6.01 Final Project Proposal

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Overview:

For our final project, we would like to implement a control system for the lab robot that consists of a user worn glove, in which certain hand configurations corresponding to certain robot motion controls. The overall system would be comprised of a controller glove (with flex sensors and a gyroscope sensor) for the user that sends commands and then a controller on the robot to receive commands and feed them to the motors. We believe being able to develop this system will show our ability to incorporate a circuit/control system. We will then work to implement Bayesian reasoning by having the glove control system first gain confidence in a configuration before actually sending the command to the robot. The way this will work is that our command configurations will be predefined for the user, and so as they move their fingers, the system will gain more confidence of the actual correct configuration the user's hand is in, and once we hit a threshold of confidence, the command is sent to the robot.

Intended Functionality:

1. Our primary objective is to control the motion of the robot (specifically forward/backward speed and rotating speed) with different hand configurations.
    a. This will be accomplished because a specific predefined hand configuration can correspond to a specific voltage output as a result of the variable resistance of the flex sensors, and then that voltage will correspond to a specific motion command.
2. We will then also build a reasonable probability model for the robot to recognize and gain confidence in a hand configuration, and only then execute a command.
3. We would like to include simple circuit elements to show some feedback from the probability system and from the robot (could be some LEDs showing the confidence of the robot, current command belief, etc).
4. (Advanced) Design more configurations (or movements) of the hand to control more complicated motions of the robot.
5. As a stretch, we could add a learning mode. This would use the probability framework we developed for the robot, and by doing different gestures we let the robot itself learn to take the movement we want it to make. (without a predefined configurations provided for the robot.)

Technical Design:

Our project can be roughly divided in three parts:

1. Part One: The control circuit. The two flex sensors are variable resistors that change resistance proportional to the amount they are bending. We convert the resistance of the flex sensor to voltages using a voltage-divider and op-amp circuit. This voltage is read with an MCP3008 analog to digital converter. We will use an LSM9DS series or an MPU9250 for the gyroscope sensor to sense hand orientation. These two sensors put together should allow us to detect most of the user's hand configuration (orientation and flex of two fingers). The main task for this part is to design a circuit that transfer the bending degree to linear voltage measure, and figure out how to read the gyroscope sensors, and then feed all this into a microcontroller or Pi in/on the glove.
2. Part Two: The probability model. We will develop code that can use the data output from the circuit to build a belief using a Bayesian inference model and determine the confidence in recognizing the configuration/command.
3. Part Three: The connecting interface. We will utilize a tcp socket in python to send data (in the form of a motion command with high confidence) from the Pi to a computer controlling the robot.

Technical Challenges:

Our project is planning to incorporate both hardware elements, software elements, and interface between the two. As a result, we anticipate some of the following technical challenges arising:

- Building a controller circuit that implements flex sensors which is small and contained enough to fit on a user's hand.
    - Related to this, choosing a battery source which supplies enough power to achieve our desired range of voltages while still fitting hand size.
- Getting dependable voltage readings in our circuit, since the flex sensor resistance is based on degree of flex, which may or may not be consistent.
- After the glove controller determines analog voltages and converts them to digital: making sure that a confidence judgement is made quickly enough so that robot motion is smooth.
- Maintaining clear and consistent communication between the glove controller and robot receiver, which may vary based on network conditions and the like.
- If the robot receives quick, successive conflicting commands, we want to ensure that there is still some sort of motion occurring instead of just jittery motion or stand still.
- Ensuring that the glove circuit elements give enough feedback to the user to show that the system is functional.

Parts List:

Here is a list of all the parts we should need to utilize for this project. There may be other expenses, (voltage regulators, smaller components, etc.) that have not been included. A computer will also be needed for the robot, but we could simply use one of our computers or the 6.01 lab computers.

Description	Item #	Vendor	Price
Raspberry Pi Zero W (x1)	Raspberry Pi Zero W	Adafruit	10.00
MCP 3008 (x2)	MCP 3008	Adafruit	3.75 x 2
MPU 9250 (x1)	MPU 9250	6.01 Lab	0.00
USB Power For Pi and Electronics	Several Items, Cable, Battery Pack	Angel	0.00
Long Flex Sensor (x2)	FSL0095103ST	Adafruit	12.95 x 2
			Total: $43.40

Part URLS:

- www.adafruit.com/product/182?gclid=Cj0KCQiA3dTQBRDnARIsAGKSflkS--3kYcbGKQwOgK2Gvy2GFgc8xLB1Py8N--0KVm7i92e5x7QBUGIaArZDEALw_wcB
- https://www.amazon.com/HiLetgo-Gyroscope-Acceleration-Accelerator-Magnetometer/dp/B01I1J0Z7Y/ref=sr_1_1?ie=UTF8&qid=1511388435&sr=8-1&keywords=mpu9250
- https://www.adafruit.com/product/3400?gclid=Cj0KCQiA3dTQBRDnARIsAGKSflIyDHw7MpaMxfs2nVj6UxYCwvWPb_aFCN2RbPwJa4d5RmipR7Oq5ZkaAgLZEALw_wcB
- https://www.adafruit.com/product/856

Milestones and Demos:

Date	Milestone	Demo	Who does it
Nov 28	Choose and order flex sensors, analog voltage sensor, battery power, and microcontroller/Pi (and obtain gyros and Pi software from lab)	Show that parts have been ordered	Angel (with input from Matt and Kevin)
Nov 28	Formalize the hand configurations we want to correspond to robot commands	Display a chart with possible ranges for the flex sensors and what they will correspond to in terms of robot movement.	Matt and Kevin (with input from Angel)
Nov 30	Assemble glove circuit consisting of battery power, voltage sensors, and flex sensors, gyroscope sensor	Show that we can measure a changing voltage in the circuit (with voltmeter for now)	Angel and Kevin
Nov 30	Design and modify the circuit to make it have linear dependence in the voltage range we are interested in.	Show off a chart that contains a certain hand configuration, the intended motion associated with the configuration, and the voltages of the configuration we have discovered, showing that they are linear (or some other relations that we want to design).	Angel and Kevin
Nov 30	Develop code that will be able to read analog voltages from the glove circuit and translate to robot velocities.	Display how the code could pass a series of test cases in which we know the voltage and intended motion	Matt
Dec 5	Incorporate new circuit component so that voltages can be read without need of a voltmeter	Output these readings to a computer and check their accuracy via voltmeter	Kevin
Dec 5	Develop communication system between glove controller and a receiver on the robot (either microcontroller or Pi based)	Show that glove can send measured voltages to a computer without a wired connection	Angel
Dec 5	Control robot with raw voltage readings from glove controller	Show how robot responds to movement of hand, and how motion corresponds to our established hand configurations	Kevin

Dec 5	Finalize discussion of confidence-gain system, decide on probability distribution given a measured voltage	Explain the threshold, conditional probability distribution, and Bayesian Inference procedure we come up with	Matt (with input from Angel and Kevin)
Dec 7	Implement confidence-gain system, in which code does not send velocity instructions until a confidence threshold is hit.	Show how code output behaves when a series of voltage readings are fed in	Matt
Dec 7	Incorporate new circuit element on glove or robot that will show increasing confidence levels	Demonstrate an LED in the glove circuit or in the Pi increasing brightness in relation to rising confidence levels.	Kevin
Dec 7	Complete MVP: featuring glove controller, wireless communication, confidence system, and robot movement	Show functional robot movement in response to various hand configurations after a confidence threshold is reached.	Full Team
Dec 12	Sew glove circuit into an actual glove for easier wearability	Have a team member actually wear the glove and use the system	Matt
Dec 12	Develop a more complex motion or behavior set in response to a specific configuration or a series of configurations	Exhibit how unique hand configurations result in a movement that is not simply forward, backward, left, or right (examples include dance, zigzag, etc)	Angel and Kevin

Justifying Division of Labor:

We will aim to have a point person for every milestone, but we believe certain things require input from the whole team to maintain group unity. These things include part ordering, hand configuration discussion, and confidence-gain system discussion. Once these higher level goals are implemented, we can work more specifically on matters such as building the glove circuit or writing the confidence code. We try to play to each team member's' strengths, so Angel's focus is the circuit and controller communication, Kevin's is the circuit and user input decisions, and Matt focuses on the code, but each team member can and will contribute to other parts of the project. We also want to split it up so that we can parallelize some of the milestones, like building the initial circuit and initial voltage reading code. Putting these things together should lead to an overall successful project!