CGE575: Sensing
Winter 2017

Application-driven sensing, data analysis and system integration
This course will address the increasing importance of automated measurements, instrumentation design, system integration, sensor networks, and the analysis of “big data” across a broad range of scientific and Civil and Environmental Engineering domains. You will acquire an in-depth, practical and theoretical knowledge of sensing technologies, with the ability to directly apply these state of the art tools to your projects or interests. Sensor physics will be discussed to illustrate how physical processes can be measured through electrical signals and converted to digital information. Extensive theory behind leading sensing technologies and data acquisition systems will be discussed. Large-scale sensor networks will be investigated as real-time data acquisition platforms for measuring distributed systems. Commercial as well as open-source platforms will be explored, with an emphasis for developing an in-depth understanding of the benefits and limitations of various technologies. Real-time data collection and analysis will be discussed and cast into the larger framework of system integration to enable you to develop and assemble fully automated systems. All measurements and system designs will be motivated by real-world case studies across a engineering and science.

Things you will be able to do after taking this course
• Pick the right sensor for your application guided by a fundamental understanding of physical principles and sensor technologies
• Design your own data acquisition system or sensor networks, whether they be laboratory experiments or large field deployments
• Quickly process, analyze and filter data collected by your set-up
• Incorporate streaming sensor data into models and control schemes

Instructor
Branko Kerkez
2044 GG Brown
bkerkez@umich.edu
Office Hours: Mon. 12PM-1PM, and Wed. 4PM-5PM, or by appointment. In general, feel free to drop by if I’m around.

Course Website
http://tinyurl.com/iheartsensors
links to http://www-personal.umich.edu/~bkerkez/courses/cee575

Prerequisites
Given the diversity of everyone’s background, no prior experience is assumed.

Meeting Times and Location
Monday and Wednesday 10:30AM – 12PM, 1008 EECS

Course Materials and Textbook
Will be made available via course website

Lab Exercises
There will be a few hands-on activates throughout the semester. We’ll learn how to use sensors and analyze large data. I will work with everyone to find a good time. These lab sessions will not meet every week and will be announced ahead of time.
Topics

- **Sensing (how to measure the physical world)**
  - Introduction to sensing theory, physical principles and measurement quantities.
  - Resistive, capacitive and inductive sensors, MEMS systems.
  - *Example sensor applications*: acceleration, strain, pressure, wind, temperature, humidity, vapor pressure, air quality, radiation, streamflow, snow depth, loop detectors, cameras, cellphones, geophones, magnetometers, chemical and biological processes.
  - Analog to digital conversion, discretization, data acquisition systems
  - Distributed sensing and sensor networks.
  - Energy consumption for long-term deployments and studies. Wireless sensor networks and low-power system design.
- **Data processing and analysis (how to interpret measured signals)**
  - Signal processing, signal interpretation, frequency based methods.
  - Data mining, estimation, parameter identification.
  - Physics-based and statistical estimation methods.
  - Formal experimental design methods and optimal sensor placement.
- **Application integration (using collected data in real world applications)**
  - Actuation, control and loading systems. System integration methods.
  - Real-time data management for state estimation, system identification, and control.
  - Formal system design methods, interface development, data to decision support systems. Networking and the *Internet of Things*.

Project

The general idea for the project is to have you apply concepts from this course, or to explore them further through in-depth analysis. Ideally, the project should contain experimental as well as theoretical components. You are encouraged to apply topics from this course to your own research, or to team up with others on a separate project (two person groups are encouraged). A number of possible project topics ideas will also be posted on the course website. A one-page project proposal will be due in February. At the end of the course, a project report will be due and a presentation/demo session will be held.

Grading Breakdown

Take-home assignments 30%
Take-home exam, administered around the 2/3 semester mark, 30%
Final project 40%

Academic honesty

UM has a Code of Student Conduct that stipulates the university’s policy on academic dishonesty and student misconduct. The basic premise of this policy applies to this course as well. Beyond that, my expectations for you will be straightforward:

- Feel free to work in groups, unless specifically told not to do so (e.g. take-home midterms) but please always turn in your own assignment
- Always cite your sources, regardless if they pertain to homework, reports, or presentations

Accommodations

Please see me or email me if you require any special accommodations. I realize a number of you will be taking other courses, attend conferences, have paper deadlines, etc. If this is the case, please let me know ahead of time and I will work with you to make sure we can minimize the amount of stress you will experience in grad school.