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| School of Computing  Faculty of Engineering |

Control System (AI) for Wrestling Robot

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Submitted in accordance with the requirements for the degree of  
MSc Advanced Computer Science (AI)

**Session 2019/2020**

The candidate confirms that the following have been submitted*:*

*<As an example>*

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Type of Project: Exploratory Software

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# Summary

The artificial intelligence technology has been widely developped and used in many field. This project is focus on using AI technology, design a high-level control system for Zumo robot in the Sumo robot league.

The Sumo robot league is a popular robot competition, and the main rule of this competition is two vehicle-like robot without mechanical arm trying to push each other out of the ring. The Zumo robot that is going to be used in this project, it’s a off the shelf Arudino-based robot. Thus, no structure design or hardware design (e.g. circuit design) or low-level design (e.g. PWM motor speed control) in this project.

The high-level control system means the ‘brain’ of the robot. It has strategies to cope with different situations. There are many machine learning methods to develop strategies for the robot. Bascially, there are two kinds of machine learning can be applied in this project, which is supervised learning and unsupervised learning. One is to develop the control system by telling the robot which is the right thing to do and what is wrong. Another is to develop the control system by not telling what the robot should do, but only reward or punishment the robot according to the rules and it’s behaviours.

This project aim to implement and compare two different control systems, one is supervised and another is unsupervised.

Futhermore, this project will do more research about how the same control systems or the same ideas can be applied in other robot competitions or the robot in daily life.

# Acknowledgements

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*<This page should contain any acknowledgements to those who have assisted with your work. Where you have worked as part of a team, you should, where appropriate, reference to any contribution made by others to the project.*

*Note that it is not acceptable to solicit assistance on ‘proof reading’ which is defined as “the systematic checking and identification of errors in spelling, punctuation, grammar and sentence construction, formatting and layout in the text”; see* [*http://www.leeds.ac.uk/qat/documents/policy/Proof-reading-policy.pdf*](http://www.leeds.ac.uk/qat/documents/policy/Proof-reading-policy.pdf)*. >*

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# List of Abbreviations

BEAST Bio-inspired Evolutionary Agent Simulation Toolkit

GA Genetic algorithm

# Chapter 1 Introduction

## Project Aim

The aim of this project is to design a fine robot high-level control system, which is the ‘brain’ of the non-arm Zumo robot. The control system would have it’s own strategy, and drive the robot’s movement during the competition. As for the strategy, it can be assigned with specific movement in different cases or the robot can develop it’s own strategies, which may related to evolutionary algorithm. And this will be discussed later in the report.

The main goal of this project is to make the Zumo robot be competitive and perform well in the Sumo robot competition. In addition, this project will find out if the idea of control system can be applied to a wider range of different robot, such as other robot competition or the robot service in daily life.

This project is going to use the Zumo 32U4 robot, which is a complete, versatile robot controlled by an Arduino-compatible Atmega32U4 microcontroller. Therefore, extra hardware structure and improvement is not considered in the project. The Zumo robot has two motors, one Atmega32U4 chip as the brain and a variety of sensors, including proximity sensors, line sensors and accelerometer. So the Zumo robot can detect the opponent and run towards or away from it, which satisfy every requirement of a robot in the Sumo league.



Figure 1.1: Main features of the Zumo 32U4 robot

Sumo robot league is a very popular international robot wrestling competition, which is two robots attempt to push each other out of the ring. Thus, the wrestling robot must be capable of autonomously locating the opposing robot and pushing it out of the ring (Wilson et al., 2016). The last stand robot in the ring is the winner. Also, there are other rules in the Sumo league, which the control system should be designed according to these rules. And these rules will be explained in details in the next chapter.

### Objectives:

* To get familiar with the hardware functions of Zumo robot.
* Conduct a theory study to compare different control system in the wrestling case.
* Implement two or more different control system and compare it’s advantages and disadvantages.
* Create wrestling simulation environment. (Due to the lockdown policy, it’s hard to find the opponent in the real world)
* Evaluate the results with it’s performance in different simulation cases.

#### Deliverables

1. A software product that can simulate the Sumo robot wrestling. Built using BEAST.
2. A Github repository that contains the source code of the system.
3. A developer documentation that provides:

* An overview of the simulation, algorithm used, programming languages and style.
* Instructions for setting up the project in a local development environment. (Provide VM for Mac or Windows user)

1. The MSc project report.

#### Ethical, legal, and social issues

Need to be done.

No Ethical, legal and social issues related to this project.

# Chapter 2 Background Research

## 2.1 Literature Survey

There are pretty much studies in Sumo robot control, and even more research on the general intelligence control system. And there are also different aspects of these project. Some are fucus on the low-level development, some are meant to design the hardware or the construction of the Sumo robot, some are focus on the electronics and so on. And this project is going to focus on the high-level design.

One study is to develop the Neuro-Fuzzy (NF) hybrid system as the control system (Hamit, 2011). In other word, it use two system, which is ANN and Fuzzy Inference System (FIS). FIS is for detecting and tracking the opponent, which relates sensor output (IR sensor) to motor control pulses. ANN is used for rule extraction and tuning the FIS parameters. And the result shows that this control system can improve the robot responses during competition. This is a good thought to develop a good control system. It’s pettery much the low-level development. It’s just like human work out to improve physical strength, but I would focus on the brain development. However, the wrestling environment is uncertain and the data is non-linear. Thus, the method that using ANN to improve the fuzzy control is a good thought for high-level control as well.

Simularly, one project also use fuzzy logic as the main idea of sumo robot control. It use single fuzzy logic as the microcontroller for detection and tracking of opponenet in competition ring. Three infrared sharp sensors for target detection. Touch sensor for detect collision. Line sensor to detect if the robot still remian in the ring. Then the fuzzy controller fuses the sensor data and provide the control signal to the motor for driving the robot toward the opponent (Erlan et al., 2013).

There are four operation mode in the project, including searching mode, attack mode, survive mode and opponenet facing mode. Each mode

Besides, a few studies use genetic algorithm (GA) to optimize sumo robot. One study use Java with Eclipse and the *dyn4j physics engine* for simulating the sumo robot fight (Lehner et al., 2019). Each robot has six attributes (e.g. the speed, serach range), which are allocated to gene positions and can be controlled by the GA. The intensity of each genetically controlled capability is the characteristics, which is expressed with a vale ranging from 1 to 9.

The genes for robot attributes and it’s controlled capability is shown below.



Table 2.1: Genes for robot attributes (Lehner et al., 2019)

The process for each individual robot is, in the start of the fight, each robot receives a randomly selected mix of values, which is the mix characteristics for the robot. Then run the fight to determine highest fitness. The fitness is defined as how many movements are requred until it’s lose or stands last. The next step is the crossover and selection for the next generation. This project uses *roulette wheel selection*, which distributes the probability for the selection of each robot based on their relative probaility of the fitness. And 50% mutation rate per gene is also applied to increase the probability of changing the characteristics randomly. Finally, create new generation and transfers the new generation in a new loop. After thousands of generations, the last robot stands in the ring is the final winning genes of the GA optimizaiton.

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# Appendix A External Materials

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# Appendix B Ethical Issues Addressed

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