ECSE 211 - Design Principles and Methods

REQUIREMENTS DOCUMENT

GROUP 11
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Abstract

The goal of this document is to try to make sure that the requirements of the project are fully understood by the members of the team and by any future readers. It is composed of several sections, each of which tries to address one aspect of the specification and to try to identify all the related issues. This is a living document to be updated as the requirements are further understood and/or modified.

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1 EDIT HISTORY

- February 19th 2017:
  - **Alex Lam:** Initial set up of document sections (including table of contents)
- February 20th 2017:
  - **Alex Lam:** First draft of sections 3.2 and 4.0
  - **John Wu:** First draft of sections 2.4 and 3.1 (with Ethan)
  - **Ethan Lague:** First draft of section 3.1 (with John)
  - **Ian Smith:** First draft of section 2.5 (including 2.5.1, 2.5.2, 2.5.3 and 2.5.4) and 2.6
  - **Durham Abric:** First draft of sections 2.1, 2.2 (including 2.2.1 and 2.2.2) and 2.3
- February 22nd 2017:
  - **Alex Lam:** General edits to formatting and changes to section 10
- March 8th 2017:
  - **Alex Lam:** Update to sections 2.2, 2.2.1, 2.4 and 3.2 (update of project description on MyCourses)
- March 29, 2017:
  - **Durham Abric:** Update to sections 2.2, 2.2.1, 2.2.2
- April 7th 2017:
  - **Alex Lam:** Updates to sections 2.2, 2.3, 2.4, 2.5 and all included subsections

2 CAPABILITIES

2.1 Purpose

The purpose of this project is to design and build an autonomous robot that will play a game which is a hybrid of basketball and soccer. The robot must be able to play both offense and defense. Regardless of the position it is playing, the robot must be able to receive instructions via WiFi, localize and navigate the playing surface without colliding with any obstacles (including the opponent robot). In addition, when playing offense, the robot has to retrieve balls from a dispenser placed at a random location on one of the four boundaries of the playing surface (as shown in "Project Description - March 12 2017", Figure 1); then it must be able to bounce the collected ball into the target (a 10" diameter circle raised 7" of the ground) from a point South of the forward line. On defense, the robot must keep its position within the defensive zone and attempt to prevent the offensive from scoring by blocking any incoming shots.

While designing and building the robot is the primary purpose of this project, the team's purpose is also to document the entire design process in such a way that would allow a third party team to recreate the process. The team's goal is also to ultimately create a more effective robot than the other teams and win the competition.

2.2 Scope

The robot must be designed as to be able to perform on the second floor of the Trottier Building which will be referred to as the "competition room" in this document. Section 2.2.1 below outlines the tasks the robot must be able to complete and section 2.2.2 outlines the extent to which these tasks must be completed. The scope of the robots capabilities varies slightly depending on which of the three rounds it is performing in. During the first two round the robot will play either offense or defense, with an opponent robot playing the opposite role. In the third round, the robot will play offense, and no opponent robot will be on the field. Further details of the difference between rounds is found in the "obstacle avoidance" subsection in section 2.2.1 below.

2.2.1 Capabilities

- **WiFi Compatibility:** The robot must receive the parameters for the competition over WiFi before starting the round. The parameters passed to the robot are outlined in section 2.4 of this document.
- **Localization:** Once the round starts, the robot must be able to correctly determine its starting coordinates and heading before continuing on to perform it's role.
- **Odometry:** The robot must have an accurately functioning odometer, in order to implement its navigation system. The odometer can be corrected using grid-lines at each 1' interval in the X/Y direction on the field.
- **Navigation:** The robot must be able to accurately navigate around the 12' x 12' field, in order to accomplish the goals of its offensive/defensive methods.

- **Obstacle Avoidance:** The robot must be able to detect and avoid obstacles placed randomly throughout the competition field. The obstacles are expected to be the approximately 25 by 12 centimeter, wooden blocks used throughout the lab portion of this course, although it has not been explicitly stated. The obstacles will be placed perpendicular to the lines of the square in which they are placed and may be placed in clusters on or around the field. The placement of the obstacles also depends on the round of the competition. In rounds 1 and 2 the obstacles can only be placed in the 1 tile wide band surrounding the field on the South side and on the 2 tile wide strip on the East and West sides. On the south side the obstacles may encroach on the field area. No obstacles are to be placed in the 1 tile wide strip on the North side of the field. In round 3 the obstacles are free to be placed anywhere on the field except in the [w1xw2] region.
- **Offense:**
  - *Ball Retrieval:* The robot must be able to navigate to the ball dispenser, notify the TA/Professors it is ready to retrieve a ball, catch the ball from the dispenser, and maintain possession of the ball as it navigates to a shooting position. The ball dispenser's coordinates given via the WiFi parameters indicate the line on which the dispenser will be placed. It's orientation is also to be retrieved through these parameters. The ball dispenser will be placed 15cm off the ground.
  - *Shooting:* The robot must be able to launch a ball through a 10" diameter target raised 7" off the competition floor, and located at coordinates (5,10). The ball must bounce one and only one in the [w1 x w2] region, as defined by the WiFi parameters, before passing through the target. The range of values taken by w1 and w1 can be found in section 2.2.2. The robot must shoot from a position south of the forward line, the coordinates of which is denoted by "d1" and is specified in section 2.2.2. The balls used during the competition will be the red and blue, heavy plastic balls provided by the ECSE loans counter during lab 5.
- **Defense:** The robot must have a methodology for traveling to the defensive region and, once there, blocking any potential shots its opponent takes on the target. Constraints on the defensive method are found in section 2.2.2 below.

2.2.2 Limitations

The robot must operate within a 8x10 field centered on a 12x12 tile surface constructed of hardwood tiling, and stay within its designated offensive or defensive area (shown in Figure 1) once it has been reached. The defensive region is the region North of the forward line excluding the [w1xw2] region, while the offensive region is the area South of the offensive line. The values for w1 and w2 (the width and height of the green/target area) are in the range [2,4], and d1 (the position of the forward line) is in the range [5,8]. Any robot traveling outside of it's designated region for more than 10 seconds will be deducted points. In rounds 1 and 2, once the offensive robot has reached its zone it is barred from utilizing any ultrasonic sensors. In round 3 this restriction is lifted as there is no defensive robot on the field. More detailed information on the floor and field is contained in sections 2.5.1 and 2.5.2 of this document.

The robot must localize within 30 seconds and must remain within it's starting corner for the duration of it's localization procedure. Once localized, the robot must proceed to its assigned zone without colliding with its opponent; if the robots do collide, the outcome is classified as a false start. If more than 3 false

starts occur, points will be deducted from the team's total.

The length of each round has two limiting factors: number or balls provided and time. Thus, each round will proceed until all the balls have been retrieved/launched (the maximum number of balls has not been specified) , or the time limit of 7 minutes has been reached.

2.3 Constraints

Constraints on the robot size is discussed in section 2.2.1 above. Other constraints are discussed in sections 3 (Hardware Constraints) and 4 (Software Constraints) of the Constraints document.

2.4 User Functions

Since the round number is not passed to the robot through wifi at the start of the round, the team is expected to create a UI that lets the user select the round number the robot is currently competing in (see software document). Once the program begins, the user will be able to pass in parameters to a start method through a WiFi connection (see software document section 3.2 for details). The parameters will be as follows:

1. Number of the starting corner
2. Role as either offense or defense
3. The green zone dimensions (w1 and w2)
4. Forward line position (d1)
5. Location and orientation of the ball dispenser

Once the parameters are given, the user cannot interact with the robot until the round is over. The number of each starting corner is indicated in figure 1. The orientation of the ball dispenser will be given as a string with fours possible values: "N","S","E","W" corresponding to the four cardinal directions. During the round, the robot will be completely autonomous and navigate itself to do the required tasks based on its user input from the start. An emergency exit clause will cause the exit of the program if any button is pressed after the program has started.

2.5 Operating Environment

2.5.1 Floor

The floor will consist of nine 4' x 4' hardwood-covered metal panels that lock together. The surface of each panel is marked with a 4' x 4' grid that aligns precisely with adjacent panels. The junction between panels is not guaranteed to be perfectly leveled which could impact the maneuverability of the robot. The floor will not be perfectly smooth or clean. The friction along the floor may vary in certain areas which may cause the wheels of the robot to slip.

Figure 1: Example playing field
(Obtained from client requirements document)

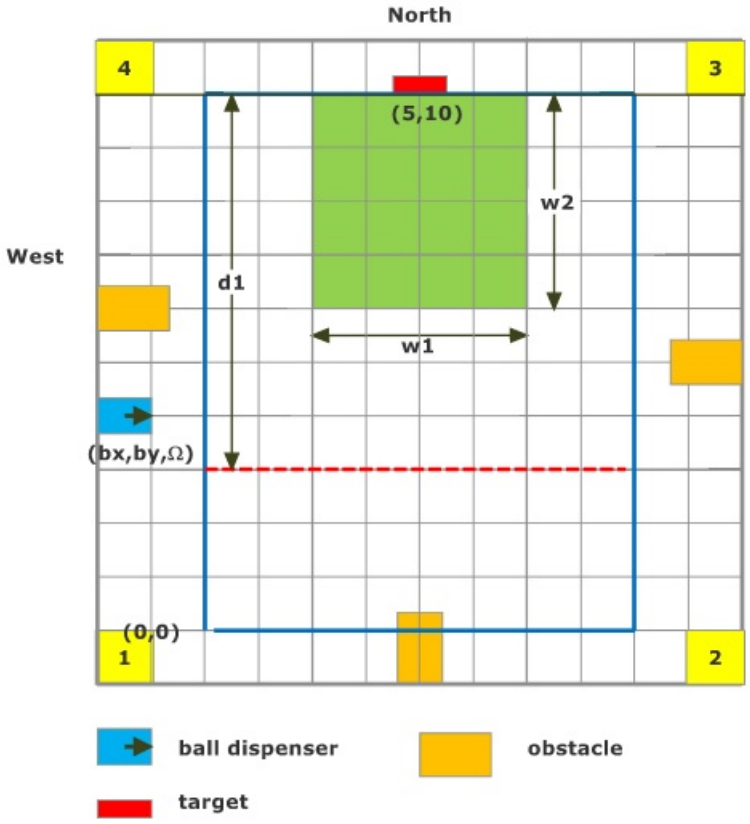

Figure 1

2.5.2 Field

The field is displayed in Figure 1: Example playing field where an example of how the obstacles may be placed in round 1 and 2 is displayed (see section 2.2.1: Obstacle avoidance).

The field being played on by the robot will be within a 8' x 10' area. The field is surrounded by a band that is two tiles wide on the sides and one tile wide on the bottom and top.

The dimensions of the field and goal are discussed in section 2.2 of this document. Figure 2: Goal dimensions shows the dimensions of the target goal.

Figure 2: Goal dimensions
(Obtained from client requirements document)

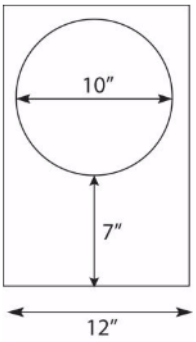

Figure 2

2.5.3 Lighting

The competition room will have many windows which implies that the level of lighting in the room is greatly subject to change depending on the weather conditions on the day of the competition. Therefore, readings from the light sensors are likely to be unreliable and measures are to be taken to ensure the reliability of the light sensor readings.

2.5.4 Ultrasonic Noise

The floor will be surrounded by walls which will help exclude any ultrasonic noise from entering the floor after a round has begun. However, during rounds 1 and 2, an opponent robot with its own ultrasonic sensor will also be present on the field which could impact our ultrasonic sensor readings. In addition, although the walls could contribute in reducing ambient noise, there is bound to be inaccuracies in our ultrasonic sensor data due to the residual ambient noise. For these reasons a filter for our ultrasonic sensor data will need to be implemented.

The floor itself will consist of 3 obstacles that need to be taken into account. The other teams robot will also be present on the field during all rounds except the last.

2.6 Performance

The minimal performance requirements for the robot are outlined in 2.2 Scope. The response time and movement capabilities are all outlined in sections 2.2.1 Capabilities, 2.2.2 Limitations and 2.3 Constraints.

3 COMPATIBILITY

3.1 Component re-use

Hardware

The base of the robot that Ethan and Ian used for all 5 of the lab demos will be re-used with adjustments made to make this version of the robot more suitable for the given specifications. While we will not re-use any other components that are already built, we will take inspiration from components used during the labs (see systems document section 5.2).

Software

The requirements are different than the labs, so the software architecture will need to be redesigned to meet the user criteria and allow all our systems to work together asynchronously. Most of the components can be integrated into different parts of our software model, but will need a lot of manipulation to function properly with the whole robot. However, individual class methods across labs of all members can be reused in many cases (see systems document section 5.1).

3.2 Compatibility with third part products

During the competition the robot will have to connect to a local server in order to receive starting instructions. It will do this through a third party USB wifi dongle that will be inserted into the USB port of the EV3 brick and accessed through the provided "Wifi connection" class. The default firmware on the brick does not support Java and for this reason was overridden by a SD card containing a different version of Linux as well as the LejoS EV3 environment. The robot must be able to pick up and toss a standard issue table tennis ball. The permission of the client is required before any hardware non-included in the provided Mindstorm kits can be used.

4 GLOSSARY OF TERMS

- Dimensions: All dimensions given in this document are given in units of tiles (1 tile is 30.48cm x 30.48cm or 1' x 1') except those concerning the location and dimensions of the goal which are in inches.
- Number of the starting corner: The number of the corner in which the robot will start it's course. The numbers are assigned as illustrated in Figure 1.
- Role: Indicator of the particular functionalities that must be displayed by the robot in a given instance. Two roles are possible for this project: Forward and Defense.
- The defender zone: Area of the playing field dedicated to the robot playing defense and prohibited to the offensive robot.
- Forward/red line: The line from which the robot playing the forward position must shoot from.
- Labs: Previous R&D sub-projects
- "The client" in this document refers to Professors Lowther and Giannacopoulos giving this course.