ECE4011/ECE 4012 Project Summary

Project Title	Modular Tactile Sensor Development Suite
Team Members (names and majors)	Josh Oldenburg (CmpE)
	Joseph Spall (EE)
	Juan Elizondo (EE)
	Austin Keener (EE)
	Varun Madabushi (EE)
Advisor / Section	Dr. Patricio Vela, ECE Single Semester ECE4873-D1A
Semester	2020/Fall (ECE 4873)
Project Abstract (250-300 words)	The act of grasping is innately tied to the human sense of touch. When interacting with the world around us, humans rely heavily on their tactile senses to understand the weight, shape, and texture of the objects they hold. To improve robotic manipulation, the ability to sense the "feel" of interacting objects or surfaces is paramount. Tactile sensing is a heavily researched area, aimed at giving robots a sense of touch similar to humans. Two such sensors are the GelSight, which measures deformations of a gel against a surface using optical techniques, and the MIT STAG, which uses piezoresistive material sewn into a glove to sense contact forces on a hand. These sensors and others like them are effective but face a number of drawbacks, such as using many wires, having large footprints relative to sensor area, and requiring complex manufacturing methods. These factors present a barrier to widespread adoption in the applications research and hobbyist spaces. We seek to introduce a product that enables individuals to easily incorporate tactile sensing in their projects. Our product will be composed of a series of tactile sensing modules. Each module will be capable of reporting the location and magnitude of contact forces within their sensing area. A key feature of our product is the ability to "tile" modules by placing them next to one another and wiring them up in a daisy-chain fashion. This permits the user to create a tactile sensing surface in whatever shape they wish, such as a flat surface or the many joints of a robotic gripper. Lastly, we wish to write an easy-to-use PC and/or Arduino API for integrating this sensor into the end-user's application software for visualization, processing, or control.

Project Title	Modular Tactile Sensor Development Suite
List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	In order to maximize our community contribution, we wish to open-source our hardware and software design, following the Open Source Initiative. We will need to appropriately license our own designs, and make sure to use open-source libraries when appropriate. We will reference IEEE and ISO standards for possible communication protocols, such as CAN, USB, or UART.
List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	The sensor applications can vary widely; therefore, making the sensor tile-able to minimize 'dead zones' is very important. This constrains the general shape and size of the sensor, as well as where accompanying circuits and components can be placed. The sensor array should be easily expandable. This constrains the communication protocols that can used to communicate between nodes and to send information back to the main controller down to chained UART or the automotive standard CAN based on our research.
Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	Our current design stack-up involves a top flexible layer with electrical contacts, a piezoresistive material that changes resistance based on force, and a rigid PCB with contacts on the back to read the change in resistance (along with providing a location for the microcontroller and connectors for chaining). However, the possibility of a fully-flexible sensor was discussed at length. In the fully-flexible sensor scenario, the sensing surface would be able to be wrapped around non-planar surfaces, like a human hand or a flexible robot. The rigid-backed solution was settled on as it reduces the complexity of manufacturing and avoids issues with internal stresses in the piezoresistive material being read instead of forces directly applied to the surface. For taking measurements, there were two main options: having a microcontroller on each node or having a simple addressable ADC chip on each node with a single microcontroller handling all of the processing. A microcontroller per node was settled on because it allows more flexibility in communication protocol and addressing schemes. While only having an ADC chip simplifies the software by eliminating software needing to be written on each node, the scheme also requires the host processor to manage all computation involved. The microcontroller per node option simplifies processing on the host processor and communication in general.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** tradeoffs, interfaces, and/or interactions.	Computing aspects will involve analog to digital conversion of the sensing grid, digital signal processing/filtering of the measured signals, and implementing a communications interface to send data from a sensing node to a central controller or interface. Of particular interest will be the communication scheme to interface with the sensors. Tradeoffs include number of physical wires, ease of software implementation, speed, noise immunity, node addressing, etc. These computing aspects will inform microcontroller selection, as the microcontroller will need to have adequate computational resources as well as contain the peripherals needed to perform sensing and implement the communication interfaces.