CS 012: Introduction to Prototyping (3 units)

Overview

Staff

Neil Janwani: `njanwani@caltech.edu`

Hope Arnett: `harnett@caltech.edu`

Objective

From SURFs to your own personal projects, prototyping experimental equipment is often a necessary component. This class aims to give students an introduction to specific class of single-board computing platforms (microcontrollers) and their applications in experimental research. Specifically, this class will be using the *Raspberry Pi Pico*: a cheap microcontroller that can be programmed in `MicroPython` and can easily interface with a wide variety of sensors. This class will also be a stepping stone into using more complex platforms, like Linux-capable machines and Arduino (which uses `C++`).

This class will not be an extensive, *in-depth* review of IoT (internet-of-things). It will also not explore Linux-running systems, like the Raspberry Pi 4B computer. Also, this class is designed to *not* induce extra stress! If you feel that you are needing to put in more than 3 hours per week, please reach out to Hope or Neil.

Pre-requisites

We ask that you are somewhat familiar with `Python`. This translates to CS 1 (or equivalent `Python` experience). Helpful `Python` resources will be provided at the beginning of the course.

Course Goals

After passing this class, you will be able to

(a) Prototype your own devices, whether it be for research, a hackathon, or your own personal project.

(b) Make design choices for the mechanical, electrical, and software components of the robotic system

(c) continue to explore prototyping through different devices, like the *Arduino* or the *Raspberry Pi 4B*

If you'd like to explore robotics even more, check out the following resources:

- ME 8: *Introduction to Robotics* (first term)
- ME/EE 7: *Introduction to Mechatronics* (first term)
- ME/EE/CS 129: *Experimental Robotics* (third term)
- CAOS: *Caltech Air and Outer Space* (ongoing Caltech club)

Overall, this class will build up to a "midterm project" of building a fan that regulates the nearby temperature, and implements certain safety features. Following the system integration of this device, teams will design and build *their own devices* using the parts from the fan in a final project. We hope that this will gradually introduce prototyping from a component level to a robot system level to students, and allow them to pursure creative final projects.

Schedule

The tentative class schedule is laid out below. Details are subject to change, but the general layout will remain the same. (Draft annotations have been added)

Week 1: *Introduction*

(a) Form groups

(b) Software Setup

Week 2: *Hardware Basics*

(a) Introduction to microcontrollers

(b) **Lab**: LEDs and circuitry (introduction to using breadboards and pins on the microcontroller)

Week 3: *A reactive robot*

(a) Forms of input: buttons and potentiometers

(b) **Lab**: Making waves with 1's and 0's (working with PWM, adding "liveliness", or reacting to stimuli, to robot behavior)

Week 4: *The electromagnetic machine*

(a) Motors, motor control, and servos

(b) **Lab**: Electric machines (learning how to actuate different motors and servos)

Week 5: *Complex Sensors*

(a) Inertial measurement units and temperature sensors

(b) **Lab**: Complex sensor peripherals (working with IMUs or temperature sensors)

Week 6: *Midterms*

(a) *Interrupt functions*: the encoder

(b) No lab due to midterms

Week 7: *Computer Aided Design*

(a) Design and 3D-printing

(b) **Lab**: Tinkering with the Techlab (printing a box to house electronic components)

Week 8: *System Integration*

(a) Building your first device

(b) **Lab**: I'm a fan of your work (building a fan from the previous labs, which utilizes sensors, motors, buttons, etc)

Week 9: *Final project*

(a) Begin development of your final project!

Week 10: *Final project*

(a) Continue development of your final project!

Week 11: *Final project*

(a) Complete development of your final project!

Weekly Structure

As this is a 3 unit course, each week will follow a fairly relaxed schedule

(a) **TBD:** (Optional, but recommended) 30 min lecture followed by a 30min-1hr brainstorm, where we attack problems in class together

(b) **TBD:** (Optional, but recommended) 1.5 hour lab session held as an "office hours" for the lab of the week. One or more TAs will be present. May be held multiple times a week for scheduling conflicts.

Labs will be released before lecture, and will be due the day before lecture at 11:59 PM. Note that students should plan to attend at least one lab section.

Grading

Grading will be based upon a system of points; labs are worth 10 points and the project is worth 40 points for a total of 100 points.

Labs and projects will be graded on completion and accuracy.

(a) If a project works well/perfectly (a few minor issues are ok), then full points are awarded.

(b) If substantial work has been done, but there is no demo or some portions are incorrect, half-points are awarded

(c) If scarce work has been done or nothing is correct, 0 points are awarded

Passline

Out of 100 points (6 labs, 1 project), 60 points must be earned to pass the class.

Late Labs

If a lab cannot be completed on time, then an extension can be given until the day after lecture at 11:59 PM. For this extension to remain valid, **the student must attend lab or lecture in the following week**.

So, for example, if in Week 4, a student turns in their project the day after lecture at 11:59 PM, they must have attended lecture on the previous day or attend lab *in person*. Students who take extensions that do not follow this requirement will receive 50% credit for the project/lab.

Groups

Labs and projects will be preferably completed in groups of 2. If you strongly wish to work in a group of 3, work alone, or are having trouble finding members, please let us know! Lectures will be designed to help people find partners to work with.