This course addresses the emergence of sensors “smart” systems across science and engineering. We will learn how sensors, internet-connected devices, and real-time data are being used to build “smart” cities, smart homes, robots, and a new generation of scientific experiments. Students will acquire practical and theoretical knowledge of sensing technologies, with the ability to directly apply these modern tools to their 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 wireless sensor networks will be covered and we’ll talk about data can be transmitted to the Internet. We will also learn about signal processing and practical machine learning methods to analyze and act upon data collected by sensor networks. No prior experience is assumed.

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 model or autonomous systems

Instructor
Branko Kerkez
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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
Canvas or http://tinyurl.com/iheartsensors
links to http://www-personal.umich.edu/~bkerkez/courses/cee575

Prerequisites
Given the diversity of everyone’s background, no major experience is assumed. You should feel comfortable doing some basic calculus, however.

Meeting Times and Location
Monday and Wednesday 10:30AM – 12PM, 1024 FXB

Course Materials and Textbook
Will be made available via course website

Hands-on Exercises
There will be a few hands-on activities throughout the semester. We’ll learn how to use sensors and analyze large data. Students will be split into groups and given sensor kits to take home.
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.
  - 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 (A=>90%, B=>80%, C=>70%)
- **30%**: Take-home assignments (homeworks and hands-on sensor activities)
- **30%**: Take-home exam, given out on March 21\textsuperscript{st}, due beginning of lecture March 26\textsuperscript{th}
- **40%**: Final project

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.