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.

Contents

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

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, and 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 specific 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 and ultimately create a more effective robot than the other teams in order to win the competition.

2.2 Scope

2.2.1 Capabilities

- **WiFi Compatibility:** The robot must receive the parameters for the competition over WiFi before starting the round.
- **Localization:** The robot must be able to correctly determine its heading using the knowledge of its starting corner (from WiFi parameters). Failure to do so will render its navigation and odometry ineffective.
- **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 navigate around the 12' x 12' field, in order to accomplish the goals of its offensive/defensive methods. If the robot cannot navigate, it will proceed on a "random walk" around the field, and fail in its other duties.
- **Obstacle Avoidance:** The robot must be able to detect and avoid obstacles placed randomly throughout the competition field. Running into an obstacle will cause large scale errors in its odometry/navigation procedures (see consequences above). 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.
- **Offense:**
  - *Ball Retrieval:* The robot must be able to navigate to the ball dispenser (as outlined in "Project Description - March 12 2017, Appendix B"), 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 will be located (14, 16) cm off the competition floor, and is expected to be mounted on a wall, although it is not required to be.

  - *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 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 blocking any potential shots its opponent takes on target. The defensive method is not allowed to block the movement of the offensive robot, nor is it allowed to interfere with the opponent's ultrasonic sensor(s).

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 comprised of a w1 x w2 tile square located in front of the target [area: (5-w1/2,5+w1/2)x(10-w2,10)], while the offensive region is bounded by the field such that the y-coordinate values are less than [10-d1]. The values for w1 and w2 are in the range [2,4], and d1 is in the range [5,8]. Straying outside these assigned zones for more than 10 seconds will result in points being deducted. In rounds 1 and 2, once the offensive robot has reached its zone it is barred from utilizing any ultrasonic sensors. More detailed information on the floor and field is contained in sections 2.5.1 and 2.5.2 of this document.

Additionally, the robot must localize within 30 seconds. 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 (3) have been retrieved/launched, or the time limit (7 minutes) has been reached.

2.3 Constraints

The robot's footprint must small enough that its center of rotation stays within its starting tile. Other constraints are discussed in sections 3 (Hardware Constraints) and 4 (Software Constraints) of the Constraints document.

2.4 User Functions

Once the program begins, the user will be able to pass in parameters to a start method through a WiFi connection. The parameters will be as follows:

1. Number of the starting corner
2. Role as either offense or defense
3. The green zone dimensions
4. Forward line position
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.

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 areas where the panels interlock with each other will have small slits that can affect the robot's maneuverability. The floor will not be perfectly smooth or clean. The friction along the floor may vary and areas may cause the wheels of the robot to slip.

2.5.2 Field

The field being played on by the product 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 goal is centered at coordinates (5,10) with a diameter of 10.0" and a height of 7.0" above the floor. While the robot plays offense, the ball must be bounced into the goal to score. The ball must bounce within the green area (w1 x w2) before scoring. The shot also must be made before the forward line shown by d1 in the diagram. The defense zone comprises the region of the field behind (i.e north of) the forward line excluding the green zone that surrounds the goal. The forward must stay in the region in front (to the south) of the forward line. The parameters are as follows: [2 ¡= w1, w2 ¡= 4], [5 ¡= d1 ¡= 8]. The rules associated with the layout of the field affect the capabilities of the robot significantly.

2.5.3 Lighting

The lighting in the competition room will be affected by many different factors. The competition room has many windows that allow light into the room. The amount of light entering the room will be dictated by the weather. Our robot will not be using a light sensor, therefore it will be unaffected by unpredictable light levels.

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

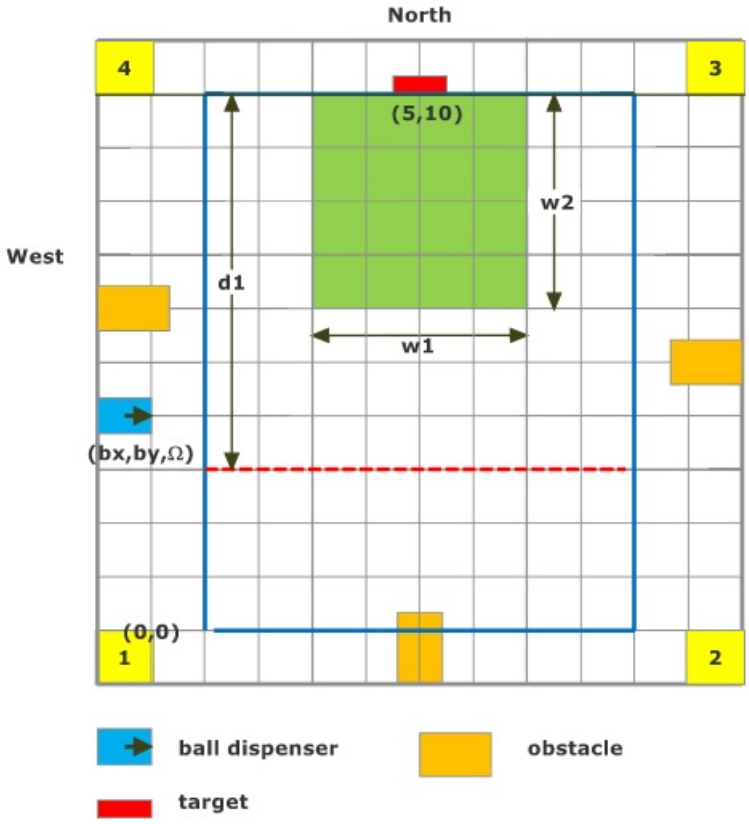

Figure 1

2.5.4 Ultrasonic Noise

The floor will be surrounded by walls which will exclude any ultrasonic noise from entering the floor after a round has begun. 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.

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

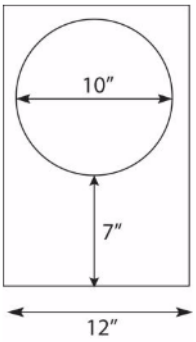

Figure 2

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.

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.

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