Automated Air Removal in IV Lines
(Technical Paper)

Introduction of Artificial Intelligence in the Healthcare Industry

(STS Paper)

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Quinn Lewis
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Technical Project Team Members
Leah Bianchi
Manuel Alvarado
Orian Churney
Bradley Lund

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

Approved: ______________________________ Date: _________________

Harry Powell, Department of Computer Engineering

Approved: _________________________________ Date: _________________

Prof. S. Travis Elliott, Department of Data Science

Introduction

When discussing the future of our workforce, Automation and AI have become buzzwords among scientists as well as the general public. There has already been significant automation of tasks in industries like manufacturing, retail, and shipping. The current rate of technological advancement in automation and artificial intelligence poses a strong threat to greatly reduce the amount of human jobs needed in these industries. Although it is not discussed as much, some of the most profound effects of Artificial Intelligence will be in the medical field. Radiology is a prime example of technology's ability to perform a task better than human doctors. Many deep learning algorithms have been proven to diagnose diseases like breast cancer, lung cancer, and tuberculosis more accurately than doctors, and the expectation is that their accuracy will only improve as available test data increases. While it is unlikely that doctors will be entirely replaced as a profession in the near future, the automation of tasks in the medical field will potentially lead to a decreased demand for doctors.

For our technical project, we will develop a device that will automate a task done by nurses daily: removing air in an IV tube. My research paper will investigate the future of automation in the field of radiology. I will utilize Actor Network Theory to break down how Artificial Intelligence, doctors, and other factors currently come together to implement AI in radiology. I plan to broaden this case to other medical fields to demonstrate how AI should or might be implemented in the near future.

Technical Project

The goal of our technical project is to create a device that mechanically removes air from an IV line from vibration. Most patients in a hospital receive an IV during their stay and very often, an air bubble gets in the IV tube. This can be potentially dangerous if air enters the veins of a patient. An alarm sounds and a nurse comes in and attempts to remove the air by flicking and reversing the tube. If this does not work, the nurse will detach and re-prime the IV line. This process is problematic in two ways: first, this requires a nurse's attention and takes them away from other patients or other tasks. Second, the alarm is very loud and can be disturbing to the patient, especially when it goes off at all hours of the night. Irregular sleep can commonly cause hospital insomnia and distress over long hospital stays.

We have designed a device with two major subsystems which are controlled by a MSP432 microcontroller: audio detection and vibration motors. The input of the microcontroller is an audio detection circuit which will tell the microcontroller when the alarm is going off. It will do this by selectively listening to the frequency of the alarm using a bandpass filter. The MSP432 will be programmed through Code Composer Studio with C code to activate the vibration subsystem when the alarm is detected.

The microcontroller will use Pulse Width Modulation to activate the vibration motors, which will be arranged on cuffs on the IV tube. Starting with the bottommost cuff, the vibration motors will vibrate the tube, pushing the air bubble up back into the IV bag. When the bubbles return to the bag, the IV pump will deactivate the alarm, resulting in the microcontroller to stop powering the motors. We will use MultiSim and Ultiboard to design a PCB board that will act as our hardware. Our device will be powered by a wall outlet and therefore we have added a regulator to control input voltages. In addition, there will be a machine learning aspect to our software. Since the viscosity of the liquid in the tube will affect how much vibration power is needed, our device will be able to optimize the vibration by whichever level of viscosity is in the tube. The user will be allowed control this power by using the buttons on the MSP432.

We hope that our device will be a clever solution to a problem that affects so many nurses on a daily basis. In the future, our device would be integrated with the IV pump so it could detect the air-in-line flag without the alarm having to go off. This would allow us to delay the alarm until our mechanical action completes, saving nurses time and patients' comfort.

STS Research Topic

Introduction

One of Artificial Intelligence's most intriguing prospects is its ability to diagnose diseases by recognizing patterns that the human eye cannot see. Using computer vision and digital image processing, these algorithms can quantitatively diagnose what radiologists can only qualitatively compare with the human eye. In a 2019 Stanford competition, a start-up group's AI was able to more accurately diagnose lung disease than a team of Stanford radiologists (Pennic, 2019). Similarly, in 2020, Google established that their AI could detect breast cancer with greater accuracy than experts (McKinney, 2020). These examples are not outliers, as many similar companies have claimed and tested their algorithms to be more accurate than current clinical standards; however, these technologies are still a couple years to a decade from being used clinically, and there remains to be some skepticism about the phenomenon. The purpose of this research paper is to understand the factors encouraging and discouraging the implementation of AI in Radiology.

To better understand the process of AI being clinically accepted in Radiology, it is important to understand how these algorithms work. Most of these Deep Learning algorithms are Convolution Neural Networks (CNNs). The CNN will take the complex images like MRIs and CT scans as inputs. It then assigns a value based on the intensity or brightness of each pixel. Using the mathematical process of Convolution, the software will begin to recognize which patterns show up on the positive tests. It will then adjust the weight or importance of every pixel for how indicative it is to a possible test. After summing all of these weights, it can output a prediction. These Neural Networks are named after the human brain because of their ability to learn as it sees more and more data. As the CNN is given more training data, its weights become more accurate and, therefore, its predictions become more accurate.

This representation of CNNs highlights how important training data is to the success of Artificial Intelligence. Lack of proper training data continues to be the primary obstacle stopping the improvement of these algorithms. While legislation like the 21st Century Cures Act has attempted to encourage the sharing of valuable image data, there are other factors making data particularly challenging (US Congress, 2016). First, for a CNN network to be trained to the level of accuracy necessary for medical standards, it needs a very large collection of these images. Classification of some rarer diseases may be impractical due to the scarcity of training data, even with abundant sharing and collaboration (Hosny, Parmar, Quackenbush, Schwartz, & Aerts , 2018). For this reason, the first implementation of CNNs in clinical setting will most likely for readily available tests like mammograms and CT scans. Second, noisy images and a lack of standardization of images leads to bad algorithms. Demand for experts to read these tests is also growing which will lead to a need for a more efficient solution.

Another factor in AI being implemented in clinical settings is the regulations set by the FDA and other groups. Even after getting FDA approval to be used clinically, gaining the "acceptance as recommended practice by experts, academic societies, or independent third-party organizations such as the US Preventive Services Task Force" requires a higher standard called "clinical utility" (Morra, Delsanto, & Correale, 2019). These groups must decide that Deep Learning Classifiers clearly provide better outcomes than the current methods. Whether outcomes are better depends on patient health, accuracy, and costs. While it seems likely that these systems will excel in terms of accuracy and cost efficiency, there may be other forces driving experts and academic societies to not welcome Artificial Intelligence into their fields. While the president of the Radiology Society of North America gave a positive outlook on the future of AI in Radiology, she did acknowledge the “fear that has caused anxiety within radiological societies” (Neri, de Souza, &Brady, 2019). This anxiety is understandable and it is worthwhile to look into resistance of AI of current radiologists.

Understanding how Artificial Intelligence is being implemented in Radiology can give us insight into how AI will be introduced in other medical fields. Analyzing the mistakes and challenges of this integration is important in guiding decisions. This paper plans to look at the STS factors involved in the implementation in order to inform the future professionals in the healthcare and Deep Learning industries.

STS Framework

I plan to use the Actor Network Theory (ANT) to investigate AI in Radiology. This is a perfect framework to understand this topic as ANT places a large emphasis on the role of non-human actors in systems. The algorithm itself, test data, and government medical regulations are all non-human factors essential in shaping the role of AI in medicine. The ANT framework allows us to evaluate all these components in an equitable way and, therefore, we can come to a better understanding of which factors are truly deterministic of the outcomes.

Methodology

Since there are no Deep Learning Radiology tests currently being done in a widespread clinical setting, I am going to focus my research on the different phases of getting to the clinical setting. I am going to look into two or three cases at different steps. First, I am going to talk about a test that is in development or a case study of a company that has developed this technology. This will lead to better understanding the factors affecting development. Next, I would like to focus on a proven technology that is awaiting approval by the FDA. Lastly, I am going to talk about a test with FDA approval like breast mammography which is in the process of being accepted by scholars and hospitals in a more widespread way. This will help us understand the social and non-social factors of implementation.

To conduct my research, I am going to heavily rely on scientific journals online for up-to-date information. Additionally, I have found some good books that describe certain aspects of the three stages I described above. Another very valuable resource I plan to consult is Professor Miaomiao Zhang. I took her class in Data Analysis last semester and now am taking Digital Image Processing with her. We cover the techniques described in this paper in class, and she is very well established in this field. I plan to consult her for the best resources to look into, and maybe interview her.

Conclusion

At the end of the semester, my group will have designed a proof of concept device for a way to automate a task done by nurses every day. We hope this can eventually be integrated into most IV pumps. Artificial Intelligence has begun to change the way we think about diagnosis and Radiology, but it has not changed the way clinical Radiology is performed yet. By looking at how deep learning and computer vision are being introduced in clinical medicine, we can make inferences about how further automation will happen in the medical field.

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