Wearable Technology: Developing a Skin-Like Temperature Sensor

The Effectiveness of Apple CarPlay on Driver Safety

A Thesis Prospectus
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Within this prospectus, the impact of Apple CarPlay on distracted driving related crashes will be examined and the development and testing of an electronic skin (e-skin) temperature sensor will be discussed.

Ever since I can remember I have had an interest in cars. New or old, it did not matter, I was fascinated by their design and how they worked. Last summer I did an internship with the National Highway Traffic Safety Association. It was there that I was introduced to the world behind vehicle safety testing. It is not enough just to design a new vehicle, but there are also hundreds of hours poured into researching and designing ways to make them safer. Even before I got my driver's permit the importance of not texting and driving was stressed to me. My driver's education included an entire chapter discussing how using your phone while driving poses a danger to you and other drivers around you. When I got a new car a few years ago, it came included with Apple CarPlay, an interface that allows users to plug in their phone and display various applications while driving. This means that I could now text and make calls with the assistance of Siri, play any of my music, use navigation features for directions, as well as a variety of other applications. Since 2014, all major car manufacturers have begun offering CarPlay as a standard inclusion on vehicle models. Seeing this new technology increase in popularity, I was inspired to study how it may affect the number of distracted driving related crashes. The National Highway Traffic Safety Association includes numerous attributes in their definition of distracted driving, some of which include adjusting the vehicle climate, eating or drinking, and cell phone use (*Distracted Driving 2019, n.d.).* In 2019, an estimated 28,000 people were injured in crashes involving cell phone use or other cell phone related activities (*Distracted Driving 2019, n.d.).*

For the technical project, I will consider the research and development of an electronic skin, e-skin, temperature sensor. Electronic skins are being developed and tested for a variety of different applications some of which includes sensing temperature, blood sugar level, pressure, and strain. A model will be created using SolidWorks software which will be 3D printed in order to create a mold. The mold will be filled with Polydimethylsiloxane (PDMS) and the channels of the PDMS will be filled with electrically conductive carbon nanotubes (CNTs). Our team will work together to research and decide on the best design of the sensor. Our design will then be printed and filled with PDMS and CNTs. The completed e-skin will then be tested to ensure it meets the appropriate specifications. The final stage will include directly mounting the sensor on human skin and monitoring the temperature associated with that area of the body.

Technical Topic

Electronic skins (e-skins) have been created and tested since the 1970s with the introduction of the first prosthetic hand with sensors(Hammock et al., 2013). Since then, scientists and engineers have attempted to develop an artificial skin that can mimic the mechanical properties of human skin. E-skins that have been recently developed can now measure a wide range of biophysical, biochemical, and environmental signals in order to analyze human performance as well as monitor overall health status(*Ray-ChemRev 2019 _sections 1-3_.Pdf*, n.d.).

This Capstone project team intends to create our own sensor capable of measuring the temperature experienced on any area of the human body. The sensor will be designed specifically to measure the temperature experienced on the inside of the upper arm, but can be placed anywhere on the human body. The sensor data can be used in a variety of different applications

including athletic training following an injury. Specific workouts can be tailored to the specifics of the athlete's injury, the sensor data can then be used to ensure further injury does not occur.

Background research has been completed by the entire team in order to determine the best structural design. After collaborating on the design, it was recreated as a computer-aided design using SolidWorks. The model created using SolidWorks will then be 3D printed in order to create a mold. On the advice of Professor Xu, polydimethylsiloxane (PDMS) will be used as the base of our sensor. In order to begin creating the sensor, the PDMS will be poured over the mold and allowed to fully dry. The tunnels within the dried PDMS will be filled with multiwalled carbon nanotubes (MWCNTs). After another full drying period, a final layer of PDMS will be poured in order to completely enclose the MWCNTs. The MWCNTs will be responsible for all electronic signals within the sensor and will be tested using an electrical meter. The team will complete more research in order to determine the best way to adhere the sensor to the skin. The final stage of testing will be attaching the sensor to skin and measuring the temperature read through the sensor with and without a hot plate.

STS Topic

Automobile manufacturers are always trying to integrate new and cutting edge technology with each new vehicle model released. The early 1970s saw a rise in compact cassette and CD players for increased on-demand music options (Laukkonen, 2021). The 1990s saw new under-the-hood technology such as adaptive cruise control and automatic emergency call services. The beginning of the 21st century saw technology such as USB connections and Bluetooth transceivers integrated, allowing for drivers to play their own music and make hands-free calls (Laukkonen, 2021). Now in 2021, many vehicles have touch screens containing Apple CarPlay and Android Auto. Some makers such as Tesla even allow drivers to stream

Netflix(Trovão, 2021). It is important to consider how these new additions affect drivers and their ability to safely operate a vehicle.

Distracted driving is defined as any and all activities that diverts attention from driving, this can include anything from talking or texting on a cell phone to eating and drinking. In 2019, distracted driving was determined to be the cause of 3,142 motor vehicle crashes (*Distracted Driving | NHTSA*, n.d.). Sending or reading a text can take a driver's eyes off the road for 5 seconds. While traveling at 55 mph, that can be equivalent to driving the length of an entire football field without looking. The National Highway Traffic Safety Association's 2016 Motor Vehicle Occupant Safety Survey (MVOSS) estimated that 33 percent of driver's tended to use handheld cell phones and 67 percent of driver's tended to use hands-free phones. In 2020, it is estimated that a total of 7.9 percent of drivers were using either a handheld or hands-free cell phone while driving(*Driver Electronic Device Use in 2020*, n.d.). The high level of distracted driving related crashes is an issue that is significant to the health of the general public.

A well known feature from the iPhone, Siri, is also integrated with Apple CarPlay. As most iPhone users know, Siri can be used for a variety of tasks such as texting, making calls, setting alarms and reminders, as well as numerous other features. Siri is defined as an Intelligent Personal Assistant (IPA) and is one example of a technological solution that offers the ability for hands-free phone interaction through a voice-controlled interface (Larsen et al., 2020). In most vehicles, Siri can be accessed using buttons integrated in the vehicle's steering wheel, allowing for drivers to use the technology without having to take their eyes off the road.

Driver distractions can be divided into four different categories: visual, cognitive, biomechanical, and auditory (Larsen et al., 2020). The integration of Siri in vehicles has the potential to decrease both biomechanical and visual distractions but, it also has the potential to

increase auditory distractions. This means that while users will no longer need to look at or hold their phones, the increased audio from Siri can still lead to drivers being distracted. Some studies have already been completed where the usability of Siri, or more broadly IPAs, while driving was looked at in a controlled environment.

Research Question and Methods

How has new hands free technology, such as Apple CarPlay, affected the level of driver distraction?

This thesis will follow the STS framework ideas of social construction of technology, or SCOT. Pinch and Bjinker pioneered the idea that technology does not determine human action, rather human action shapes said technology (Pinch, 1984). This framework will help me analyze how groups such as consumers, regulation enforcers, and vehicle producers are involved in the shaping of technology. Because the wants and needs of consumers are an important factor in product production, the next logical step for vehicle producers is to take these opinions into account when introducing new technology.

Hands free technologies, such as Apple CarPlay, are marketed with the goal of simplifying and streamlining the driving experience. Now the concept of users having an effect on the development of said technology needs to be taken into consideration. The way that government regulations can require these technologies in all new vehicles for safety reasons also needs to be examined. Completed studies will be used to look at the effectiveness of Apple CarPlay on minimizing the total number of drivers using handheld devices as well as minimizing the total distractions experienced while driving. Past government regulations for vehicle technology, such as seat belts and air bags, will be examined to determine if something similar can be expected for hands free technology. Within this thesis it is assumed that distracted driving

has an effect on the health of the entire public, making it an issue for both the government and drivers. A focus will be placed on the effectiveness of past hands free technology, such as bluetooth, and how that can be compared to technology such as Apple CarPlay.

Conclusion

The intended outcome of the technical project is to develop a working electronic skin temperature sensor. A special focus will be placed on making it as small as possible as well as ensuring it has similar characteristics to human skin. The team will work together on creating a mold using the computer-aided design software SolidWorks. Following the printing of the mold the sensor will be manufactured using PDMS and MWCNTs. After completing the sensor it will first be tested using an electrical meter and it will then be tested by applying it directly to human skin. New vehicle related technology, such as Apple CarPlay, is being constantly developed. It is important to recognize how the new technology affects the users. As we examine how hands free technology can lead to less distracted driving related crashes, we will also consider how manufacturers create products with that in mind. The research done for this social project will be used to determine whether or not drivers have the ability to influence the technology being placed in their vehicles.

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