EENG498BC Systems Exploration, Engineering, and Design Laboratory: Syllabus

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Colorado School of Mines

Semester/Year: Spring 2016

Course Info

- Class meeting schedule: 12:00AM - 1:15PM, Monday and Wednesday.
- Class location: Brown Building 304 and 305.
- Course Webpages:
    - Blackboard (`http://blackboard.mines.edu/`). All current CSM students should have a blackboard account, and students registered for this course will be automatically enrolled. Check with CCIT if you do not have a blackboard account.

Instructors

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Objectives

Students will be able to:

- Design and debug integrated systems as an intra-disciplinary team.
- Design experiments and gather data to solve engineering problems and/or demonstrate performance of sub-systems or systems.
- Predict the performance of a designed system and verify their predictions experimentally.
- Work effectively in intra-disciplinary teams to solve engineering problems.
- Engage in reflective learning and demonstrate an ability to engage in life-long learning.

Section Specific Objectives:

Embedded Systems

Students will be able to:

- Interface various kinds of sensors to a microcontroller.
- Use a microcontroller to drive and control motors.
- Implement communication between processors using wired and wireless protocols.
- Design a user interface to enable a human being to interact with their integrated system.
- Exploit built-in features within a microcontroller such as ADCs, DACs, and timers to design an efficient system.

Section Specific Objectives:

Control Systems

Students will be able to:

- Use Simulink to model a dynamic system.
- Design and execute experiments to find unknown parameters describing a dynamic system.
- Design and implement a PI controller to regulate the speed of a motor.
- Design and implement a controller to stabilize an inverted pendulum.
- Design and implement a controller to regulate the horizontal position of a balancing robot.

Project Description

Your employer has determined that a highly maneuverable robot with small footprint that can carry items from one location to another has a viable market for sale to hospitals and in other institutional settings. Your team is assigned to design and build a prototype device, which is a two-wheeled balancing robot that can cary cargo to a desired destination. This prototype should be self balancing, and able to move in a straight line. While many balancing robots use a complete inertial measurement unit (IMU) that incorporates a gyrometer, accelerometer, and compass, these sensors are quite expensive. Your boss has asked you to balance using the robot using *only* a gyrometer, which measures angular velocity. Other available sensors are wheel encoders, line sensors, and ultrasonic sensors. It should be able to receive commands wirelessly, which include: stop and hold position, move forward, and move to target. The robot should also be able to detect obstacles and stop if detected. For the demonstrations, the cargo will be a 0.5 liter or 1 liter water bottle filled with water.

For convenience, some aspects of the design have been fixed: the motors, wheels, battery size, available sensors, and available

Group Work

You will be working in groups to complete the activities in this lab. This is done for several reasons. Researchers have shown that students that students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats. In addition, the ability to work in a diverse group is an educational objective in itself, and one of the student outcomes that we are required to measure for accreditation of the electrical engineering degree is the ability to function on multidisciplinary teams.

We will model a multidisciplinary team by having some members concentrate on embedded systems, and some members concentrate on control systems. Even though you are all electrical engineers, you will need to learn how to cooperate and communicate with team members whose expertise is different from yours.

In order to assist in the formation and monitoring of the teams, we will use the CATME website. You will also be using CATME when you are in senior design. You will first fill out a team maker questionnaire with information about your background and skills. We will then use CATME

Work Process

Although we will be meeting in lab for 3 hours a week, it is expected that you will be working outside of lab as well to complete this course. You should plan on at least 1 hour of work outside of lab for every 1 hour in lab, plus additional time for meetings and communicating with your group members.

On blackboard, you will find a short document from the Derek Bok Center for Teaching and Learning, Harvard University, on best practices for working in groups. All students are expected to have read this document and are ready to participate in their groups once they are assigned.

Lab Availability/Office Hours

Mon	Tues	Wed	Thurs	Fri
11:30am-12:00pm Joel Kuenning Office Hours **12:00pm-1:30pm** SEED Lab **1:30pm-3:00pm** Joel Kuenning Office Hours **3:00pm-5:00pm** Joshua Nelson Office Hours	Lab Not Available	**10:30am-12:00pm** Jonathan Hong Office Hours **12:00pm-1:30pm** SEED Lab **1:30pm-2:00pm** Jonathan Hong Office Hours **3:00pm-5:00pm** Henry Dau Office Hours	Lab Available	**12:00pm-1:00pm** SEED Lab Debrief

Grading Scale

Teams earn points up to the total listed in the grading scale below.

Available Points

Stage	Assignment	Points
Aruino Intro	Documentation	50 points
Preliminaries	Documentation	150 points
Demo 1	Documentation	200 points
	Performance	100 points
Demo 2	Documentation	100 points
	Performance	150 points
Final Demo	Documentation	100 points
	Performance	150 points + 50 bonus points
Total		1000 points

Performance Scoring

The performance will be judged in certain criteria for each demo. There will be three demonstrations during the semester, and the robots will be judged in each category. The score for each category is determined as follows:

- Best score in category (B): 55 points
- Other scores (S):
  - Larger is better: $\frac{S}{B} \times 50$
  - Smaller is better: $\frac{B}{S} \times 50$

Teams earn the sum over all available categories, up to the maximum listed above.

Performance Criteria:
Demo 1

In the first demo the robot does not have to balance on 2 wheels, and can use 3rd or 4th passive wheel. There will be multiple runs. Different runs may have different cargo, and the course may be sloped. For the first demo, the performance metrics for the robot are

- Robustness: Number of failures to receive a command to start, or detect an obstacle (smaller is better).
- Size: Largest dimension of the of the robot (height, width, or depth, smaller is better).
- Speed Regulation: Variance of delivery time (smaller is better).
- Stopping Accuracy: Average distance from target when stopped (smaller is better).

Performance Criteria:

Demos 2 and 3

In the second and third demos, there are additional criteria. Note only robots that balance on two wheels can qualify for Balancing Capacity.

- Robustness: Number of failures to receive a command to start, or detect an obstacle (smaller is better).
- Size: Largest dimension of the of the robot (height, width, or depth, smaller is better).
- Speed Regulation: Variance of delivery time (smaller is better).
- Stopping Accuracy: Average distance from target when stopped (smaller is better).
- Balancing Capacity: Weight of cargo that can be successfully carried to target (larger is better).
- Telemetry: The amount of data that can be wirelessly transmitted regarding robot performance during a run (larger is better).

Documentation

The documentation score includes the following

- CATME (score for completion on catme.org).
- Reflection logs (score for completion, submitted on Blackboard).
- Weekly team work log - work plan, team member obligations, problems, solutions (score for completion, loaded on team shared folder).
- Documentation requested in handouts or as posted on Blackboard (loaded on team shared folder).
- Presentations - after each demo, groups will give a short presentation on their design to the rest of the class.

Once you are formed into groups, you will be provided a shared directory for your group accessible through the CSM network. As appropriate, you should post your documentation to this shared directory, using subfolders to separate work by week or by demo.

Lab and Equipment Safety

The equipment you will be working with is sensitive electronic equipment, and you are responsible for knowing the limitations and proper handling of this equipment. Some good reading is

- `http://www.ruggedcircuits.com/10-ways-to-destroy-an-arduino/`
- `http://playground.arduino.cc/Main/ArduinoPinCurrentLimitations`

The robots are fairly lightweight, but the motors are strong enough to move the robot around at high speed. Take care and be aware any time you are operating the robot. The motors can also be damaged if they are hit or if excessive weight is applied to the robot.

You will be working with batteries with significant energy storage. If the batteries are shorted, a large current can occur, causing heat and perhaps fire. Be aware of potential short circuits.

The equipment that you will be provided must be returned in good working condition. The team is jointly responsible for damaged equipment. An updated inventory of your teams equipment will be provided.

Absenteeism

From the bulletin:

> *Class attendance is required of all undergraduates unless the student is representing the School in an authorized activity, in which case the student will be allowed to make up any work missed. Students who miss academic work (including but not limited to exams, homework, labs) while participating in school sponsored activities must either be given the opportunity to make up this work in a reasonable period of time or be excused from such work. It is the responsibility of the student to initiate arrangements for such work. Proof of illness may be required before makeup of missed work is permitted. Excessive absence may result in a failing grade in the course. Determination of excessive absence is a departmental prerogative.*
>
> *The Office of the Dean of Students, if properly informed, will send a notice of excused absence* of three days or more *to faculty members for (1) an absence because of illness or injury for which documentation will be required; (2) an*

Academic Honesty

The Colorado School of Mines affirms the principle that all individuals associated with the Mines academic community have a responsibility for establishing, maintaining and fostering an understanding and appreciation for academic integrity. In broad terms, this implies protecting the environment of mutual trust within which scholarly exchange occurs, supporting the ability of the faculty to fairly and effectively evaluate every student's academic achievements, and giving credence to the university's educational mission, its scholarly objectives and the substance of the degrees it awards. The protection of academic integrity requires there to be clear and consistent standards, as well as confrontation and sanctions when individuals violate those standards. The Colorado School of Mines desires an environment free of any and all forms of academic misconduct and expects students to act with integrity at all times.

Academic misconduct is the intentional act of fraud, in which an individual seeks to claim credit for the work and efforts of another without authorization, or uses unauthorized materials or fabricated information in any academic exercise. Student Academic Misconduct