ME218b Smart Product Design

ME 218b Winter 2015 Project: DRED KART

DrEd Research Engineering and Design Killer Autonomous Racing Technology

Project Preview on March 1, 2015 6-10PM in SPDL **Grading Session** on March 3, 2015 6-10PM

Project Presentations on March 4, 2015 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 a challenging and fun-to-watch game against a pair of opponent machines.

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 speed, skill and strategy against machines constructed by other teams from the class.

The Game:

The disarmament of DrEd's Doomsday Devices led to the destruction of his evil lair. Reliable sources place DrEd inside his lair 30 seconds before the explosion. DrEd's demise has led to a power vacuum that has been filled by his former hostages. Teams that were once working together are now seeking to take over the remains of DrEd's technological empire. The conflict comes to a head when DrEd's Research Engineering and Design facility is discovered. Rumors tell of a vast wealth of knowledge, including the answers to the ME218b final exam. The former hostages must now race to reach the facility first, while avoiding obstacles and booby traps along the way.

Specifications

The Race Course:

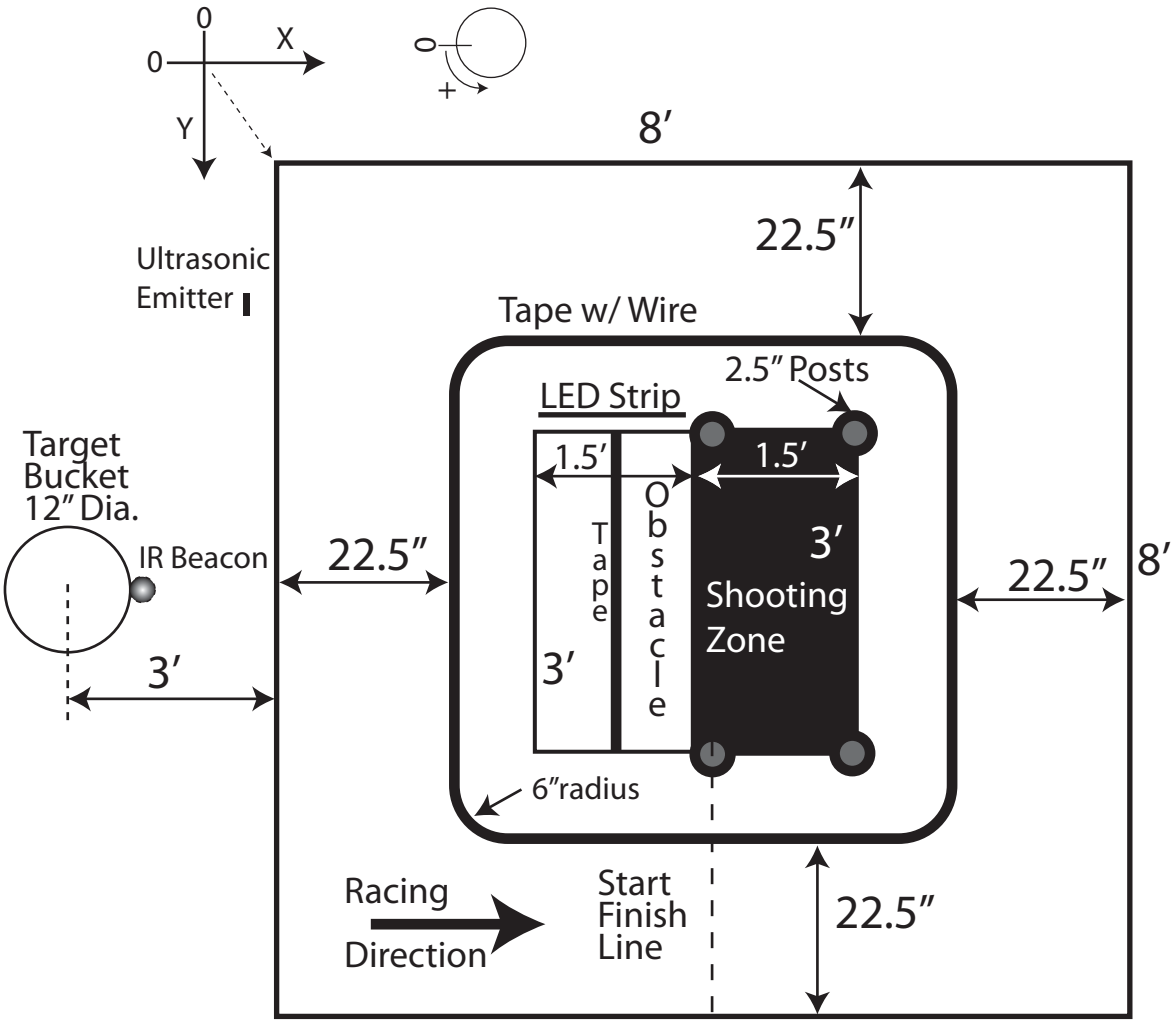

Fig. 1 The Race Course

- ☐ The playing field is an 8'x8' area with exterior walls 3.5" tall.
- ☐ The central area contains an obstacle (a see-saw) and an area designated as the "shooting zone" as shown.
- ☐ The LED strip will be lit while the see-saw (obstacle) entrance is raised from the playing field.
- ☐ The posts are 12" tall 2-1/2" diameter foam cylinders, not attached to the floor.
- ☐ Along the wall there will be an ultrasonic emitter positioned 12" off the race course and oriented to emit along the length of the wall at the entrance of the obstacle. It will emit 40kHz ultrasound while the see-saw entrance is raised from the playing field.
- ☐ The target is a 5 gal Home Depot paint bucket with a beacon emitting IR modulated at 1250 Hz mounted at the lip of the bucket closest to the race course.
- ☐ There will be a 1" black tape stripe along the center-line of the obstacle.
- ☐ There will be 1" black tape loop, as shown in Fig. 1. Beneath the black tape will be a wire carrying a 100mA current modulated by a sine wave at 20kHz.

The Obstacle:

- ☐ The obstacle will be a see-saw 18" wide x 36" long weighted so that in the absence of a racer, the end of the see-saw nearest the LED strip will be down.
- ☐ In the un-loaded position, the angle of the see-saw will be 15 deg. up.
- ☐ When the see-saw is tipped in the opposite direction, the angle will be 20 deg. down

The Racers:

- ☐ Your KART must be a stand-alone entity, capable of meeting all specifications described in this document. Only NiCd battery power is allowed. No more than two 7.2V batteries may be used to drive the motors that transfer force to the ground.
- ☐ Each KART must have a mechanism to designate the KART as KART1, KART2 or KART3.
- ☐ KARTs must be autonomous and un-tethered.
- ☐ The only parts of the KART that may ever touch the playing field surface are wheels, ball transfers, or slippery supports used to balance the KART.
- ☐ There must be a bumper surrounding the perimeter of your KART extending for 2" vertically with its bottom edge 1" (+- 1/16") from the track.
- ☐ Your KART must be fully contained within a 1' cube at the beginning of the race. The longest distance between any two parts of your KART may not exceed 12" when projected onto the plane of the track at any point in the race.
- ☐ The KART must provide a white or black flat upper surface at 12" off the playing field to carry the Tracking Target used by the vision system portion of the field infrastructure.
- ☐ Each KART may carry a maximum of 4 balls at any time. Each KART will start a round loaded with up to 4 balls, as desired by your team.
- ☐ The foam balls must exit your KART with an above-horizontal trajectory, land no more than 10 feet from the KART and reach a peak height of no more than 8' above the floor of the playing field.
- ☐ Each KART will carry an easily accessible switch. The purpose of the switch will be to cut power to the KART in case of a software or hardware malfunction.
- ☐ No part of the KART may have a color matching any of the colors on the Tracking Targets.

- ☐ No part of your KART, may obscure the Tracking Target from the vision system.
- ☐ Each KART 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 KART must have a radius of at least 1/4".
- ☐ You are limited to an expenditure of **$200.00/ 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.
- ☐ Each KART must provide a clearly visible indicator when it thinks that the game is in progress. This indicator should be activated when the KART determines that a race has started and be de-activated when the game status indicates the end of the race.
- ☐ The supplied motors must be used to drive anything that transfers force to the ground.

The DRS:

- ☐ The DrEd Reckoning System (DRS) will provide information to the racer about the position and orientation of all racers and status of the race.
- ☐ The DRS will communicate with your robot over a 4-wire SPI bus.
- ☐ The DRS will be recognized by and communicate wirelessly with the field infrastructure, so it should be mounted where it will have good radio reception.
- ☐ A complete description of the DrEd Reckoning System, from both an electrical and protocol standpoint, is included in a separate document that accompanies this project description.

Game Play:

- ☐ The race is a head-to-head-to-head contest among three KARTs as they complete laps around the course passing across the obstacle at least once and making at least one shot into the Bucket.
- ☐ A lap consists of passing counterclockwise around all 4 posts.
- ☐ A KART may take no more than 1 shot at the bucket per lap and shoot only when the KART is fully within the shooting zone.
- ☐ The race will begin when a query to the DRS indicates that the game state has changed from "waiting for start" to "Flag Dropped".
- ☐ A race will consist of 3-5 laps, determined at the start of a race.
- ☐ A KART that is stationary or obviously jammed for more than 10 seconds will be removed from the course.
- ☐ KARTs will start on the left hand side of the field behind the start-finish line. The highest seeded team places their KART first and each subsequent team may place their KART no closer than 2" from KARTs already placed in the course.
- ☐ A race ends when the first KART crosses the finish line after completing the required laps, crossing the obstacle, and scoring a shot.
- ☐ A race may also end if no KART finishes after a maximum of 1 minute per required lap.

Rules:

- ☐ No solder-less breadboards (proto-boards) are permitted in the final project.
- ☐ Light contact is permitted, but intentional interference with the operation of another KART is prohibited.

- ☐ Each KART must start and remain in one piece during the round. Any locomotion of the KART should cause all parts of the KART to move.
- ☐ Your KART may not **IN ANY WAY** alter the condition (e.g. mar the walls or the floor) of the playing field or the foam balls.
- ☐ Intentional jamming of your opponent's or the DRS's senses is prohibited.

Safety:

- ☐ The KART should be safe, both to the user and the spectators. The teaching staff reserves the right to disqualify any KART considered unsafe. This also applies during testing, so keep the KART velocity and shooting velocity low enough so as not to cause problems.
- ☐ KARTs must be stable in the presence of a 30MPH wind.
- ☐ No part of the machine may become ballistic. The foam balls are not part of your machines.
- ☐ 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 KART can use only one, quart-size, zip-top, clear plastic bag.
- ☐ Red, Green, and Blue shells are prohibited. Any Banana peels must stay within the confines of your KART at all times.
- ☐ KARTs may alter the Space-Time continuum only during the public presentations.

Check-Points

Design Review:

During the day on **02/10/15** we will conduct design reviews. A few teams at a time will meet with the teaching staff to present their ideas and get feedback on their proposals. Each group should prepare a **few** sheets of paper showing your idea(s). The focus should be on the overall design and how you are tackling what you think are the critical subsystems. These should be scanned into a no-frills PowerPoint file for projection. You will have 10 minutes to walk us through your ideas. The members of the other teams, the teaching staff, and coaches will be on hand to hear about your ideas and provide feedback and advice. ***Start you engines.***

First Check-Point:

On **02/13/15**, 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. ***Here we go!***

Second Check-Point:

On **02/18/15**, you must demonstrate your un-tethered, motorized platform moving under autonomous software control. Your platform must be able to drive a lap under software control. At this point you do not need to traverse the obstacle. ***Finishing races is important, but racing is more important.***

Third Check-Point:

On **02/21/15**, you must demonstrate the integration of the DRS with your mobile platform and your robot's ability to communicate with the DRS to exercise all of the DRS's capabilities. Evidence of achieving this functionality will be demonstrated by driving one lap of the race course starting from an arbitrary starting location upon initiation of a "Flag Dropped" status from the DRS. ***This is not racing, it's a suicide mission.***

Fourth Check-Point:

On **02/25/15**, you must demonstrate your robot's ability to 1) orient to the goal and shoot a ball at the goal, 2) cross the obstacle. ***Good luck out there in the field...and please return the equipment in one piece.***

Project Preview:

At the Project Preview on **03/01/15**, each KART must demonstrate (in an integrated form) 1) the ability to move around the course under software control and 2) the ability to communicate with the DRS and 3) the ability to orient and shoot at the goal and 4) cross the obstacle. This will be tested by communicating a "Flag Dropped", 3

laps remaining status from the DRS. ***If you're in control, you're not going fast enough.***

Grading Session:

During the **Grading Session on 03/03/15** each KART will be required to demonstrate a complete race. If your KART 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 with only a single KART on the course. Evaluation for grading purposes will occur only during these sessions. At the time of the grading session, you must submit a copy of your Keil Project folder that you run during the grading session to your Reports folder for archiving. ***The distance between insanity and genius is measured only by success.***

Public Presentation:

Will take place on **03/04/15** starting at 7pm in the Peterson Atrium. ***The closer you are to death, the more alive you feel. It's a wonderful way to live. It's the only way to drive.***

Report:

Draft due on **03/09/15** at 4:00pm. Final version with revisions due by 5:00pm on **03/13/15**. ***Groovy Baby!***

Evaluation

Performance Testing Procedures:

One or more of the team members will operate the KARTs during the performance evaluation. A competition among the class's KARTs 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**.
- ☐ **Coaches Evaluation (5%)** Evaluation by your coach: did you make use of their input before the design review and during the course of the project.

- ☐ **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 03/13/15. 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** 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 the items borrowed from the SPDL, including but not limited to Tiva, power supplies, logic analyzer, tools....

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.