MECHATRONICS SCORING MACHINES

ME210 Project, Winter 2015

Project Performance Checkoff *anytime before* 2015-03-06 16:00
Project Presentations on Monday, 2015-03-09, 19:00 in 550 Atrium
A full checkpoint/review schedule appears on the last page.

Introduction

Several years ago, Sasha Vujacic was a member of the Los Angeles Lakers , known by some as “The Machine”. Sasha had a not-distinguished career on the Lakers, contributing in minor ways to two championships, and otherwise establishing himself and his nickname in social media. Today, the Lakers are a sad franchise, known only for their machine-like efficiency at missing easy shots and playing poor defense. They are destined for the NBA Lottery.

Fortunately, we in the Bay Area are witnessing a rare event: the Golden State Warriors, longtime bystanders to NBA success, are on a path to the best record in the NBA, led by Steph Curry and Klay Thompson, who are both truly Legitimate Scoring Machines. Just in a single recent week, Thompson had 49 points in a game, including a NBA record 37 in a single quarter, and Curry had a 50-point game.

Here in the ME Department, we take Steph Curry and Klay Thompson as our inspiration for the 2015 ME210 project - Mechatronics Scoring Machines. Quite literally, your goal is to design and build a machine capable of shooting balls into baskets with efficiency comparable to Curry and Thompson!

PURPOSE

The purpose of this project is to provide you with an opportunity to apply all that you have learned so far in ME210 to solve an open-ended mechatronics design problem. The task is to design an autonomous machine that will compete against an opponent in a miniature mechatronic sport.

MOTIVATION

There is nobody who doesn’t like sports! Well, except for robots, they can’t really *like* or *dislike* anything. However, we can make robots play sports. Why keep paying human pro athletes exorbitant salaries when we could just build robots to play the sports for us while we watch? Can we build ‘bots that can have scoring efficiency that would rival the best professional athletes (Curry and Thompson)?

LOGISTICS

Projects are to be completed in teams of three or four (all teams already assigned). While it might seem “efficient” to divide the work for the project and allocate responsibilities to the team members with the most relevant expertise, keep in mind that you will learn more if you have everyone somewhat involved in every task, and especially if every team member has some responsibility outside of their “comfort zone”. It is also true that all members of your team will be able to participate in late-stage troubleshooting if everyone has some understanding of all aspects of your machine.

So – don’t specialize! Specialization is taught in all other courses at Stanford. You signed up for ME210 because you wanted to escape specialization! True Mechatronics Engineers can do it all, and this is

your chance to learn some of the things you may not already have known way back before Week 0!

Project Specifications

The objective of Mechatronic Scoring Machines is simply to score more points than your opponent. Your ‘bot can score points by causing balls (“Nerf Ammo” to be provided) to pass through baskets located at the periphery of the arena. A ‘bot starts with no balls, and must request balls by depressing the ball request bumper (BRB) located on one short side of their section of the arena. At the end of each 2-minute round, the ‘bot with the higher total score wins the round.

The Arena

- ☐ The Arena will be constructed from particle board, the playing surface of which will be uniformly covered with white laminate.
- ☐ The Arena will be evenly divided into 2 separate regions, one side for each ‘bot. Each half will measure 8’ × 4’.
- ☐ A protective border will be installed around the perimeter of each half of the Arena. This will serve to clearly demarcate the boundaries of the Arena, and to ensure that ‘bots are not able to navigate off the edges of the Arena to their doom. The borders will be constructed of ¾”-wide wooden boards and be 4” tall relative to the surface.
- ☐ The two halves of the Arena are physically identical, and will be placed side-by-side to form the entire Arena. The dimensions of the fully assembled Arena are 8’ 1½” long × 8’ wide.
- ☐ A center divider will separate the two sides of the Arena, and will constitute the protective borders from each half placed adjacent to each other. The total thickness of the center divider will be 1½”.
- ☐ Each side of the Arena will have a ball inbounding zone (BIZ) along one of its short edges.
- ☐ The balls are spherical, lightweight balls made of closed-cell foam, approximately 4cm in diameter and with a mass of 2gm. Detailed specifications for the balls will not be provided; Instead, each team will be issued a set of 5 balls, and the balls themselves will serve as representative of the specifications, which are, in turn, obviously, representative of the balls.
- ☐ The short edge along which the BIZ is aligned also supports a ball request bumper (BRB). By depressing the BRB by a distance of no more than 1cm, a ‘bot may request that one ball be dispensed

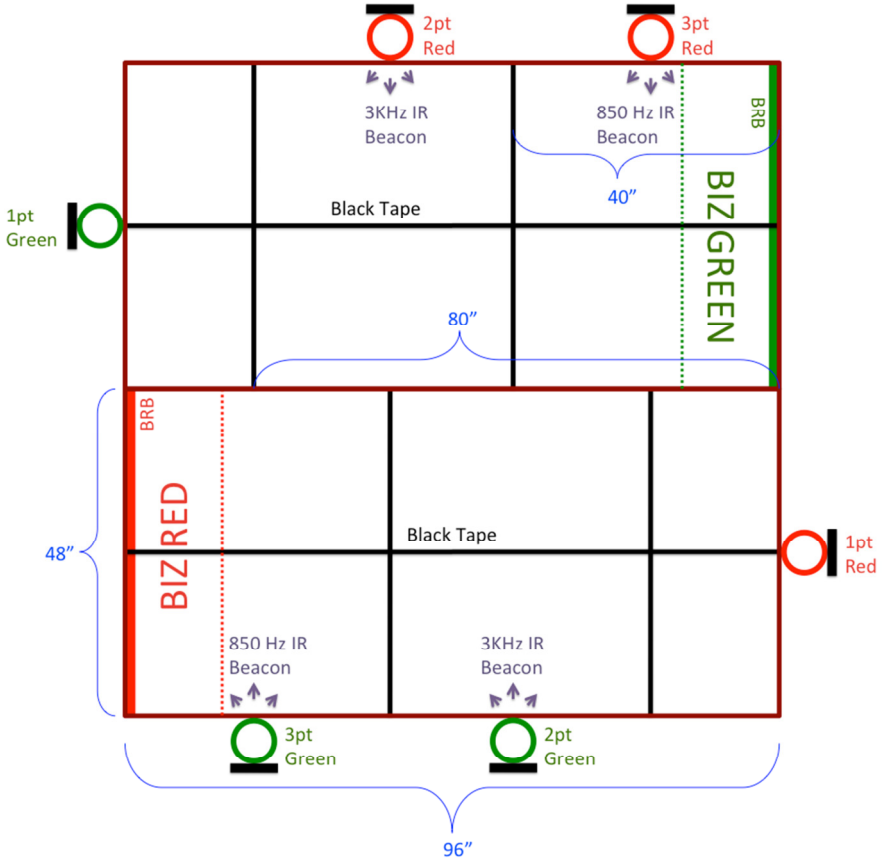

Figure 1: The Arena

from a human member of the ‘bot’s team. Balls will be dispensed by a team member by dropping them straight down into the waiting ‘bot. There can be no time when the ‘bot, ball, and human are all in contact with each other.

- ☐ Three Baskets will be located on each half of the Arena. They are worth 1, 2, or 3 points per scoring instance depending on their position.
- ☐ The 1-point Basket is located on the same half of the Arena as the ‘bot which is permitted to score in it, along the short side *opposite* the BIZ.
- ☐ The 2-point and 3-point Baskets are located on the half of the Arena that is *opposite* the ‘bot which is permitted to score in them, along the long side of the Arena.
- ☐ The 2-point and 3-point baskets are positioned at 40” and 80” along the long side opposite from the BRB for your ‘bot.
- ☐ The physical design of the Baskets are described in the section titled “The Baskets”.
- ☐ A 1” wide non-reflective black tape line runs the length of each half of the Arena, along the centerline. Additional Strips of nonreflective tape are perpendicular to the centerline at 40” and 80” from the end of the arena where the BRBs are positioned.
- ☐ ‘Bots are placed inside their respective BIZs at the start of each 2-minute round. The orientation of the ‘bot may be determined by the ‘bot’s team, however, its exact position inside the BIZ will be subject to randomization, determined by representatives of the teaching team.

The Baskets

- ☐ The Baskets feature a “Hoop” with an opening that is 6” in diameter, positioned 18” above the surface of the Arena.
- ☐ A backboard with dimensions 6”x6” is positioned behind the hoop, extending to 24” above the surface of the Arena.
- ☐ The 2-point basket includes an array of infrared (IR) Beacons modulated at approximately 3KHz, and positioned 15” above the surface of the Arena.

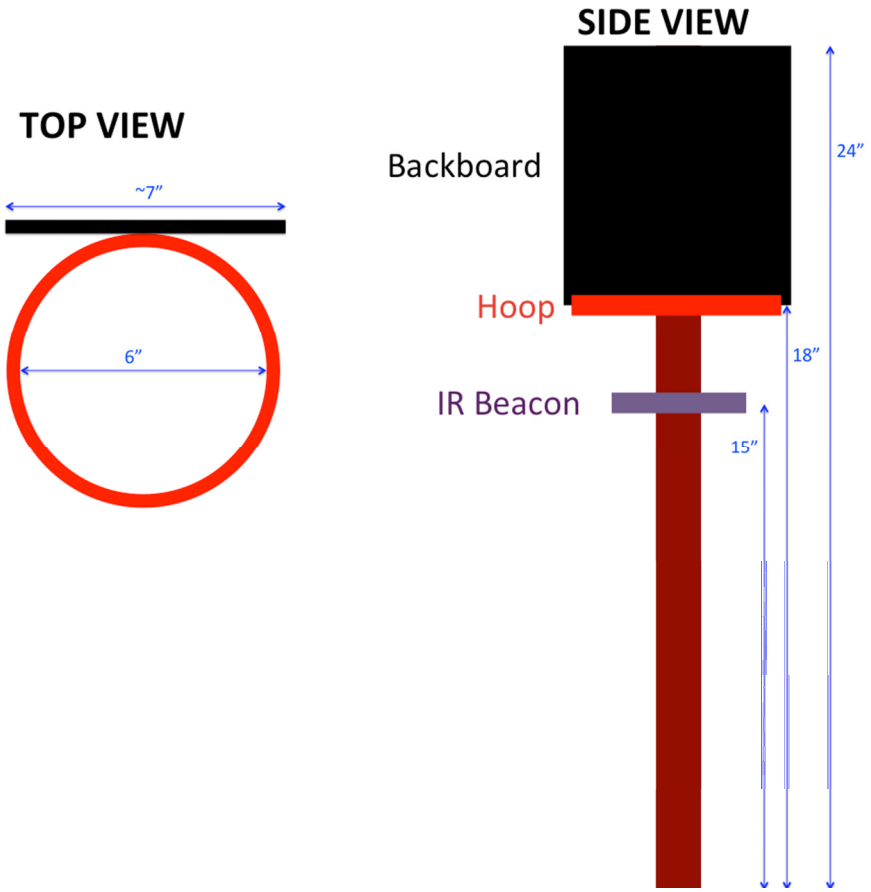

Figure 2: The Basket

- ☐ The 3-point basket includes an array of IR Beacons modulated at approximately 850Hz, and positioned 15” above the surface of the Arena.

The ‘Bots

- ☐ Each student team will be responsible for designing, building, and demonstrating a ‘bot. The ‘bot is an autonomous machine which will run in the Mechatronics Scoring Machines tournament according to the specifications and rules defined in this document.
- ☐ Each ‘bot must be a stand-alone entity, capable of meeting all project specifications.
- ☐ Power for each ‘bot must be supplied by batteries, which are to be carried on board each ‘bot. Each team will be provided with two 7.2V NiCad rechargeable battery packs. Additional batteries may be used if desired, and may be purchased (depending on availability).
- ☐ Each ‘bot must operate completely un-tethered during grading and competition.
- ☐ The ‘bot’s control software must execute from the flash memory of an Arduino Uno. Workstations will not be permitted to be tethered the ‘bot during its operation.
- ☐ Once a ‘bot has been activated at the start of a round, the operator may not touch it again until the entire round is complete, with the exception of emergencies requiring human intervention.
- ☐ ‘Bots must automatically cease all motion 2 minutes and 10 seconds after the start of a round.
- ☐ Each ‘bot is required to fit within a 12” × 12” × 12” cube at the start of a round. An official ME210 dimension verification enclosure (DVE) will be used to ensure that each ‘bot fits entirely within the specified maximum volume.
- ☐ ‘Bots are to not breach the perimeter of the other team’s playing field.
- ☐ Each ‘bot shall incorporate an easily accessible toggle switch on its top which will serve as an emergency stop switch. The switch shall cut all power to the machine when toggled.
- ☐ No element or action of a ‘bot may make contact with an opponent or impede the movement of an opponent, or alter any aspect of the Arena, Baskets, or associated structures in any way.
- ☐ No part of the ‘bot may become ballistic and leave the field of play. Balls are not considered part of the ‘bot.
- ☐ Each ‘bot must be constructed as part of ME210 activities during the remainder of the quarter. It may not be based on a commercial or otherwise pre-existing platform. Rulings from a member of the teaching team may be requested if there are questions about the content of your ‘bot.
- ☐ Each team is limited to an expenditure limit of US$200 for the materials and parts used in the construction of the project.
- ☐ ‘Bots may be in contact with a maximum of 3 different balls at any point in time.

Mechatronics Scoring Machines Game Rules

- ☐ Prior to the start of each round, each ‘bot will be placed at a random position within the ball inbounding zone (BIZ). Its orientation may be determined by its team members, and location shall be determined by a member of the teaching team..
- ☐ Each ‘bot must start each round with no balls touching the ‘bot.
- ☐ A verbal start command will be issued by a member of the teaching staff, at which time teams will initiate the actions of their ‘bot. This is the last human interaction permitted with the ‘bots until the 2-minute round has concluded.
- ☐ ‘Bots are to distribute their balls among the Baskets with the objective of scoring as many points as possible.
- ☐ Rounds last for 2 minutes. The ‘bot with the highest cumulative score at the end of the round wins the round, and progresses to the next level of the tournament bracket.
- ☐ In the event of a tie, a sudden death round is played in which the first ‘bot to advance their score above 0 wins.
- ☐ At any time, ‘bots may contact the ball request bumper (BRB), which is a bumper at the rear of the BIZ, to request that a ball be dispensed.

- ☐ Only one ball may be dispensed per BRB press, (one ball per 3 secs, and must be a new BRB press to receive ball)
- ☐ The human team members are responsible for initiate the 'bot, using a button, switch or other simple start indication. Once initiated, the human team members are not allowed to touch the 'bot, or to touch the balls that are in contact with the 'bot.
- ☐ Human team members are also not allowed to position themselves in a way that will interfere with the activities of the opponent's 'bot. Polite, "G-rated" heckling is permitted, of course.

Performance Requirements

- ☐ For the purposes of grading, the minimum requirement for each 'bot is to "beat a brick" (the standard, inanimate ME210 check-off opponent). Specifically, each machine must be able to score at least 2 points, within 2 minutes, when competing against – literally – a brick.
- ☐ Failing to meet the minimum requirements during the first official attempt will result in having to meet the requirements 2 times in a row in the next official attempt. Failure to meet the requirements 2 times in a row will increase the number to 3 times, which must also be consecutive. Subsequent failures do not increase this count beyond 3.
- ☐ It is important for all teams to remember that the minimum performance requirement is the goal for the class. There are no "extra credit" points awarded for performance above this minimum. Student teams are strongly encouraged to strive for demonstration of the minimum performance functionality as early as reasonably possible, so that the members of these teams may return to their regularly-scheduled lives.
- ☐ The results of the tournament held at the public presentation session will not affect grading. The Public Presentation is purely an opportunity for you to enjoy the devices you've created, and to show your friends and families what you have been doing for the past 3 weeks.

Documentation Requirements

- ☐ An HTML-based final report describing the technical details of your machine is required.
- ☐ The report shall include sufficient detail that a person skilled at the level of ME210 could understand, reproduce, and modify the design.
- ☐ You must turn in the actual HTML source code for your report, rather than building a site on a 3rd party host and linking to it.
- ☐ Using software tools to edit HTML in ways other than editing the code directly is permitted, as long as the final submission is in HTML format.
- ☐ These reports will be posted on the public ME210 website in the future, so please make sure that the content is appropriate and do not disclose information that you do not wish to be made persistently public.
- ☐ Each design team shall maintain a logbook (which may be in electronic format).
- ☐ At a minimum, this logbook shall contain up-to-date mechanical, electrical, and software documentation. This is expected to also include things such as task lists, schedules, sketches, notes from brainstorming meetings, solid models, schematics, code listings, notes about software and hardware versions, and the like.

Other General Guidelines and Safety

All machines and devices must be safe to users, to the lab, and to any spectators.

For this project, excessively-high-velocity ball discharge is discouraged.

The teaching staff reserves the right to require you to reduce the speed of any mechanism for safety purposes.

Pyrotechnics of any kind are prohibited.

All projects shall respect the spirit of the rules, as established in this specification and in the culture of ME210. If you are considering something that may bend or violate the rules, you shall first consult with a member of the teaching staff. Interpretations and rulings are the sole domain of the teaching staff.

Tolerances on the dimensions of the sports playing arena are ±1 in unless otherwise specified.

Evaluation

PERFORMANCE TESTING PROCEDURE

All machines will be interfaced to by one of the team members. There will be one round played for grading purposes, and one (or more) rounds played for entertainment purposes.

Level 1: Grading evaluation. Each machine will be graded based on its performance during the check-off period, the last day of which is Friday, March 6 2015. The public presentation will be on the evening of the following Monday, March 9 2015. During the grading session, each machine will have up to 2 minutes to meet the minimum project requirements. Grading is not based on the score achieved during the evaluation, only on the ability to meet the requirements.

Level 2: Public evaluation/performance. After a warm-up period, teams and machines will be entered into a head-to-head, single-elimination tournament. Each machine will receive points based on the scoring scheme outlined above, and the winner of each game will advance to the next round. The brackets for the single-elimination tournament will be seeded based on the order in which teams successfully meet the grading criteria during the grading session.

GRADING CRITERIA

1. Concept (25%) This will be based on the technical merit of the design and programming for the machine. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware and software and use of physical principles in the solution.

2. Implementation (25%) This will be based on the machine displayed at the evaluation session. Included in this portion of the grade will be evaluation of the physical appearance of the machine and the quality of its construction. Aesthetics will not be judged, rather, craftsmanship and finished appearance are the focus of this portion.

3. Performance (25%) Based on the results of the performance during the evaluation session.

4. Coach Evaluations (10%) Based on the four project milestone reviews (see below).

5. Report (15%) This will be based on an evaluation of the final report. It will be judged on clarity of explanations, and on the completeness and appropriateness of the documentation. This report should be prepared in HTML format (as a website), and submitted as a compressed ZIP archive on Coursework ready for publication on the Internet.

A NOTE ON RESOURCE PLANNING

This is a *mechatronics* project design activity. While aspects of electronics and software design were emphasized this quarter, it is important to realize that *any mechatronic project also requires substantial mechanical design*. Grading in this class is based on complete system design and function. Therefore, a “beautiful” electronics system is not a successful project if the mechanical part of the machine fails. Be certain to allocate resources (energy, time, and people) to all aspects (including mechanical) of this project.

Project Milestones

EVENT	DELIVERABLES
First review Tuesday, 2015-02-17 09:00 (in class)	*Computer presentation of ~5 min. duration* At least 5 design concepts, with sketches Time schedules, project plan Personnel assignments
Second Review by Friday, 2015-02-20 23:59	*Turn in physical documentation (Lab or 550-103)* Calculations System block diagram Preliminary testing results
Third Review by Tuesday, 2015-02-24 23:59	*Presented to coach; check-off by teaching staff* Demonstration of all functional subsystems per block diagram: ball delivery, beacon sensing, tape sensing, mobile platform, etc.
Fourth Review by Tuesday, 2015-03-03 23:59	*Check-off by teaching staff* Integration of subsystems Working software to test all systems Working versions of all systems
Grading Session by Friday, 2015-03-06 17:00	*Check-off by teaching staff* Demonstrate minimum functionality on the playing field set up in the lab or in the 550 Atrium
Final Presentations Monday, 2015-03-09 19:00	*Public presentation and tournament in the 550 Atrium* Finished, operational, presentable machines
Final Report by Friday, 2015-03-13 17:00	HTML format Suitable for publishing on ME210/SPDL website