Thesis Project Portfolio

Wearable Technology: Developing a Skin-Like Temperature Sensor

(Technical Report)

Analogical Reasoning Applied to Skin-Like Sensors: Meaningful Comparisons with Implications for Manufacturing and Security

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

(Executive Summary)

Investigating the Technical and Systemic Viability of Skin-Like Sensors in the Medical Industry

It isn't that they can't see the solution. It is that they can't see the problem.

- G. K. Chesterton, *The Scandal of Father Brown*, p. 128

My technical and STS topics are closely related, each focused on a different aspect of skin-like sensors. My technical research produced a skin-like temperature sensor, while my STS research developed a framework for understanding such sensors. Skin-like sensors show promise for increasing the efficiency of current healthcare systems, which has become increasingly important due to recent population trends around the world. Despite the apparent benefits of skin-like sensors themselves, however, no benefits are guaranteed. This becomes clear with a careful consideration of these sensors from a sociotechnical systems perspective. Within the systems in which these sensors are designed to act, several oppositional forces could arise, but sociotechnical systems thinking provides a means of predicting and addressing them preemptively. To foster such thinking, my STS research developed a new means of studying skin-like sensors through comparisons with existing technologies.

The technical portion of my research considered skin-like sensors from a purely functional perspective. My team developed a temperature sensor with two materials: polydimethylsiloxane (PDMS) and carbon nanotubes (CNTs). CNTs had first piqued my interest during my freshman year when I learned about them in one of my favorite classes, MSE 2090, so I was thrilled to be able to work with them before graduating. This experience did not disappoint, and we demonstrated the ability of a PDMS and CNT sensor to exhibit some of the requisite characteristics for use in medical applications. In addition to the technical efficacy of the sensor, the manufacturing methods required to produce it significantly affect its chances of commercial success. To address this significance, my technical research also evaluated two manufacturing processes. The first process utilized 3D printed molds to cast the PDMS substrates for the sensor, while the second process used a laser cutter to fashion the substrates from films of PDMS. Since skin-like sensors will never reach the market without efficient means of production, this evaluation was as critical as the design of the sensor itself.

To supplement these technical considerations, my STS research focused on studying skin-like sensors from a systemic perspective, as well as the challenges they could face and what can be done to increase the chances of their success. At the beginning of my research, the benefits of skin-like sensors seemed self-evident and their downsides appeared inconsequential, but as I attempted to consider them from perspectives other than my own, I came to realize that the issues surrounding them were not so settled. In order to study skin-like sensors effectively, I implemented an analogical method comparing them to cardiovascular pacemakers and COVID-19 vaccines. Each of these comparisons yielded unique insights into skin-like sensors, one from a technical perspective and another from a developmental perspective. Two of the primary insights my research produced are the necessity of data security within the sensors' networks and the importance of all sensors functioning properly upon their release to market. Both of these will be necessary to maintain consumers' trust and to achieve economic success. Of course, the economic success of skin-like sensors was never the goal of these projects. Rather, they were intended to produce knowledge.

To that end, these projects enriched one another. Together, they provided a real-world rehearsal of responsible product development and sociotechnical systems thinking that will be valuable throughout my career. Ultimately, engineering is concerned with problem solving, but few problems can be solved effectively by technology alone. Even good products can cause harm if they are integrated poorly into existing systems. As a result, careful consideration must be given to the systemic impacts of technical solutions before, during, and after their development. Not only do such considerations foster ethical development and effective implementation, but they often improve the technical solutions themselves. Rehearsing these things this year has given me a glimpse of what it means to practice engineering ethically. Over the next several years, I hope to practice it more fully and to expand that glimpse into a panoramic perspective.