)

[3. Project schedule 2](#_Toc429570696)

[3.1 Methodology 2](#_Toc429570697)

[3.2 Tasks, milestones and timeline 2](#_Toc429570698)

[3.3 Risk assessment (if appropriate) 2](#_Toc429570699)

[References 3](#_Toc429570700)

[Appendix A. How ethical issues are addressed 3](#_Toc429570701)

## 1. Background Research for the project

### 1.1 Context

There is a Zumo robot wrestling league, which is a large and popular international league. The competition aims to seek out the opponent robot and push it out of the ring and avoid being pushed out of the ring itself.

And Zumo robot is an Arduino-controllable robot. It has the essential mechanical parts and electronics, including a dual motor driver, three-axis accelerometer and compass, etc. Some necessary sensors, like infrared ray, phototransistor.

### 1.2 Problem statement

For this project, I don't need to worry about the hardware, they are fixed. What I need to focus on is to write code to control the motor according to the data from the sensors to achieve the goal.

And the main problem is to design an intelligent control system. This control system should make the decision to control the robot's movement precisely under different circumstances. And how to transmit the decision from high level to the motor is also a problem to be considered. Besides, there are lots of kinds of control system and predicated model nowadays. And each of these control systems has it's own advantages. So I plan to focus more on design and implement an intelligent control system for the Zumo wrestling robot.

### 1.3 Possible solution

First of all, about the whole control system. I would like to use three-layer architecture, which is a very popular hybrid architecture. This architecture consists of a reactive layer, an executive layer and a deliberative layer.

The deliberative layer, which is the most critical layer use models for decision, predication and strategic making. So far, I think there are three possible models can be useful for my project.

* Decision tree. It's a ubiquitous machine learning algorithm. And it’s easy to understand and implement. Trees can be seen as generative models of induction rules from empirical data. There are several algorithms to generate optimal trees, such as ID3, C4.5, etc. However, the disadvantage of decision tree is that they are unstable, meaning that a small change in the data can lead to a significant difference in the structure of the optimal decision tree. Sometimes they are inaccuracy when they compare to other predicated model. And it's also easy to be overfitting due to too many nodes are generated. Some of these disadvantages can be fixed, like using random forest or pruning tree, and this requires further study and experiment. Also using genetic algorithm to modulate the decision tree can be alternatives.
* Using Markov Decision Process (MDP) to achieve reinforcement learning. Markov chain means in a random step. The next state is only related to the current state. And MDP has two more attributions, the action (allowing choice) and reward (giving motivation). At each time step, the process is in some state, and the decision-maker may choose any action that is available in this very state. Then moving to the next step, and rewarding the decision-maker. And the goal is to find the optimal strategy, which means discover the maximum of reward.
* Bayesian network is a directed acyclic graph (DAG) that represents a set of variables and their conditional dependencies. This network can represent and use conditional probability to solve the decision problem under uncertainly. However, this method is widely used as a classifier, and it assumes that the distribution is independent. So if the input variables are related, it could cause a problem.

The executive layer serves as the glue between the reactive layer and the deliberative layer. This layer is responsible for integrating sensor information into an internal slate representation. And transmit the decision to the reactive layer.

The reactive layer provides low-level control to the robot, such as the two motors in the Zumo robot. And PID control may be helpful in this layer. It can give accuracy movement of the robot.

In conclusion, I would like to implement these control step by step. For example, use PID do some simple movement, like go straight ahead, turn right/left. Do some experiments by using three different decision-maker in different scenarios, like when detect opponent on the right, then move towards it or avoid it. Then train the predicated model/decision maker with a set of training data. Inspect its performance and modulate the model to make it performs better.

‌

### 1.4 How to demonstrate the quality of the solution

By looking at the performance of the robot when competing with another Zumo robot. If my Zumo robot reacts like what I expect to the decision-maker, then it succeeded.

## 2. Scope for this project

### 2.1 Aim

Test different systems in deliberative layer, find out which decision-maker is more suitable for the wrestling scenario. Design strategies and implement such control system of Zumo robot based on Arduino. Learn to use PID control as the lower level control system. Finding a good solution to transmit and execute the commands well from the higher level control system.

### 2.2 Objectiv**e**s

* Deliverable – One report along with its code.
* Measurable – The performance of the robot in different wrestling scenarios. Be able to push the opponent out of ring and make sure the robot won’t run out of ring itself.
* Appropriate – Design and implement a control system for this competition and robust performance when competing with different opponents with different strategies. And an accurate lower level control system would execute the commands as expected.
* Agreed – By my supervisor, assessor, other members of the school.

### 2.3 Deliverables

Background study (e.g. search strategies, hierarchical planning). Basic hardware as well as sensors in this Zumo robot. The sensor data transmission. The comparison of different decision-makers. The transmission of decision to execution. The low-level control implementation. The code.

## 3. Project schedule

By the end of week 24, do more research on the control system. Design small experiments for each possible solution and compare.

By the end of week 30, working on implementation for both decision-maker and PID control.

By the end of week S2, complete the implementation and work on real robot training match.

By the end of week S4, improve the design and complete chapter 1,2 and 3 of the report.

By the end of week S8, complete the report and finalise the whole dissertation.

### 3.1 Methodology

Finding and reading papers about the control system. Inspect relative control system open source code on Github.

### 3.2 Tasks, milestones and timeline

### 3.3 Risk assessment (if appropriate)

No

## References

*Kamiński, B., Jakubczyk, M. and Szufel, P. (2018). A framework for sensitivity analysis of decision trees. Central European journal of operations research, [online] 26(1), pp.135–159. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29375266 [Accessed 19 Jan. 2020].*

*Russell, S. and Norvig, P. (2010). Artificial intelligence : a modern approach. New Jersey: Pearson.*

*Wikipedia Contributors (2019a). Bayesian network. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Bayesian\_network [Accessed 1 Nov. 2019].*

*Wikipedia Contributors (2019b). Decision tree. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Decision\_tree.*

*Wikipedia Contributors (2019c). Markov decision process. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Markov\_decision\_process [Accessed 29 May 2019].*

## Appendix A. How ethical issues are addressed

The robot will fight with each other rather than human beings.