

Infusion Pump Air Removal Device

STS Review of the Neuralink Company's Link Device

**A Thesis Prospectus Submitted to the**

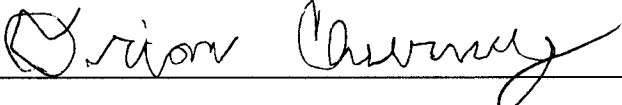
Faculty of the School of Engineering and Applied Science  
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In Partial Fulfillment of the Requirements of the Degree  
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On my honor as a University Student, I have neither given nor received  
unauthorized aid on this assignment as defined by the Honor Guidelines for  
Thesis-Related Assignments

Signature  Date 12/4/2020

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## **Introduction**

My group for my technical topic in Electrical Engineering has created a project that is an automated IV Pump device that works to remove bubbles inside of an IV line so nurses wouldn't have to go to the IV and do it themselves. This device could have some problems with regard to government approval of the device, as there would be problems regarding safety for the patient.

My STS prospectus is a look into the company "Neuralink" and its device, called the "Link", which is a Brain-Computer Interface that, at first, is going to be for medical uses in the case of people who have spinal cord injuries so they can connect to a computer which will help them communicate and control computers.

The technical subject of the STS prospectus and the technical topic for the Dept. of Electrical and Computing Engineering are not related.

## **Technical Topic**

### **Problem Framing**

The overall reason for having a device that removes air bubbles is that if there are air bubbles on an IV Line, they could get into the bloodstream and cause heart problems. Normally, there is a system that sounds an alarm if a bubble is detected in the IV-Line. After the alarm goes off, one way of removing bubbles would be for a nurse having to go to the line and 'flick' the line until the bubbles are dissipated.

With regards to similar devices, my group found that there aren't very many devices that can help with removing bubbles from IV Lines. With this device my group is working on, they will help make these types of devices more widespread.

### **Design Principles**

With my group's technical topic about IV Pumps and removing air bubbles in the IV Line, we decided that the best way to remove the bubbles would be to have a set of vibrating motors to shake the line, starting from the lowest motor to ones higher on the IV Line. The way the bubbles are detected is through an alarm that goes off on the IV line if it detects bubbles in the line, so we used a microphone to detect if the bubbles were present.

### **Design Procedure**

The base of this device is a MSP 432, which is a type of small computer that is connected to a circuit board my group designed, which connects the microphone and the motor system to the MSP.

With regards to the circuit board, my group split up the circuit board into different subsystems in order for the device to detect audio and make the signal be readable to the MSP.

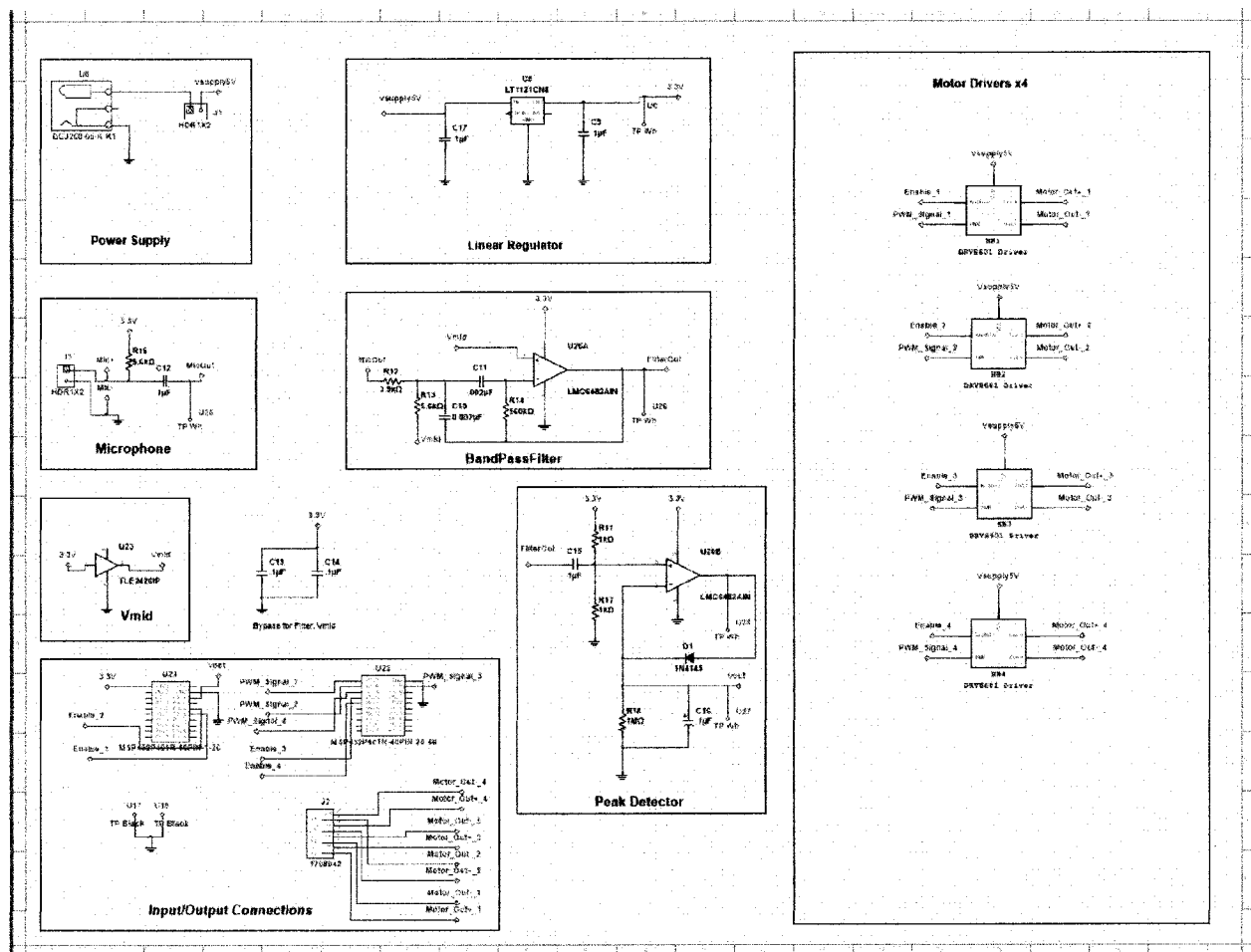
We also worked on the programming for the MSP 432 to create a system that works alongside the circuit board we developed.

After the board was designed, we got the board ready and started to test parts of it. Our board had to have some slight changes, so we had to work with the one we had in order to make the final board work correctly without having to rewire it.

To test the board, we first tested the circuit board without using the MSP 432, to make it easier to tell if it's a part of the circuit board or if it's a part of the programming we ran off of the MSP. We first tested the power sources, then the microphone subsystem, the amplifier, the filter, the peak detector, and then each of the motor drivers.

We are currently still working on testing the circuit board and testing it, as of this report's date.

This next diagram is the overall layout for the circuit board that my group worked on. It has a variety of systems that work together to hear the sound, and also to manipulate the signals so they can be easily used by the MSP432.



## Deliverables

For the overall device, we will have an enclosure to surround the MSP 432 and the circuit board we designed. This should be connected to the IV Line with the motors attached to the line as well as the speaker close enough to detect the noises and move the motors when needed.

## STS Prospectus

### Introduction

My research topic is based off of the “Neuralink” company, run by Elon Musk, and its Brain-Computer Interface device called the “Link”. This device is similar to other devices, although this device was marketed as an improvement. The overall device is currently being developed for medical uses, but Elon Musk wants the device in the future to be for general use. This device is an improvement over previous devices in the amount of connections between the brain and the device. Elon Musk has a goal in the future for letting people without medical issues use the Link device, with the goal of connecting people’s brain and mind further to computers, and to eventually merge humans and Artificial Intelligence.

For my literature review, I looked at a variety of articles on what people’s opinions are on the device itself. The device overall seems that it is a step in the right direction for helping patients, but there are a variety of social issues and concerns about the device as a whole.

The main focus for the Neuralink company right now is working with medical patients who have problems moving. The device would help them communicate by using their mind to control a computer.

The social groups that this company interacts with are going to affect how the device is used and implanted, in the sense that for the government regulators, they have to work with the company to make sure it is useful and not harmful to patients. There are also the medical researchers, who have to be worked with to test the device, as well as the patients themselves, as they are the ones that use the technology directly.

To compare to another device, I will look at another Brain-Computer Interface type of device; one that doesn’t involve directly connecting a brain with a computer. This device is specifically a computer game to help children with ADHD. The device is called “EndeavorRX” and essentially is a tool to help with improving their attention.

Science, Technology, and Society (STS) researchers are researchers that work with pieces of technology and see how they interact with social groups and the interplay of society with the device. In this paper, I will use a tool called ‘SCOT’, which stands for “Social Construction of Technology”. This device focuses on the interplay between technology and various social groups. Specifically, it looks at each main social group and the ways the technology affects them, along with the way they affect how the technology is used or developed.

## **Research Question**

My research question is: How will the Neuralink company and its technology affect the users of the device, and what is the interplay between the device and the groups that are affected by it?

## **Literature Review**

Elon Musk's first paper on the Neuralink device was first in a paper in October 2019. There are other papers that people have written about the device, and it's potential benefits or drawbacks that would occur with a device this complex, some of which are privacy issues.

The first paper that was written by Elon Musk (2019) was about a Brain-Computer Interface device that would directly connect a human's mind to a computer. This device could be useful for helping patients who have trouble communicating, or with trouble with a variety of medical problems. This device has been fairly influential because of the advancement of the device, which has a large amount of connections between the brain and the device, which allows for more uses for the device. There are some downsides to this device that people have brought up, such as privacy issues. The device that they had created uses a USB for testing this device. The devices that they will base off of this version will be implantable with wireless power and data transfer from beneath the skin, as the device will be implanted under the skin of the user.

Neuralink (2020) had a Youtube conference with Elon Musk showing their progress with the Neuralink project, with the goal of trying to get more researchers on the project. This device was one that was an improvement that their first prototype was leading toward, as it is fully underneath the skin. This device was implanted inside the brains of pigs, and showed some of the interaction between the brain and the device. Elon Musk also mentioned that the device will also have further uses for things connecting a brain to a computer. The company also gained the Breakthrough Devices Designation from the FDA that is given to medical devices that are for devices that provide for more effective treatment for diseases or conditions.

Straiton, J. (2020) mentioned that Elon Musk had a wish of merging humans and Artificial Intelligence. There are a variety of reasons why that might be problematic, as the devices are invasive, and access to people's thoughts, moods, and motivations could lead to human rights problems. But on the other hand, it can help plenty of people medically, and also can start a new way for people to interact with technology.

Fourneret, É. (2020) detailed the Neuralink Project's relation to transhumanism - which is the integration of the human mind with computer devices, allowing for the human mind to do more,

and Elon Musk envisions the fusion of humans and AI. This paper details three issues that might have been looked over. The first is that Neuralink is a startup company, not a medical company. There is also a difference between having the device work with patients on one side, while also having the eventual goal of enhancing a brain that doesn't have a medical need. The article goes on to detail the question of what the reasoning was to mention the goal of enhancing a brain, and also gave an idea that it was a marketing strategy for the company, to support the medical research, and partially because of Musk's ego. The next issue is if the project is realistic or not. To fuse a human mind and an AI would need more research on the topic, as that technology hasn't been developed yet. There is also the question on if there is enough research in the field to create the link between humans and AI. The last issue is that it is difficult to anticipate future technological development. The article mentions the idea of "flying cars" that would show up in the future, that ended up not showing up. There's also a problem with learning about the problems if devices such as these were commonplace, as there wouldn't be a way to learn about the problems unless the devices were widespread.

O'Brien, J. (2020) mention some of the problems with the merging of AI and human brains, as is one of the goals with BCIs in the future. This would specifically be for cognitive enhancement as well as rapid transfer of information from people and computers. Some of the problems include data security as well as things that could cause physical harm or influence the behavior of people.

Pisarchik, A. (2019) mentions that the device could have some benefits with the advancement of the technology compared to previous devices, as the Link could have some benefits with the amount of connections between the device allowing for more access to parts of the brain below the surface.

Valle, G. (2019) shows some benefits to the Neuralink device, specifically the density of the connections between the brain and the device, as well as the ability for the brain to receive signals from the device bidirectionally, instead of having it just go one way from the brain to the device. This is needed if there is to be better control between the brain and the device, as it is easier for people to use the interface if they have signals going both ways.

Maynard, A. (2019) details some of the ethical issues that the device carries, even though devices similar to this will have the potential in helping medical patients. Some of the ethical issues mentioned were issues on if the brain implant would be in a subscription-style device, or if the device would be owned by the company developing it. These types of issues are important if the device is to be helpful for patients and other people.

Lewis, T (2020) mentions that the device has been based on decades of previous research on the topic of BCIs. However, the company has been putting significant resources into developing this device. According to the paper, the notable change is the insertion of electrodes into the patient's brain. There are also a number of improvements that need to be done to put everything on a small coin-sized device.

Naufel, S. (2020) has a survey of Brain-Computer Interface researchers asking whether or not the research participants should have access to the data that they gave to the researchers - and most of them felt they should have access to the data, but not the ability to donate or sell the research.

Zhao, W. (2020) interviews Professor Bin He, the department head of Biomedical Engineering in Carnegie Mellon University with non-invasive Brain Computer Interfaces that connect the brain to a computer without having to have something surgically implanted into the user's brain. Compared to invasive BCIs like the Neuralink project, the non-invasive devices don't have nearly as much as invasive devices. The professor, when asked about the Neuralink technology, he thinks that, if the news reports are accurate, that it's a step in the right direction, but he also thinks that non-invasive procedures have more possibilities than invasive type devices.

Zhang, X. (2020) details some of the ways that BCIs are set to develop in the near future. They also mention BCIs like cochlear implants, which enables people with hearing loss to hear again using a medical device. There are also other implementations such as patients with paralysis, speech synthesizers, and optical usage. These types of implementations are research questions for the future, as they need to integrate AI with the BCI in order to do some of the processing that would be needed for the devices to accurately work alongside the brain. Some of the BCIs are most likely going to be expensive, which has problems with affordability. There are also problems with brain information in that there might be ways to infer what a patient does with their mind. Overall, BCIs need to be developed more if they want to have more data on the usage of these devices.

Nield, D (2020) gives an overview of the "EndeavorRX" device and how it can help young children with ADHD to improve their attention. This is an example of a non-invasive BCI, in that it is a way to connect a brain to a computer so the brain can learn how to do things alongside a computer.

## **STS Framework and Method**

The conceptual tool used in this paper is SCOT, which will help with looking at social groups that are affected by this device, and how they might impact its development in the future.

SCOT stands for "Social Construction of Technology". This is a framework that looks at a piece of technology and looks at the interaction between the developers of the device, as well as the users of the device. This allows a researcher to look at the entire picture of how a device is going to affect the general population, as well as how the device interacts with the users, like how their opinions on the piece of technology affect further work that the developers will put out after having reviews from public opinion as well as opinions from other professionals.

As SCOT looks at the interplay from a variety of groups in the development of a piece of technology, there are many ways in which a given device will affect what people think of it, and



their reviews of the device get told to other people, who then affect the creators of the device by them either purchasing or using the device if they like it, and not using the device if it is something that they don't like. If not enough people use the device, then that device will fall out of use, which wouldn't be useful for the creators of the device - so they would have to go and change the device if they still want to market it and have it be used by people.

The groups that affect the device are called Relevant Social Groups, or RSGs. These RSGs could be the creators of a device, or they could be one of many groups that are subsections of the groups that purchase the device, or governmental groups that have rules that need to be followed, or professionals in the field that will do research on the topic and see if the device is useful.

Alongside seeing the RSGs, SCOT also includes the way each RSG is affected by the device, which looks at the interplay of the device and the reasons social groups use the device. This is important because just having a list of social groups isn't enough information to see how the device affects them, as the device will affect each group in different ways depending on how they use it. They also use the device for different purposes, which end up affecting how the creators of the device market it.

Because there are different purposes for each group, they end up having to either group together based on their shared views on how the device is used, or they have to negotiate with each other on how the device could be changed, which then will affect how the device is further developed.

With regards to the Neuralink company and its device, there are some social groups that interact with the device and its development. One is the Neuralink company itself, as they create the device and have the main say in how it gets developed further. Another is the government regulators, who have to get involved with the device in order to make sure that it is safe to use on patients and other beings. Another group is the medical patients that could benefit from the device for medical reasons. There is also the health system, who need to make sure that the device is safe to use on patients as well as something that will be beneficial. Finally, there is the group of people who don't have a medical reason for the device, as one of Elon Musk's further goals is to use these devices on healthy patients.

The Neuralink company wants to create a device to create a bridge between people and computers through their minds. They are starting out with medical patients as there is a better reason to test the device if they have a medical reason, instead of doing testing on healthy patients who don't need a brain implant. The people they are starting out with are people who have trouble controlling their body, and the Link will help them communicate with a digital interface.

Another RSG are the government regulators that the company has to work with in order to test and use their device with. They would have to work with the overall restrictions to help develop the device further with connecting to the brain.

The group of patients that would benefit from the device are another RSG. This group looks like it would benefit the most from the device, as people with different kinds of medical problems have trouble with communicating. This device would allow them to control computers without directly having to use their body.

The healthcare professionals are the ones that would allow or prevent the patients from using the device, as they are the ones that work with the patients and are the ones that the company would have to work with in order to use the device on patients.

The last group I will be investigating is the group of healthy individuals that would use the device for non-medical reasons. This group includes people interested in connecting their brains to computers to become basically a 'cyborg' with the merging of technology and their minds. The Neuralink company has a further goal of working with this group, but they will have to work with patients first as if there isn't a reasonable goal to connect a brain to a computer, the government wouldn't probably let them test on people that don't need the device.

In order to develop the device, the Neuralink company needs to work with the other RSGs to develop their device further. They first need to generally make sure the device is safe to use in humans, and beneficial for patients who have medical problems. But in order to do so, they need to work with government regulators, medical groups, and patients themselves to test the basics of the device. The FDA gave the Neuralink company limited human testing via a Breakthrough Device designation, according to Elon Musk. That would allow the company to test the device on a small amount of people. However, this device wouldn't be able to be tested on healthy individuals until the FDA approves of doing so.

Overall, the Neuralink company needs to work with the other RSGs to develop the device further, if they want to go with the goal of merging human brains and computers. They also need to make sure the device is safe, in the long term as well. The other groups will end up helping decide how the company will develop this device in the future.

Another usage of SCOT is with the EndeavorRX device. This device has four RSGs. The first is the company that develops this device. The second is the FDA and other government agencies. The third are the doctors that prescribe the device. The fourth are the patients. The overall RSGs function similarly to the RSGs from the Neuralink company's RSGs.

## **Timeline**

For my research, I will look for a variety of academic sources, and will end up making a framework that allows me to see how people view the Neuralink company's device, and how the device will

end up being further developed. I will do some more research for a month or two, and then will work on synthesizing the information so that I can make an argument on how this device will be developed and how people will affect this device's success or failure. I will also work on writing the overall effect that this device will have on people in general, using the SCOT framework.

## **Conclusion**

My STS prospectus will have a qualitative summary of how people see the "Link" device and what their opinions on the device would be, and if it would be a beneficial device. I will also look at if the device will be something that can actually be used on healthy individuals.

This device will affect the general field of Brain Computer Interfaces as it is one that has a large amount of connections, as well as the small package that the coin-sized device has. My overall paper will be written about the interplay between users and creators of the Link device.

This device is a step toward both helping medical patients with their problems, as well as the goal of merging a human with an AI. But for the goal of merging with a computer, the device has to be tested on people who have medical problems first, as this device is currently being developed as a medical device because the needs of the patients are more important to work with, as they need its help to communicate and do things.

I will also do some research on other types of Brain Computer Interfaces, and their differences and similarities that could impact their usage in the future.

Overall, this device seems to be a step in the right direction for the idea of helping people using technology that interfaces with the brain, as well as for the goal of letting healthy people use the device further on.

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