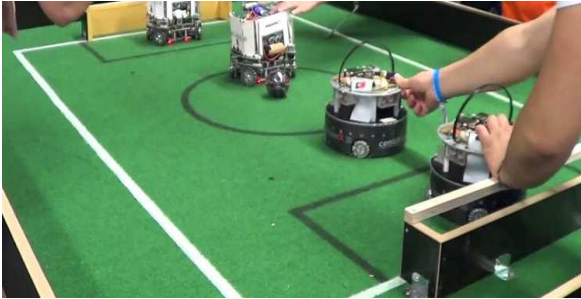


University of Glasgow
James Watt School of Engineering
Robotics Team Design Project M (ENG5325)

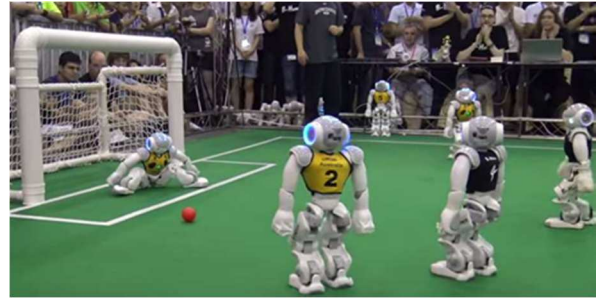
Simulated RoboCup Soccer Teams

Introduction

Robotic competitions have become extremely popular over the last few decades. Some of the most popular competitive activities have involved the replication of sporting events e.g. robotic Olympics, swimming, soccer. This particular project will focus on the design and development of robotic teams for a soccer competition based on RoboCup leagues and rules (see Figure 1).



(a) Wheeled robots for RoboCup Soccer



(b) RoboCup Humanoid Soccer

Figure 1: RoboCup Soccer Competitions

The particular purpose of this project is to design and develop virtual soccer teams and a virtual environment for the teams to play on. These teams and the virtual playing environment will represent the same entities and environment used in the real competitions.

Problem Specification

The Teams

In this project the robot players shall be humanoid robots based on the construction, actuation, dynamics and kinematics of a NAO6 robot (see Figure 2).

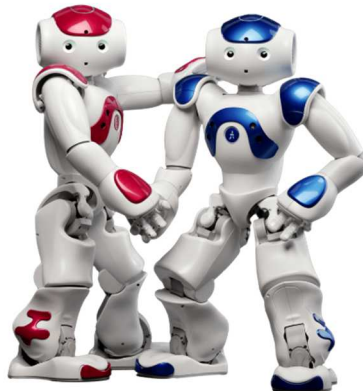


Figure 2: NAO6 Robots

Following the rules and guidelines for the KidSize Humanoid Soccer League (<https://humanoid.robocup.org/>), each team will consist of 4 humanoid robots. These robots will replicated the motion and actions of real soccer players e.g. kick the ball, dribble, pass the ball, run, intercept.

Within each team the robots will exhibit different types of behaviour depending on the function of the robot within the team and the state of play. These are:

Striker – This behaviour focusses on scoring points by kicking the ball into the opposing team's goal. The strikers could exhibit more aggressive behaviour and will be goal focussed when the team has the ball. When the team does not have the ball then the striker behaviour will seek to intercept and gain control of the ball.

Defender – This behaviour focusses on defending their team's half of the pitch and the goal area. The defender behaviour could be defensive in nature in that its primary function is to prevent the opposing team from getting the ball near to the defending team's goal. The range of the defender could extend depending on the current situation of play.

Goalkeeper – This behaviour focusses on guarding the goal and preventing the opposing team from scoring.

Whether your team has specific set formations, i.e. specific behaviours are assigned to particular robots within the team and this does not change, or there is a dynamic allocation of behaviour, i.e. behaviours change depending on the position of the robot on the pitch, all depends on your design for the team. In addition, the team must follow the general rules of soccer as outlined by RoboCup.

Control Guidance of Robots

The control, guidance and navigation of the robots must be totally autonomous with no input from an external operator. The robots should react to the state of play during a match and adopt an appropriate behaviour. Design of the control, guidance and navigation system for each robot is a key aspect for the project. The specification of the control system is determined by the performance requirements for each playing behaviour and how the robot responds to the current state of play.

The Pitch or Field of Play

The dimensions of the Pitch for the KidSize Humanoid competition are 9m by 6m. The line spacing and configuration is shown in Figure 3 below.

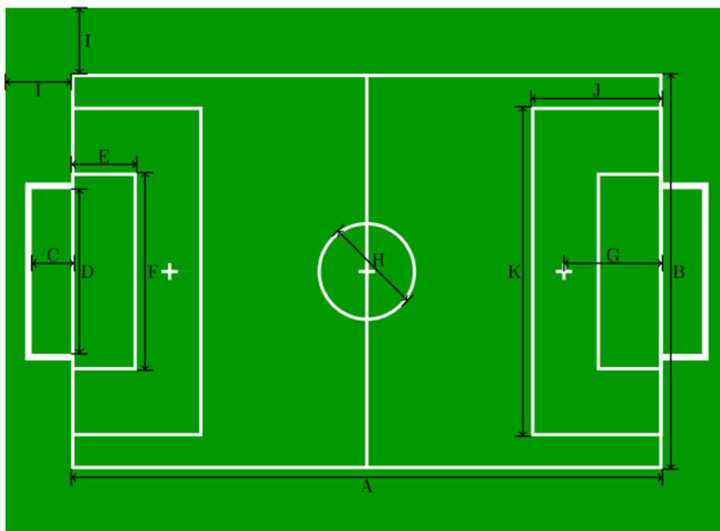


Figure 3: Pitch Markings

The particular measurements and dimension of this pitch are shown in Table 1:

Table 1: Pitch Dimensions

Code	Description	Measurement
A	Pitch length	9m
B	Pitch width	6m
C	Goal depth	0.6m
D	Goal width	2.6m
	Goal height	1.2m
E	Goal area length	1m
F	Goal area width	3m
G	Penalty mark distance	1.5m
H	Centre circle diameter	1.5m
I	Border strip width	1m
J	Penalty area length	2m
K	Penalty area width	5m

This pitch is the main operating environment for your robot teams and they should function appropriately within its confines.

The ball

The ball is taken to be similar to FIFA Ball Size 1 in dimensions which is 45cm in circumference. This relates to 14.3cm in diameter. The material used for the outer covering of the real ball is leather.

Project Management

In order to manage a project there are a number of different techniques that are favoured by industry. Each company has its own pet technique that it has tailored its processes to fit. In this case your team is advised to follow the stages defined by the following *Waterfall Diagram*.

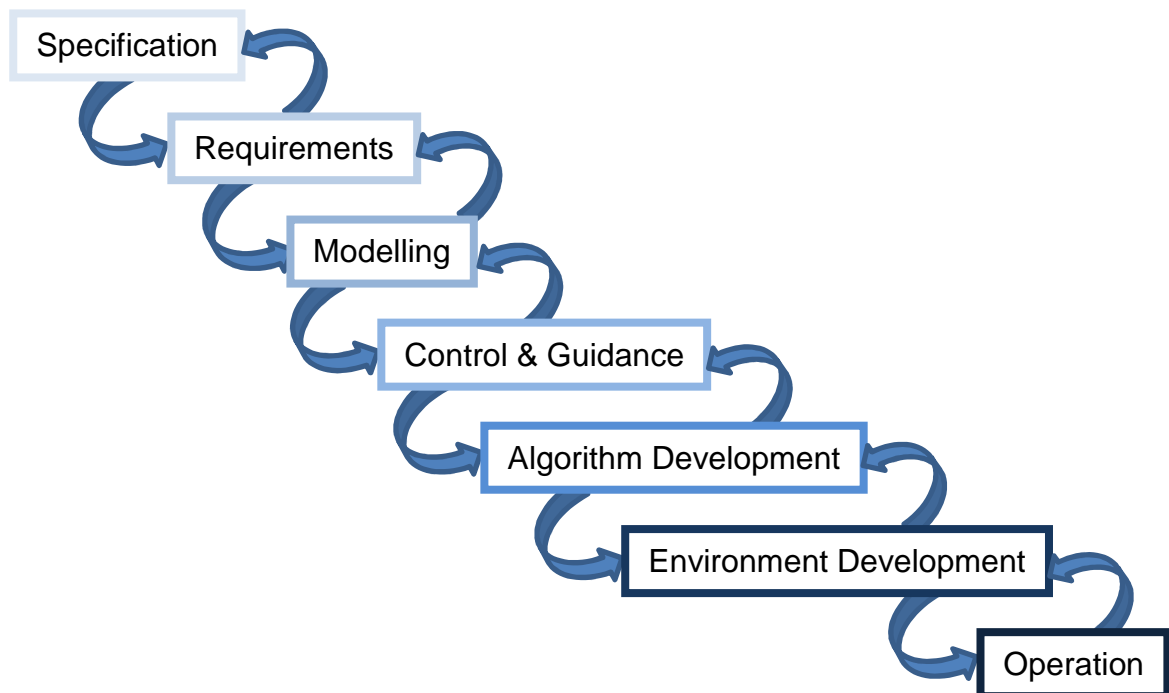


Figure 4: Waterfall Based Project Plan

A typical Waterfall Diagram describes the stages or workpackages involved in designing, evaluating and testing a system. In this particular case the stages of the project are the simulation based stages that will enable your team to produce a virtual humanoid robot soccer team and playing environment. The development stages will allow the performance of your design to be assessed by means of an appropriate test schedule for each stage. Each stage illustrated in Figure 4 is described in detail below:

Specification provides the team with the design outline for the project, which is presented in this document and given in the initial project briefing.

Requirements stage allows the team to outline what is needed from each part of the system and the resources needed for the complete development. Also involves the project planning and time/cost management activities.

Modelling involves the development of a model describing the motion characteristics of the robot players and the ball. These model provides the simulation entities that will be used as the basis of your virtual soccer match.

Control & Guidance determines the lower level control and guidance behaviour of the robots. These systems are used to provide the robots with the fundamental controlled motion needed to perform the primary functions for the player types.

Algorithm Development involves the development of the algorithms that determine the behaviour and interaction of the robots with other robots, the ball and the playing environment. These high level algorithms should take into consider the behaviour of each player type as well as restrictions imposed by the environment and the competition rules.

Environment Development involves the development of the playing environment and the visualisation of the players, environment and ball. This defines the workspace for the robots and their operation environment. The visualisation should be such that it accurately represents the play during the match between 2 teams.

Operation represents the production stage for the final tested product. In this case it will involve the reporting activities i.e. the delivery of a written report and an oral presentation.

Your teams will follow these stages in order to satisfy the design specifications for this project. Each stage has its own associated deliverables and milestones that have to be completed successfully and given to your project managers. It follows that that the Waterfall Diagram can be used to construct a timing diagram (e.g. a Gantt chart) for your team to follow. This will enable you to schedule your work, complete each workpackage and deliver your milestones in sufficient time. Also it will allow you to determine the Critical Design Reviews that will allow you to progress onto other stages of the project or integrate deliverables for different stages together.

Continual Reporting and Estimating Costs

In order to monitor the progress being made by the team and the amount of effort being applied by each individual, a *Time Allocation Record* (TAR) will be completed by each team at the end of each 2 week period and delivered at the project supervisor's meeting. This form will indicate the amount of time that each member of the team has spent on the specified milestones for that period. The time indication will be used to assess the individual contribution to the project and the overall staff costs.

The staff costs have been set at £100 per hour for this project. In addition, the cost of additional expert help have been set at £1000 per hour (this does not include consultation at weekly meetings).

An estimate of the total cost for the project should be put together during the Requirements stage using the timing diagram (Gantt chart) that your team puts together. Both should be presented at your first meeting with your supervisor.

The accurate record of the actual time resource used during the project will be collected using the TARs outlined above. This can be used to calculate the actual costings in terms of staff and expert help. These will be analysed in your report and a comparison against your estimates made.

Final Reporting and Deliverables

The final evaluation of the project will be through a written report and an oral presentation. Each team should produce a separate report that gives a clear and concise account of the design process and evaluation of their Robotic Soccer Teams and their playing environment. In addition to providing appraisal of the performance of the virtual soccer system, the report should provide an estimate of the cost of developing this design and assessment of how well the team worked together. Individual contributions to the project work, report and presentation should be indicated in the report and during the presentation.

The completed reports should be submitted via the Moodle page for this course by 4pm on 19th April 2023.

Each team will give an oral presentation that outlines the salient points of their report. The presentation will be 20 minutes long with 5 minutes for questioning. Every member of the team will be expected to deliver at least one part of the presentation. The presentations shall be held during the week beginning 17th April 2023. Time and venue to be announced.

Please note that the University's plagiarism policy applies to the material presented in the team reports and presentations.

Peer Review Report

Each team member will be asked to complete a Peer Review Report at the end of the project. This report will allow each team member to give peer and self-review regarding the contributions made by all the members within their team. These reviews will be taken into consideration during the assessment of the project.

Assessment Mark

Each student will receive an individual mark for this course, which will be determined through the following components:

- *Report* (60% - Team mark)
- *Teamworking* (30% - Individual element of mark)
- *Presentation* (10% - Team mark)

The teamworking element is determined through a combination of the TAR data, weekly meeting assessment and peer review. Individual components of the report and presentation will be determined using peer review.

Dr McGookin
January 2023

Useful Webpages

RoboCup main webpage: <https://www.robocup.org/>

RoboCup Humanoid Soccer webpage: <https://humanoid.robocup.org/>

RoboCup Humanoid Soccer Rules: <http://humanoid.robocup.org/wp-content/uploads/RCHL-2020-Rules-Dec23.pdf>

NAO6 Robot Webpage: <https://www.softbankrobotics.com/emea/en/nao>

Matlab Onramp: <https://uk.mathworks.com/learn/tutorials/matlab-onramp.html>

Simulink Onramp: <https://uk.mathworks.com/learn/tutorials/simulink-onramp.html>

Stateflow Onramp: <https://uk.mathworks.com/learn/tutorials/stateflow-onramp.html>

Robot operating System: <https://www.ros.org/>