Department of Electrical and Computer Engineering
Course ECSE 211 – Design Principles and Methods
Fall 2018 Project Description
Revision 1.0, February 9, 2019

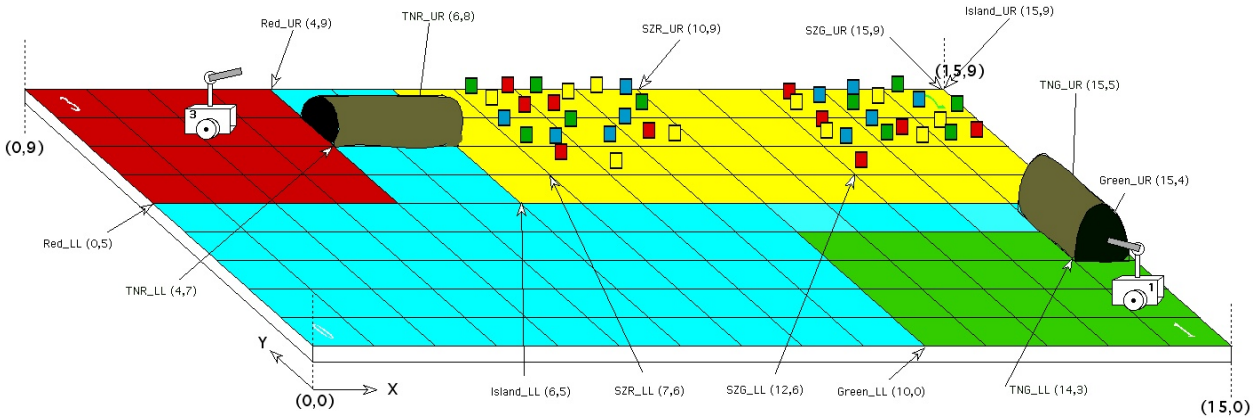

Figure 1

Overview

The goal of this project is to design a machine that can autonomously navigate a closed course in search of 210 ml soft drink cans for recycling. Here two robots will compete with one another to determine who can recover the most re-cyclable material in a given time interval. Cans come in two weights with four different colors for a total of 8 different color-weight combinations, with the heavier cans being more "valuable". Each robot is given a specific colored can to look for as well as a region in which to search. Points are awarded for each can correctly retrieved (i.e. with the right color), with double points for the heavier cans. In the following material, please note that the coordinate system used differs from the one you used in the lab experiments.

The competition scenario is depicted in Figure 1 for 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 search zone. 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 search zone located at SZR_LL (7,6) to SZR_UR(10,9). Similarly, the green player would cross using the tunnel located at TNG_LL (10,3) to TNG_UR (11,5), and navigate to the search zone located at SZG_LL (12,6) to SZG_UR (15,9).

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 search zone, it begins scanning to determine the locations of each can within the zone and its respective color, and then proceeds to retrieve one or more cans for the return trip home. There are a number of 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 cans can be transported at a time. Similarly some sort of grasping/lifting mechanism will have to be devised to pick up each can, weigh it, 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 search zone. Upon arriving, each machine will again stop and issue a sequence of 3 beeps.

6. Each machine begins the search process. Upon detecting a can, the machine stops, assesses the can (color and weight), and issues one or more beeps according to the following table:

Color	Number of Beeps	
	Light (short beep – 500 mS)	Heavy long beep – 1000 mS)
Red	4	4
Yellow	3	3
Green	2	2
Blue	1	1

   A key part of the challenge is devising a method to distinguish beween light and heavy cans.
7. Each robot proceeds to either return with a single can or place the can in storage and attempt to grab additional cans. Note that the value of each can corresponds to the number of beeps issued in the above table. In addition, the can's value is doubled if it corresponds to the heavy version.
8. Upon returning to the starting corner, each robot unloads cans, halts, and issues a sequence of 5 beeps.
9. In order to count, cans must be placed upright and lie within the start square.

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 can 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=1,23) – Team starting out from red zone
GreenTeam (i=1,23) – 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
SZR_LL (x,y) – lower left hand corner of the red player search zone.
SZR_UR (x,y) – upper right hand corner of the red player search zone.
SZG_LL (x,y) – lower left hand corner of the green player search zone.
SZG_UR (x,y) – upper right hand corner of the green player search zone.

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

SZR_UR_x – TNR_LL_x:	Min=2, Max=10
SZR_UR_y – TNR_LL_y:	Min=2, Max=10
SZG_UR_x – TNG_LL_x:	Min=2, Max=10
SZG_UR_y – TNG_LL_y:	Min=2, Max=10

Color Mapping

The color assignments are as follows:

Red	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 cans, grasping, weighing, 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 initial revision and will be revised based on feedback from the team meetings up to the Beta Demo.

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 weigh a can, skip it and proceed with the search. 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.

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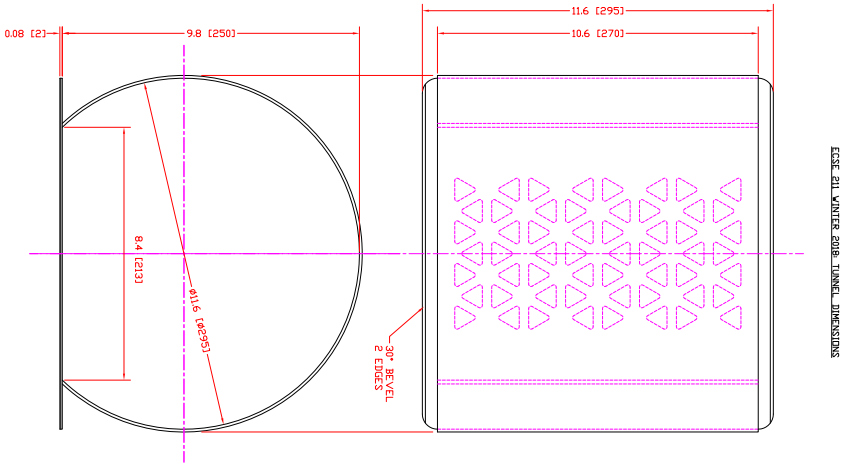
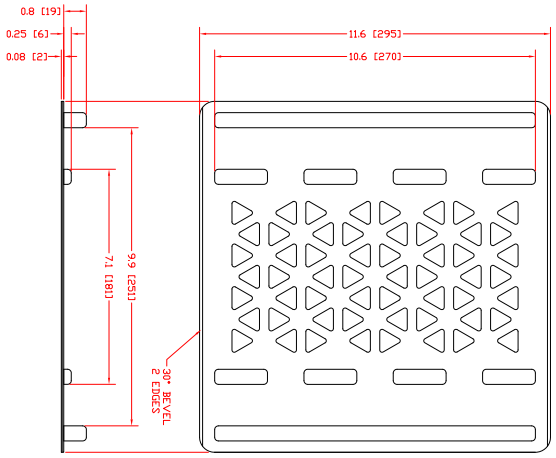
dal/fpf

Appendices

Bridge and tunnel drawings, length = 1 tile
For the Winter 2019 competition we will only be using the tunnel component



ECSE 211 WINTER 2018 TUNNEL DIMENSIONS



ECSE 211 WINTER 2018 BRIDGE DIMENSIONS

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

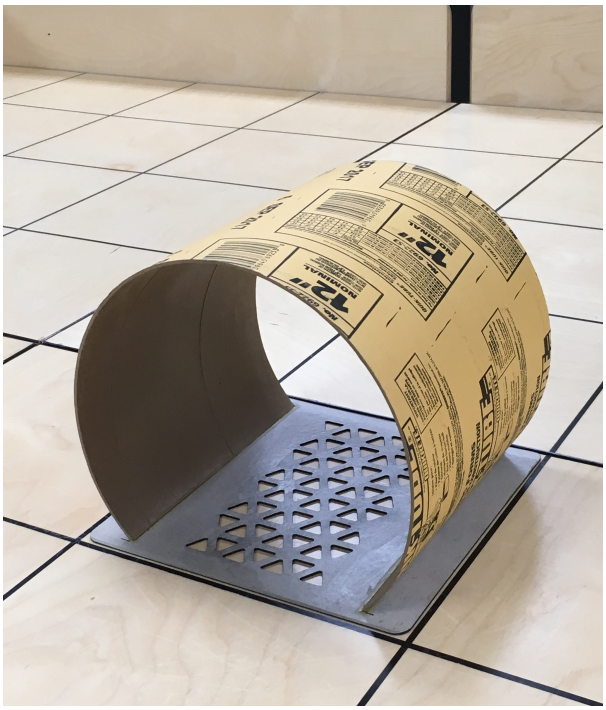


Photo: Bridge with speed bumps

Photo: 220 ml Cans

Red – 4

Yellow – 3

Green – 2

Blue – 1