Autonomous Plant Nursery

High-Intensity Focused Ultrasound as a suitable replacement for X-Ray

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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General Research Problem: Non-Invasive Methods of Body Imaging

Can a replacement be found for x-rays to prevent radiation exposure?

As radiology has grown and developed, advancements have been seen at a much higher rate than in the 20th century. It is still a relatively young field of medicine. As time went on, side effects and issues developed and took root. Radiation exposure, which has become synonymous with radiology, is common in many methods of practice and has a negative impact on patients. The impacts are strong enough to prevent it from being more commonly used and must force the radiologist to carefully consider if it will be beneficial to the patient undergoing diagnostics. Despite this, there has been a surge in the use of higher radiation dosage tests in recent years. A wide variety of exams have come to be born under radiology, but all of them have grown to share the same risks. Multiple radiology exams emit radiation; however, it is not the only way doctors perform body imaging. Sonography is another field that allows for images of the interior of a patient to be constructed using sound frequencies. So, the question becomes, "Can radiology adopt the nearly risk-free methods of sonography, or should it be replaced outright?" It is imperative that this prospectus answers this question, as medicine must provide the safest and most effective care to its patients. This prospectus can contribute to discussions and decisions about improving the quality of services and outcomes. It will divulge the workings of ultrasound and its radiology counterparts. The limitations of each method need to be explored and compared. The main purpose and target of this research are to determine if one method is more effective than the other and if the continuously developing field of ultrasound could stand alone as the sole method. The X-ray will stand as the representative of radiology in this comparison, as it can be seen as the most well-known radiation-exhibiting method. The physics of ultrasound and x-ray must be discussed, as well as how they interact with the human body. This will allow us to fully understand their side effects and potential damages.

My Electrical and Computer Engineering Capstone team has not developed a system to solve the problem relating to my personal STS research, as it was developed independently. The Capstone was meant to solve another problem, the common neglect of household plants. Unlike pets, who provide some sort of feedback to reflect the quality of their care, plants do not, thus leaving the owner of plants to consistently need to remind themselves of the necessities of the plants they wish to care for. In the busy lives of the average person, plants have a 70% mortality rate. The Capstone is designed to assist the user in the care of plants with little interaction from the user.

Creating a garden that self-regulates (Technical)

Can we create a way for household plants to thrive with little human interaction?

My technical capstone project focused on giving consumers' household plants the ability to self-sustain. The autonomous plant nursery is an autonomous farming environment that will provide plants with all the moisture, light, and nutrients that each plot has been programmed to need. The idea for this project came to us when we saw a friend struggling to maintain a few of his plants and noticed this was a common occurrence amongst those who owned plants and lived busy, compact lives.

The idea for the project is a device that allows plant users to raise different plants simultaneously. Although we limit the scope of the project to just handling two plant pots for now, we have reason to believe it can be expanded to work on a greater number of plots and possibly provide some function in the agriculture industry. There are already a great number of systems like this out there, so at least there is a market for them; ours is a bit different with the ability for diversity. We plan to use multiple working components that are similar to what we have used in classes.

The design that was drawn up was that the nursery would provide water, light, and liquid nutrients, monitor the state of the plants, and be able to relay all this information to the user easily. To accomplish this, we would need some pumps to move the liquids to the plants, sensors for monitoring, bulbs, and a display so that the user can see the information. However, we would need a way for all these moving parts to be able to communicate with themselves so that their operations do not overlap, essentially a traffic conductor, a device to tell the pumps to move the liquids, turn on and off the lights, and collect the data from the sensor and display it in a way for the user to understand. The device chosen to perform this function for the system will be a microcontroller, specifically the MSP432. This device will communicate with every part, telling each one when to operate. Despite this, we noticed that the microcontroller would be too weak to continuously do its task. A PCB, or printed circuit board, was then constructed to provide the necessary amount of power to the MSP and prevent any electrical mess. The display was a simple LCD screen (liquid crystal display), and it could only show 4 rows of 20 characters, so what could be shown was limited. We chose a microcontroller to run the entire project since it can be programmed to run efficient software systems to perform its task, for example, the Finite State Machine (FSM) when developing thresholds for the moisture levels. A "finite state machine" is a term used in programming, mathematics, and other professions to describe a model of a system that has a specific number of conditional states of being. Inside an FSM, all states under consideration exist in a finite list, and the abstract machine can only handle one at a time. This approach allows for each input and output to be observed and tested. For an example of how we can implement this machine, we may want the device to water the plants at 10%, continuing until it gets to 30%. FSMs are perfect in this application because we could program a "begin watering" state at 10% and then go into a "standby" state at 30% or above. The device would periodically monitor the conditions of the plants; we scrapped our original idea of having two sensors and went with a chip that could measure impedance, essentially the electric flow in the soil. This was to avoid having the microcontroller have two components running at the same time, causing an overload. We had picked out two liquid pumps, running on 12 volts, to deliver water to the plants. To correctly implement this, we made MSP432 send specific signals, allowing each pump to be turned on and off individually. The PCB is designed to receive power from a wall outlet and convert it to the appropriate voltage to be used by the MSP432 LCD screen and lights. The system includes storage of some kind that holds a collection of information on the more common household plants since our design cannot hold an infinite amount of data. To work around this, we allowed for customization of that data if the user did not find the correct preserved settings for their specific plant. This had the added benefit of not being the same for all plants, which have different requirements. This information includes moisture for their soil, how much light there is, and levels of nutrients. For any settings the user would like to change, there will be buttons on the PCB that will manipulate what is on the LCD screen. This will allow the user to enter their parameters. Despite this, the capstone project was not made to solve the problem in the STS research. Despite the fact that the two are vastly different, they both tackle social issues. The Plant Nursery was designed to streamline the care of houseplants and provide a reason for more people to begin raising plants. My team had foreseen possible environmental impacts with our design, such as cleaner air and possibly easier access to produce since they can grow their own.

The Field of Radiology (STS):

Is there a need for multiple methods of radiology?

What Is High-Intensity Focused Ultrasound, or HIFU, and Could It Replace X-Rays? That is the question that I will work towards answering. The background for this question stems from the fact that replacing methods of radiology commonly used in hospitals will greatly impact how medical imaging procedures are done. Since X-rays and ultrasounds are among the most commonly used methods, making sure they provide the best results with minimal risks is the goal for any radiologist. The reason why medical institutions make sure their practices are up to standard is self-evident: they would not want a practice that is used to cure an ailment to accidentally create a new one. The persons involved, which include but are not limited to radiology technologists, are the ones performing the procedures and studying the techniques to pick the right method to be used in each specific scenario.

Framework (STS)

The multitude of options for imaging practices can be seen as a benefit for these specialists, as they provide a way to get the best diagnostics in case of unforeseen circumstances. So, if one method were to be seen as the best and replaced by the others, the radiology technologists would have no choice but to rely on said procedure despite its potential shortcomings. Hospital patients and those who undergo some sort of medical therapy are primarily the ones who will feel the changes in medical practices and patterns. If there were anything to change, it would have to be to their benefit. In defense of these multiple methods, having them ready on standby is due to the specific limitations of each one. Ultrasound is not best suited to look at and analyze bone structures. It can, but not to the proficiency of x-rays. So, getting rid of x-rays would remove a great tool that could provide clear and precise readings of the skeletal structure. However, that limitation is bound to certain ultrasounds that are used at the skin level, known as micro-focused ultrasound (MFU). HIFU penetrates much deeper and has evidence of reading tissue as well as solid bones, thus allowing ultrasounds to compete with X-rays on an even scale. The limitations of x-rays are not just that they emit radiation, but also that the radiation accumulates over time each time the patient is in front of the machine. In non-medical environments, such as airports' X-ray machines, regulations have put in place a hard limit on the exposure to members of the public; however, from the viewpoint of medical and dental needs for patients, there are no documented limits. The medical professional must then weigh the benefits against the risks; this introduces human error into an area that can have permanent damage in worst-case scenarios. This is the primary need for finding an alternative to radiology. With such a long history, there are bound to be some shared beliefs, some of which are not necessarily incorrect but simply a thought or knowledge shared by the majority. For example, it is well known that x-rays give forth radiation that can prove harmful to the subject if care is not practiced. This common knowledge is true and has led to the practice and habit of wearing lead chest plating. If X-rays were to become an obsolete practice, this norm would fall out of favor. There are technical papers that I would use to develop my idea.

Methods (STS)

The approach for answering and developing the question would be to bring in a wide range of perspectives from experts involved in the discussion of medical imaging. Evidence shows that replacing X-rays with HIFU is within the realm of possibility, but the investigation would still involve the views of the involved parties. Documentation on the operation of radiology and sonography would need to be collected, primarily from radiologists and sonographers in research hospitals as well as the manufacturers. Getting their insight into the workings of each technology could help us understand the risks and their particular uses. Since it is possible to replace X-rays with ultrasound, we now need to understand how they can be replaced. To do this, reports and statements from hospital administrators, regulations from safety officers, and government legislation can be useful. This will demonstrate why the push for HIFU is uncommon; the difficulties must be highlighted. Counterarguments may arise, and they should be considered, so any statements from radiologists as well as patients could broaden the view of the social impact of the transition. This analysis will give me an idea of where this technology may be best implemented and most beneficial from a social, organizational, and technical perspective.

Conclusion

I believe that my STS study has the potential to positively influence the disciplines of radiology and sonography. By outlining each side's advantages and drawing the appropriate comparisons, we can keep patients safe and receive better care. Despite their disconnection, two initiatives, STS and Capstone, will provide a better understanding of how technology may affect individuals, some on a daily basis. I will comprehend the parts of the medical sector that may need to be addressed, and I may learn what those adjustments are. I'll eventually gain a thorough understanding of the issues surrounding the environment, society, and ethics.

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