**Automated Air Removal Device for Intravenous Infusion Pump**

**The Impact of Automated Technology on Healthcare Accessibility**

A Thesis Prospectus
In STS 4500

Presented to the School of engineering and applied science
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In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Electrical and Computer Engineering

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

## Introduction

Automated technology is a tool used to increase efficiency in a variety of industries, however, adoption in healthcare has been slower. In 2018, 8.5% of Americans, or 27.5 million people, did not have insurance (Bureau, n.d.). Hospitals can cover their care when necessary, but it strains the system, leading to medical errors and poor patient care. Automated technology offers a solution to increase efficiencies in the workforce so more patients can receive high quality care. The most widespread attempt at automation in healthcare is with Electronic Medical Records (EMRs). However, these systems have many problems which may decrease the healthcare system's inclination to adopt them. My technical project automates a common task carried out by nurses. It is an example of how technology could be used to free healthcare workers time so they can focus on patient care or see more patients. I will use the social construction of technology framework to explore the complexities of this issue. The central goal for my research project is to understand why automated technology is not currently widely used in healthcare and investigate its effect on accessibility to healthcare.

### Technical Project

*Background*

Intravenous (IV) lines are used on many patients in a hospital setting to dispense medications and fluids. Infusion pumps are used with them to control the flow of liquids being administered to patients and alert the users of any irregularities in the system. If air were to pass through a line into a patient's bloodstream, it could cause a potentially deadly venous embolism (Munson, 1993). Therefore, one common problem detected during an infusion is air in the IV line, which is detected by a photosensor within the infusion pump. When this happens, an alarm is activated, requiring a nurse to enter the room and manually manipulate the line to coerce the bubble toward the IV fluid bag. This current method to fix this simple error is problematic for a variety of reasons. First, it is a tedious job that adds to the already overwhelming list of tasks nurses have to carry out during their shifts. Second, this alarm has negative psychological and physical effects on patients and leads to alarm fatigue in healthcare workers (Simpson & Lyndon, 2019). It has been reported that between It increases anxiety in an already stressful situation and can go off at night or other times when the patient is trying to get sleep. The goal of our project is to automate the air removal process from an IV line to decrease the burden on healthcare workers and patients receiving fluids.

Two important burdens we are overcoming are the difficulty interfacing with the infusion pump and the regulations regarding silencing alarms. Because infusion pumps are extremely expensive, we are using what clinical engineering at UVA hospital lends to us. We are unable to directly interface with the circuitry or software on the infusion pump, so we are using audio detection to determine when the alarm goes off and then carry out the air removal action. This is problematic for two reasons. First, if it goes off for a reason other than air in line, the mechanical action will progress anyway. For the sake of the project this is ok because it has no negative effects on the system, it is just less ideal because it draws power and makes noise when unnecessary. The second burden is the FDA regulations regarding silencing alarms in a hospital setting. While alarm fatigue is a serious issue within healthcare that we had originally hoped to focus our project on, it may be unrealistic due to the overbearing nature of the regulations in place.

*Methods*

The project is divided into 3 subsystems based on the tasks carried out. One subsystem is purely responsible for interfacing with the infusion pump. Its primary task is to filter the alarm frequency to tell the device when air has been detected in the line. A second order butterworth filter allows only the alarm frequency (2.2kHz) to pass to a peak detector, which converts this signal into a DC voltage that the microcontroller can read. The next subsystem is a microcontroller that handles the software regarding how to relay the information from the infusion pump interface to carry out a mechanical action. Some specific tasks carried out by this subsystem are telling the interface to silence the alarm, allowing the mechanical action to progress for a specific amount of time, and controlling the specific vibration motors in order to optimize the ability for the device to remove the air. The third subsystem is a system of vibrating components, ideally in the form of cuffs around the IV line near the photosensor. The placement of the cuffs will be decided based on testing.

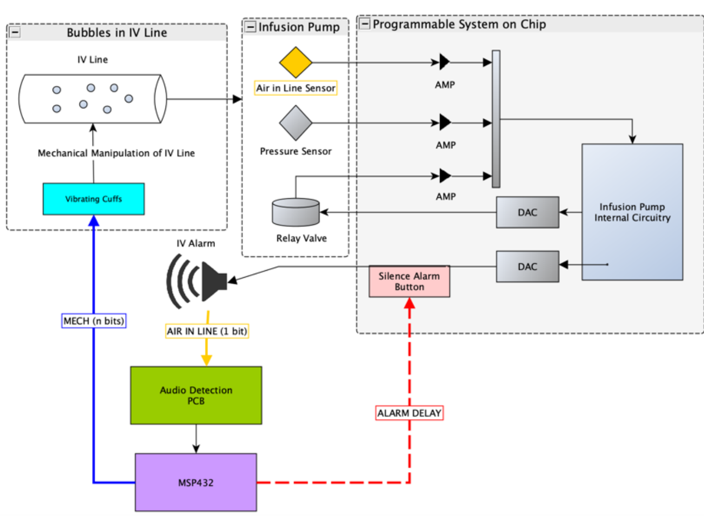

**Figure 1**: Diagram of Subsystem Interfaces and Infusion Pump (from capstone midterm review)

The overall system will be low intrusive and easy for healthcare workers to operate. The alarm will be silenced at most 1 time to decrease alarm fatigue while still allowing a nurse to monitor any problems with the system. We do not expect it to fix every instance of air in line being detected but rather hope to lessen the number of times the attention of a healthcare worker is required to fix the problem. All testing of the overall system will be carried out in clinical engineering at the hospital, while testing of the individual electrical components and subsystems will be carried out in NI lab at UVA engineering school.

**STS Research Topic**

*Problems regarding EMRs*

My overall topic is how automation can increase accessibility to healthcare. EMRs offer a great deal of insight into this question because their use is currently widespread in healthcare. While the goal of EMRs is to increase efficiency in the workplace, this is not always the case in practice. For one, EMR adoption by physicians has been contested due to lack of technical knowledge, decreased interaction with patients, increased time spent filling out records, and lack of integration into their workflow (Rose et al., 2005). Another major problem of EMRs is the lack of interoperability between services, which prevents providers that use different systems from being able to share information (Dodd, 2016). There is a severe lack of regulations and standards in place regarding interoperability, a sharp contrast from almost any comparable product on the market. The outdated user interfaces of EMRs can deter potential healthcare workers from entering the field. While there are standards laid out in Section 508 Standards for Electronic and Information Technology to ensure people facing disabilities can use software, these are generally not applied to medical software (Goldberg et al., 2011). Therefore, otherwise good doctors can be turned away from medicine simply because the technology does not meet their individual needs.

*Problems with accessibility to healthcare in the US*

The United States is unique with respect to how it delivers healthcare. While it leads the world in cutting edge technology, there are many problems regarding high costs, low quality of care, and shortages in the workforce. One problem preventing patients from being able to see doctors is the high cost of deductibles, copays, and out-of-pocket expenses in the US. As the system becomes increasingly complex and decentralized, the overhead costs increase and make access to medicine less possible for uninsured Americans (Council (US) et al., 2013). Another problem is the geographic spread of healthcare providers across the US. There are many people living in rural areas that do not have access to medical care because of distance (Comer, 2015). This problem is exacerbated for low income and disabled patients. Another problem is patient anxiety associated with healthcare, generally surrounding quality of care. For example, it is necessary for doctors and nurses to discuss sometimes embarrassing or stigmatized topics, such a mental health, sexual activity, obesity, or drug use. The sensitivity of subjects that doctors must bring up to obtain a complete patient history causes many Americans to exclude themselves from the healthcare system. Automated technology can offer a route for patients to get necessary medical care without shame or embarrassment associated with speaking to a doctor.

Accessibility to healthcare is vital for many ethical and practical reasons. In practical terms, a healthier population is more capable of working and supporting the economy. Allowing more patients access to healthcare has benefits to hospitals as well. If more insured patients are seen, the hospital brings in more money. Therefore, it is practical to increase efficiency and reduce bottlenecks preventing providers from being able to see as many patients as possible.

## *STS Framework: Social Construction of Technology*

To analyze how automated technology impacts the accessibility of healthcare, I will use the Social Construct of Technology (SCOT) Framework. Three key tenets of this framework will allow me to explore a variety of subject while still relating them to accessibility. First, by analyzing interpretive flexibility I can look into how these technologies benefit some while excluding others, and certain trade-off that must be compromised. For example, I want to look into how, when designing systems, engineers must try to meet the personalization features that physicians want while still adding more detailed task-centric approaches necessary to automate the systems (Rose et al., 2005). A specific relevant example for this is an algorithm created to track infections within a hospital (Trick, 2013). The SCOT framework will also help me look into what relevant social groups are needed for the proper design and adoption of technologies. For example, while physicians are occasionally consulted when designing EMRs, patients rarely are, leading to patient portals that can be daunting and stressful (Goldberg et al., 2011). It will also be interesting to analyze the interaction between government regulations, physicians, and engineering systems in relation to trying to decrease alarm fatigue. Finally, using the problems and conflicts side of the SCOT framework will allow me to analyze problems different groups face and look into how different designs and automated projects can mitigate their specific problems. The primary example I want to use here is a case where an automated web application was used to help combat veterans, a group grossly underserved by the healthcare system, self-manage their PTSD and substance abuse (Possemato et al., 2015).

*Plan for the Thesis*

I will gather information in 3 primary ways. First, I will use papers and books to get information on current technologies and how past automated technologies were accepted or rejected. I have gathered a lot of information on how the certain design techniques carried out by engineers and requirements set by healthcare workers impact the success of the final products. This research will ideally give me data on if past technologies helped to mitigate inefficiencies in workflow, or how they exacerbated bottlenecks and hurt doctors and patients. Since there is not a lot of research done integrating technology and healthcare accessibility, I will collect some of my own data in 2 ways. First, I sent out a survey to a lot of doctors, nurses, and other people who use EMRs in their workplace. The two main questions are 1) do EMRs make your job more efficient and 2) do EMRs allow you to see more patients. I added another optional section on the survey to discuss grievances with the technology and talk about other automated tech used in their workforce and if it affects efficiency or number of patients seen. Next, I have three doctors with their own private practice in different geographic locations (Daytona Beach, Florida; Tallassee, Alabama; Missoula, Montana) and specialties (trauma surgery, Gastrointestinal medicine, Rheumatology) who I can interview to gain more detailed insight into how technology impacts overheads and efficiency at their practice.

**Conclusion**

Both my technical and STS topics focus on accessibility to healthcare. While my capstone project offers a physical solution to fix a common inefficiency, my STS topic explores the barriers that such automated technologies face to adoption and their effect on healthcare accessibility. With the SCOT framework, I will explore my two STS subtopics in more detail using published papers and books, bridging the discussions with data I will collect myself.

It is important to research the factors influencing accessibility to healthcare in order to make reasonable changes to the system that benefit both patients and providers. Automated technology has optimized workflow for many other industries. Once it is introduced and utilized correctly within healthcare, it could potentially better the patient experience, save lives, and lead to a healthier population.

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