EE3810 Lab 7: Force Sensing Resistors and Surgical Robotics

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1 Concepts

Physiology

1. minimally invasive surgery
2. arthroscopy, endoscopy
3. sensory feedback

Engineering

1. pressure sensors
2. force sensing resistor
3. buffer
4. robotic control
5. feedback control

2 Background

Many critical surgeries require accessing organs and tissue that are well below the surface of the skin and/or buried behind other organs. Traditionally, such surgeries would have required making a large incision and opening up the cavity of the body to the extent that the infection risk is very large, and recovery time is very long. Fortunately, with the advancement of new technology, including endoscopy and robotic surgery, surgeries can be minimally invasive, requiring incisions only large enough to allow passage of a catheter and/or small surgical tools.

In these minimally invasive surgeries, a very small camera might be attached to the end of a catheter with only 1mm diameter so that images can be captured in the innermost parts of the body. Then, surgical tools are manipulated by a robot rather than by a surgeon's hands. The surgeon can control the robot remotely through a hand-held manipulandum device while viewing the camera's images. However, to control the delicate movement, position, and operation of the surgical tools, the surgeon would normally grip the tools with different amounts of force depending on what type of tissue they are dealing with or what procedure they are trying to perform. The first step in actuating the right amount of force via the tools is to sense how much force the surgeon desires to apply. Our hands (and our skin) contain receptors, or sensors, which are triggered by touch and pressure. These receptors provide sensory feedback to the brain about our environment - e.g., what the hardness of the object one is touching is. Then the brain would adapt the motor output of the hand or fingers to grip the object with an appropriate amount of force. Thus, the hand-held manipulandum would need some sort of pressure sensors embedded in them.

Force sensing resistors (FSRs) are an example of a sensor that are sensitive to force and therefore, could potentially be used in a robotic surgery application. However, you should be able to decide whether these sensors are an appropriate choice or not. FSRs are a thick film device with a conductive polymer which decreases resistance as force is applied to the active area.

3 Objectives

In this experiment, you will measure the sensitivity of pressure sensors that could be used in a haptic robotic device and observe the effect of using a follower circuit with the sensor.

4 Pre-lab reading / assignment

- Sketch the circuit schematic of the circuit you will construct in part 5.1. (Don't forget to label nodes; and important, relevant quantities. This applies to all circuit schematics you draw).
- Sketch the circuit schematic of the circuit you will construct in part 5.3**??**

5 Procedure

5.1 Voltage divider construction

1. Construct a voltage divider circuit that would output a voltage which increases with increasing pressure on the FSR. You will also be provided a 10KΩ resistor. Use a single supply voltage of 6V.
2. Quickly observe the operation of a force sensing resistor by monitoring the FSR output on the oscilloscope while you press on the sensor to varying degrees with your fingertip.

5.2 Sensitivity analysis

1. Lay the FSR flat on the table, and place the plastic (3D-printed) part in the center of the FSR.
2. Record V_{out} and gradually add more weight.
3. Determine the sensitivity of the FSR using the weights provided.

5.3 Buffering sensor output

1. Watching V_{out} as you do this, add a load resistance of 100Ω. What is the effect?
2. Conduct the sensitivity analysis (for 5 different weights, taking necessary measurements).
3. Add the follower circuit according to your pre-lab circuit diagram.
4. Repeat the sensitivity analysis with the follower circuit.

6 Questions

1. Discuss the effect of the resistive load, and what engineering approach you can take to mitigate the effect.
2. How appropriate would this sensor be for the robotic surgery application? Explain your answer.