ME218b Smart Product Design

ME 218b Winter 2012 Project: Hi-tech Indoor Ping-Pong Orbital Sumo

Project Preview on March 1, 2012 6-10PM in SPDL
Grading Session on March 6, 2012 6-10PM
Project Presentations on March 7, 2012 in the Peterson Atrium starting at 7:00 PM

Goals:

The goal of this project is to provide you with an opportunity to apply your knowledge to solve an open-ended problem. The task is to design and build a machine that can play an interesting game against an opponent machine.

Purpose:

The underlying purpose of this project is to give you some experience in integrating all that you have learned. The avenue through which you will gain this experience is the design and implementation of an autonomous mobile robot that can compete in a game of skill and strategy against a machine constructed by another team from the class.

The Game:

The object of the game is to gather up ping-pong balls off the floor of the field and deposit them into bins at the corners of the field.

Specifications

The Field:

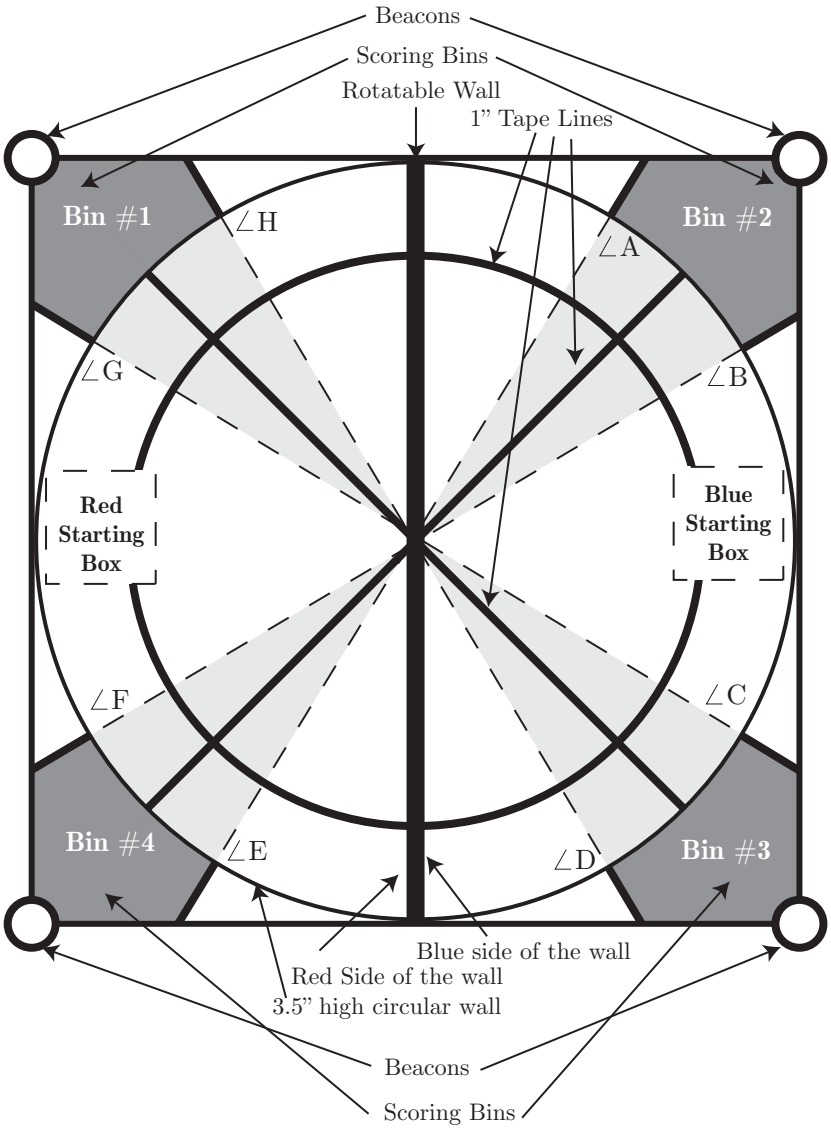

Fig. 1 The Playing Field

- ☐ The playing field is a circle with a diameter of 8' formed by a 3.5" tall wall.
- ☐ The Red 'bot will start on the Red side. The Blue 'bot will start on the Blue side.

The Scoring Bins:

- ☐ Each scoring bin will have a beacon emitting modulated IR driven by a 50% duty-cycle square wave. The emitters for the beacons will be LTE5208A IR LEDs. The IR emitters will be mounted at a height of 10" off the playing surface.
- ☐ The beacon on Bin #1 will be modulated with a period of 20mS, the beacon on Bin #2 will be modulated with a period of 18mS, the beacon on Bin #3 will be modulated with a period of 16mS, and the beacon on Bin #4 will be modulated with a period of 14mS.
- ☐ The back edges of the scoring bins (those along the circumscribing edges of the bounding square) will have netting 12" high.

The Rotatable Wall:

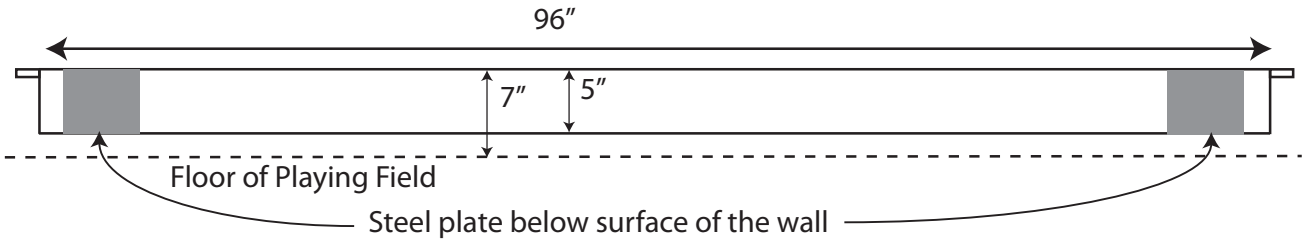

Fig. 3 The Rotating Wall (Side View)

- ☐ The dimensions of the rotatable wall will be as shown in Fig. 3.
- ☐ The pivot point for rotation is at the center of the playing field.
- ☐ At 2" inward from the outer edge of the playing field, for a horizontal distance of 6" the wall will have a steel plate below the vertical surface of the wall.

The Field Status Reporter:

- ☐ The Field Status Reporter will communicate with your robot over a 4-wire SPI bus.
- ☐ The Field Status Reporter will provide information as to the number of balls in each of the bins as well as the current angle of the rotatable wall.
- ☐ The Field Status Reporter will communicate wirelessly with the field infrastructure, so it must be mounted on the top-most level of your robot with no structure above or surrounding it.
- ☐ A complete description of the Field Status Reporter, from both an electrical and protocol standpoint, is included in a separate document that accompanies this project description.

The Robots:

- ☐ Your robot must be a stand-alone entity, capable of meeting all specifications described in this document. Battery power is required. Your robot must execute from code on either (or both of) the 'C32 and 'E128.
- ☐ Robots must be autonomous and un-tethered.
- ☐ The only parts of the Robot that may ever touch the playing field surface are wheels, ball transfers, or slippery supports used to balance the Robot.
- ☐ The smallest bounding box (rectangular prism) that entirely encloses your robot must not exceed a 1 cubic foot volume at the beginning of the game.

- ☐ If your robot shoots the ping-pong balls, then the ping pong balls must exit your robot with a horizontal or above-horizontal trajectory, land no more than 5 feet from the robot and reach a peak height of no more than 2' above the floor of the playing field.
- ☐ Each robot will carry an easily accessible switch on the top of the robot. The purpose of the switch will be to cut power to the 'bot in case of a software or hardware malfunction.
- ☐ Each Robot must, under software control, determine and identify itself as playing the Red side or the Blue side and display this information in a highly visible manner to the audience. The robot may not move out of the starting box until it has displayed the side on which it is playing.
- ☐ Each Robot must be constructed as part of ME218b. It may not be based on a commercial or otherwise pre-existing platform.
- ☐ Any exterior corners on the robot must have a radius of at least 1/4".
- ☐ You are limited to an expenditure of **$150.00/ team** for all materials and parts used in the construction of your project. Materials from the lab kit or the Cabinet Of Freedom do not count against the limit, all other items count at their Fair Market Value.
- ☐ 'Bot speed must be kept low enough to be safe to the other 'bot on the field and to the field infrastructure. We reserve the right to disqualify any 'bot for excessive speed. If in doubt, get an assessment from Ed before proceeding.
- ☐ The supplied motors must be used to drive anything that transfers force to the ground.

Game Play:

- ☐ The game is a head-to-head match up between Robots as they attempt to score points by gathering ping-pong balls off of the floor of the playing field and depositing them into the scoring bins.
- ☐ At the beginning of each game, the robots will be placed on the field by a member of the team. The centroid of the normal 2-D projection of your robot onto the plane of the field must lie within the starting box at the start of the game.

  An equal number (1-120) of balls will be placed on each side of the wall before the beginning of a round.
- ☐ The game will begin when a game status query to the Field Status Reporter (FSR) indicates a non-zero number of balls in play.
- ☐ Ping-pong balls in Scoring Bins at the end of the round on the Red side of the wall score +2 points for the Red team, ping-pong balls in Scoring Bins on the Blue side of the wall score +2 points for the Blue team.
- ☐ Ping-pong balls on the floor at the end of round on the Red side of the wall score -1 points for the Red team, ping-pong balls on the floor on the Blue side of the wall score -1 points for the Blue team.
- ☐ At the end of the round, ping-pong balls either in a robot or with any portion of the ball under the rotatable wall do not count against either team.
- ☐ At the end of the round, if the rotatable wall lies within the light grey region of Fig. 1 (defined by angle positions of A-B, C-D, E-F, G-H) the scoring bins at the ends of the wall are taken out of play and do not count for either side.
- ☐ The round ends 2 minutes after the Field Status Reporter first reported the Running state. At that time, 'bots must stop all movement.
- ☐ In case of a tie at the end of a round, the robot with highest bin score wins
- ☐ If the score does not change throughout a round, then both robots are removed from the competition.

Rules:

- ☐ No solderless breadboards (protoboards) are permitted in the final project.

- ☐ No part of the robot may extend beyond your side of the rotatable wall.
- ☐ Each Robot must start and remain in one piece during the round. Any locomotion of the robot should cause all parts of the robots to move.
- ☐ Your Robot may not **IN ANY WAY** alter the condition (e.g. mar the walls or the floor) of the playing field or the ping-pong balls.
- ☐ Intentional jamming of your opponent's senses is prohibited.

Safety:

- ☐ The Robots should be safe, both to the user and the spectators. The teaching staff reserves the right to disqualify any Robot considered unsafe. This also applies during testing, so keep the 'bot velocity low enough so as not to cause problems.
- ☐ Robots must be stable in the presence of a 30MPH wind.
- ☐ No part of the machine may become ballistic. The ping-pong balls are not part of your machine.
- ☐ All liquids, gels and aerosols must be in three-ounce or smaller containers. All liquids, gels and aerosols must be placed in a single, quart-size, zip-top, clear plastic bag. Each 'bot can use only one, quart-size, zip-top, clear plastic bag.
- ☐ Robots may alter the Space-Time continuum only during the public presentations.

Check-Points

Design Review:

During class-time on **02/14/12** we will conduct a design review. Each group should prepare a few sheets of paper showing your idea(s) and a preliminary software design (module breakdown & upper level state chart). These should be scanned into a no-frills PowerPoint file (landscape, 4:3 format, .ppt, not .pptx) for projection in Rm 200. You will have 5 minutes to walk us through your ideas. The other members of the class, the teaching staff, and coaches will be on hand to hear about your ideas and provide feedback and advice.

First Check-Point:

On **02/17/12**, you will turn in a set of Protel schematics, textual descriptions and software design documentation (including refined state chart) that describes the state of the design *at that point in time*. The designs need not be tested at this point, but must include designs to address all of the major subsystems. It must be turned in as soft copy. Only one team member needs to submit your checkpoint.

Second Check-Point:

On **02/21/12**, you must demonstrate your motorized platform moving under software control. Your platform must be able to rotate in 90° increments and drive forward under software control.

Third Check-Point:

On **02/23/12**, you must demonstrate your robot's ability to communicate with the Field Status Reporter and exercise all of the Field Status Reporter's capabilities.

Fourth Check-Point:

On **02/27/12**, you must demonstrate your robot's ability to sense and identify each of the IR beacons while positioned in the Red starting box.

Fifth Check-Point:

On **03/01/12**, you must demonstrate your robot's ability to gather at least one ping-pong ball and deposit it into a bin.

Project Preview:

At the Project Preview on **03/05/12**, each Robot must demonstrate 1) the ability to move under software control and 2) the ability to communicate with the Field Status Reporter and 3) the ability to gather at least one ping-pong ball and deposit it into a bin, all in an integrated package.

Grading Session:

During the **Grading Session on 03/06/12** each Robot will be required to demonstrate the ability to status information from the Field Status Reporter to begin the game, and during the following two minutes pick up and deposit at least 2 ping-pong balls into a bin and stop moving at the end of two minutes. If your 'bot fails at its first attempt to demonstrate its ability, it must then demonstrate the ability two times in succession at its next attempt. These increases continue after repeated failed attempts to a maximum of 4 required successive demonstrations. This evaluation will take place without an opponent. Evaluation for grading purposes will occur only during these sessions. At the time of the grading session, you must submit a copy of the .S19 file that you run during the grading session to your Reports folder for archiving.

Public Presentation:

Will take place on **03/07/12** starting at 7pm in the Peterson Atrium.

Report:

Draft due on **03/12/12** at 4:00pm. Final version with revisions due by 5:00pm on **03/16/12**.

Evaluation

Performance Testing Procedures:

One or more of the team members will operate the Robots during the performance evaluation. A competition among the class's Robots will take place after the performance evaluation.

Performance Evaluation:

Performance evaluation will take place twice during the project duration, at the Project Preview and at the Grading Session. Everyone will participate at this level.

The Competition:

On the night of the public presentations, a tournament will be held. **Performance during the tournament has no impact on your grade**.

Grading Criteria:

- ☐ **Concept (10%)** This will be based on the technical merit of the design and coding for the machine. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware, software and use of physical principles in the solution.
- ☐ **Implementation (15%)** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will not presume to judge true aesthetics, but will concentrate on craftsmanship and finished appearance.
- ☐ **Check-Point Performance (10%) Based on demonstrating the required functionality at the checkpoints.**
- ☐ **Preliminary Performance (10%)** Based on the results of the performance testing during the **Project Preview.**
- ☐ **Performance (20%)** Based on the results of the performance testing during the **Grading Session**.

- ☐ **Report (20%)** This will be based on an evaluation of the written report. It will be judged on clarity of explanations, completeness and appropriateness of the documentation. The report should be in the form of a web site and must include schematics, pseudo-code, header & code listings, dimensioned sketches/drawings showing relative scale, a complete Bill-of-Materials (BOM) for the project as well as a 1 page description of function and a "Gems of Wisdom for future generations of 218ers" page. The web-site must be submitted as a single **Zip** file (The zipping software (7-zip) is installed on all the workstations in the lab). The only file types in your final report should be HTML (including style sheets if you choose), JPEG or other viewable image files and PDF files. Schematics should be PDF files, **not** bitmaps (PNG, JPEG, GIF, etc.). A bitmap place-holder with a link to a PDF is the best solution to readability. Do not include .doc, .docx, .xls, .xlsx or other files that require opening a separate application outside of the browser. **Do not embed video files** directly into your site. If you want to include video, link to a You-Tube or other video sharing site. It is critical that your report be in the Reports folder on time so that the peer reviewing team will have an adequate opportunity to review it before class the following day. Final versions of the reports, incorporating the review comments are due (also in the form of a single zip file) by 5:00pm on 03/16/12. The front page of your project description must be in a file called `index.html` at the root folder of the web site. Test your zip-file by unzipping it into an empty folder. Once un-zipped, you should be able to view the entire site starting from the `index.html` file. Make sure to test all of your links before submitting. If we can't simply unzip it and read it on our machines, then we can't grade it.

- ☐ **Report Review (10%)** These points will be awarded based on the thoroughness of your review of your partner team's report. Read the explanations, do they make sense? Review the circuits, do they look like they should work?

- ☐ **Housekeeping (5%)** Based on the timely return of SPDL components, cleanliness of group workstations as well as the overall cleanliness of the lab. No grades will be recorded for teams who have not returned their tool kit and E128 & C32 boards.

Team Organization

While it may be tempting (as more efficient) to organize your teams around specialists who handle, for example, communications, sensing, motion, etc. I believe that in the long run this will be a mistake. I have heard from many 218 alumni who did this and reported that they were sad that they had because they didn't get, for example, communications experience. I would like to encourage you to remember that, first and foremost, the purpose of the project is to enhance your learning of the material. An organization that deeply involves all of the team members in the details of the design, implementation and debugging of all subsystems will not only provide a better learning experience, it will also prevent you from getting hung up during the integration and testing phase because the "expert" on that subsystem is not available.