Department of Electrical and Computer Engineering
Course ECSE 211 – Design Principles and Methods
Fall 2018 Project Description
Revision 2.0, November 4, 2018

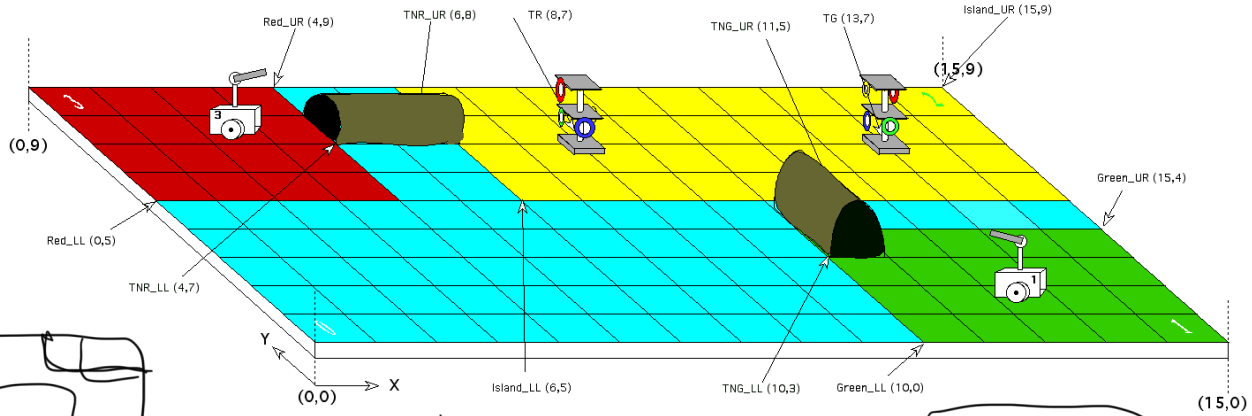


Figure 1

Overview

The goal of this project is to design and construct a machine that can autonomously navigate a closed course in search of a set of colored rings. Once found, the machine must determine how to grasp and retrieve as many rings as possible, taking into account the value of each ring as depicted by its color. In order to count, a ring must be returned to the starting corner. Consider the scenario depicted in Figure 1, with two players labeled 1 and 3. The labels indicate the corners each machine started in, so Player 1 starts in Corner 1 (Green Zone) and Player 3 in Corner 3 (Red Zone). Each of the zones is surrounded by a virtual river (blue regions), connected to a central island (Yellow Zone) by tunnels. Each zone corresponds to a rectangular region defined by its lower left (LL) and upper right (UR) corners relative to the origin. In the example shown in Figure 1, the red zone is defined as Red_LL (0,5) to Red_UR (4,9), and the green zone is defined as Green_LL (10,0) to Green_UR (15,4). Information is transmitted to each machine/player using a provided WiFi class. In the Wifi dialog, these coordinates are passed as individual components, hence Red_LL (x,y) would be sent as Red_LL_x and Red_LL_y.

The playing field measures 15’ x 9’, with the origin located in the lower left hand corner, (0,0), as shown in Figure 1. At the start of a round, both players are placed in their respective corners at a random orientation and started. Each player waits for a set of game parameters to be downloaded from the game server (more about this later). Once the parameters are received (which describe the layout of the laying field), each player must cross the river over to the island. The key parameters here are RedTeam, GreenTeam, RedCorner and GreenCorner. Each player has an assigned team number, so it can determine whether its in the red corner or green corner by matching against RedTeam or GreenTeam. Once the team color is identified, the starting corner can be located by the RedCorner and GreenCorner parameters respectively. From here two key

landmarks become available: the location of the tunnel connecting the starting zone to the island, and the location of the corresponding ring set. In the example shown in Figure 1, the red player would cross using the tunnel located at TNR_LL (4,7) to TNR_UR (6,8) and navigate to the ring set located at TR (8,7). Since a ring set is defined as located at the intersection of two grid lines, it is specified as a single coordinate pair. Similarly, the green player would cross using the tunnel located at TNG_LL (10,3) to TNG_UR (11,5), and navigate to the ring set located at TL (13,7).

Pay close attention to how the tunnels are positioned relative to the red and green zones. Notice, in this example, that the tunnel connecting the red zone joins at the boundary whereas the tunnel connecting the green zone overlaps by one square. This will always be the case when the border separating two zones is one square wide.

Once each player reaches its corresponding ring set, it begins scanning to determine the location of each ring in the tree and its respective color, and then proceeds to retrieve one or more rings for the return trip home. There are a number of design challenges implicit in this task. Given the dimensions of the tunnel, there is a limit to how large each machine can be which subsequently limits how many rings can be transported at a time. Similarly some sort of grasping/lifting mechanism will have to be devised to remove a ring from its holder and place it on the vehicle for transport. Since there is a time limit (which will be announced after the results of the Beta demo are in), machines must be nimble enough to move with a reasonable speed. In starting your design, you can assume that the nominal time limit is 5 minutes from receipt of parameters to completion of task. If this time is changed, it will be adjusted upwards (more time).

Specific Details:

The WiFi class which you will receive before the Beta demo, delivers the game parameters which are summarized in the following section. The procedure that each player must follow is summarized in the following steps and *must* be adhered to:

1. Each robot is placed in the corner specified by the marshal running the competition round. You will be instructed as to where to place and orient your machine.
2. Once placed and the start button pushed, you are no longer permitted to touch your machine. If there is any contact with the machine the team is disqualified for that round.
3. One started, the machine waits for the game server to deliver the parameters for the current run. This is done through a method call which will block until complete.
4. Each machine localizes to the grid. When completed, the machine must stop and issue a sequence of 3 beeps.
5. Each machine navigates to their corresponding tunnel, transits, and then proceeds to their ring set. Upon arriving, each machine will again stop and issue a sequence of 3 beeps.
6. Each machine begins the search process. Upon detecting a ring, the machine stops and issues one or more beeps according to the following table:

Color	Number of Beeps
Orange	4

Yellow	3
Green	2
Blue	1

7. Each robot proceeds to either return with a single ring or place the ring in storage and attempt to grab additional rings. Note that the value of each ring corresponds to the number of beeps issued in the above table.
8. Upon returning to the starting corner, each robot unloads their rings, halts, and issues a sequence of 5 beeps.

Each team will have an opportunity to participate in 4 runs. A design will be deemed "successful" if it succeeds in delivering at least one ring over the series of runs. The "competition" aspect relates to the number of points accumulated by each team for completing the different steps outlined above. On completion, each team is ranked in terms of the total number of points acquired. This is for bragging purposes only – your course grade is based on the quality of your design and not just the number of points accumulated.

Parameters

Game play is determined by a set of parameters, which are sent to the client (player) from a server. The following parameters are defined according to the details provided in Figure 1:

RedTeam (i=1,20) – Team starting out from red zone
GreenTeam (i=1,20) – Team starting out from green zone
RedCorner (i=0,3) – Starting corner for red team
GreenCorner (i=0,3) – Starting corner for green team
Red_LL (x,y) – lower left hand corner of Red Zone
Red_UR (x,y) – upper right hand corner of Red Zone
Green_LL (x,y) – lower left hand corner of Green Zone
Green_UR (x,y) – upper right hand corner of Green Zone
Island_LL (x,y) – lower left hand corner of the Island
Island_UR (x,y) – upper right hand corner of the Island
TNR_LL (x,y) – lower left hand corner of the red tunnel footprint
TNR_UR (x,y) – upper right hand corner of the red tunnel footprint
TNG_LL (x,y) – lower left hand corner of the green tunnel footprint
TNG_UR (x,y) – upper right hand corner of the green tunnel footprint
TR (x,y) – location of the red player ring set
TG (x,y) – location of the green player ring set

Note that the (x,y) coordinates listed correspond to the grid coordinates shown in the Figure 1. In the WiFi class, point parameters (x,y) are sent individually, e.g., TR (x,y) would be sent as TR_x and TR_y

Parameter Ranges

Red_UR_x – Red_LL_x:	Min=2, Max=10
Red_UR_y – Red_LL_y:	Min=2, Max=10
Green_UR_x – Green_LL_x:	Min=2, Max=10
Green_UR_y – Green_LL_y:	Min=2, Max=10
Island_UR_x – Island_LL_x:	Min=2, Max=10
Island_UR_y – Island_LL_y:	Min=2, Max=10

TNR_UR_x – TNR_LL_x:	Min=1, Max=2
TNR_UR_y – TNR_LL_y:	Min=1, Max=2
TNG_UR_x – TNG_LL_x:	Min=1, Max=2
TNG_UR_y – TNG_LL_y:	Min=1, Max=2

TR_x:	Min=0, Max=14
TR_y:	Min=0, Max=8
TG_x:	Min=0, Max=14
TG_y:	Min=0, Max=8

Color Mapping

The color assignments are as follows:

Orange	4
Yellow	3
Green	2
Blue	1

Game Play

Both players act almost independently, so the design can focus mainly on navigation, mobility, search and retrieval. Some collision avoidance will be necessary in the event that both players are in the same vicinity. Each team will participate in 4 rounds for which a cumulative score will be determined. The score is based on points awarded for exhibiting each of the behaviors required to play the game: localization, navigation, traversing the river, searching for the rings, grasping, and returning them the starting corner. These points effectively validate the components of your design. On top of this we also record how long it takes for you to complete the entire process. These figure prominently in ranking the performance of the teams with respect to the "competition".

Materials

Each team has up to 3 Lego Mindstorms kits worth of parts available. In addition, a MakerBot Replicator 2 rapid prototyping machine is available for fabricating parts for those inclined. You may also purchase additional materials, but these must receive prior approval from the

instructors. Another note – all computation must be done on board the EV3 brick(s); no offloading to an external machine is permitted.

Final Notes

This document is the second revision and incorporates feedback received up to Milestone II. It is still subject to change, but the specifications can be considered stable.

Final Considerations

You are being evaluated on your robot's ability to complete the various tasks that make up the game, so it is important to show what your machine can do. For example, if you are unable to perform the block search, skip it and proceed to the return leg. Unless your machine does nothing at all, you will be awarded points for what it can do.

FAQs

Will be posted below in an updated version of this document.

1. Is Figure 1 meant to represent the actual competition layout?

   - Figure 1 is *not literal.* It is meant only to provide meaning for the parameters listed. The sizes and shapes of regions may differ considerably from what is shown in the figure.

2. Are there any restrictions on placement of the ring sets?

   - Yes, the ring trees must be located within the Island region.

3. Do both teams see all the parameters listed

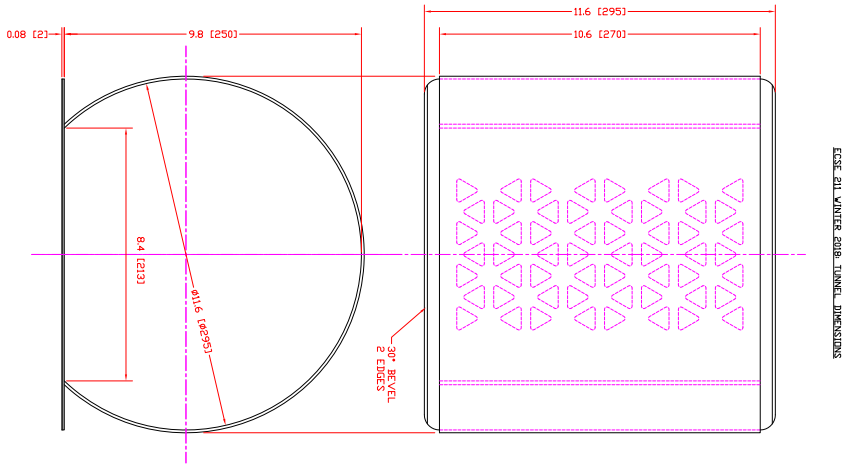
   - Yes, both teams get the complete parameter set.

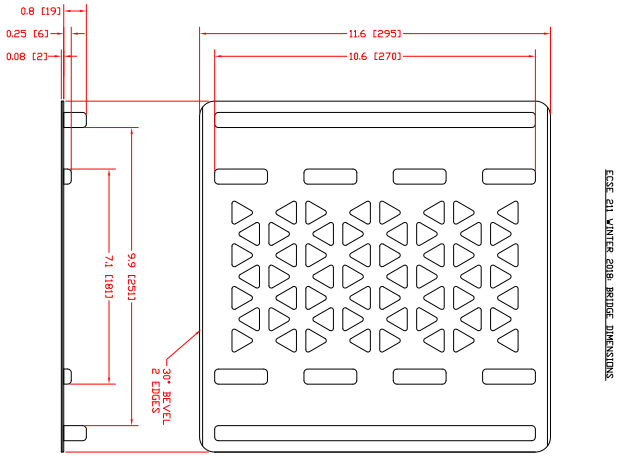
4. Can I use adhesive tape to grab the ring?

   - No, you may not use any component that leaves a residue on any of the surfaces.

Appendices

Bridge and tunnel drawings, length = 1 tile
For the Fall 2018 competition we will only be using the tunnel component





Photos: Tunnel (left) and Bridge (right)
(speed bumps on bridge not shown; floor of tunnel is smooth, no grating pattern).

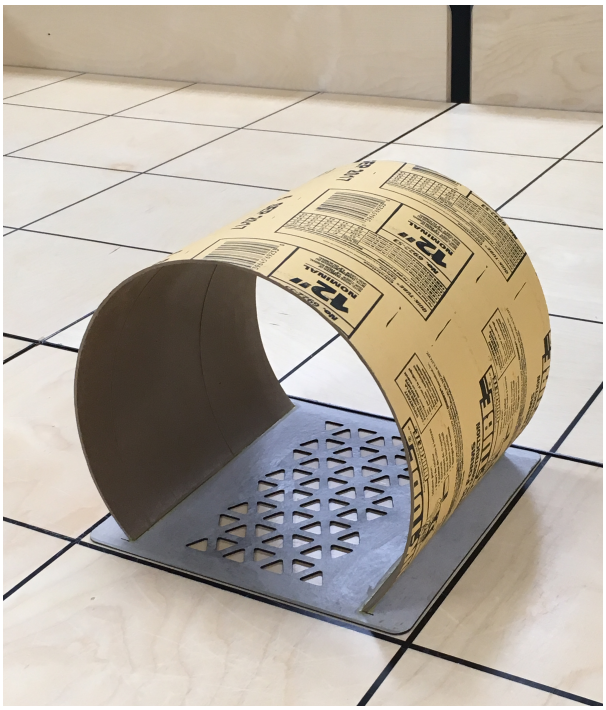


Photo: Bridge with speed bumps

Photo: Ring Set