Undergraduate Thesis Prospectus

Quality Control in the Determination of Delineation Errors in Radiation Therapy

(technical research project in Biomedical Engineering)

Distrust of Vaccination in the United States

(sociotechnical research project)

by

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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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STS 4500 (3:30)

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Prospectus

General Research Problem

How can errors in the medical field be improved?

Head and neck cancer kills nearly 14,500 people in the US annually (NCI, 2020). Radiation Therapy (RT) is projected to save 3.38 million people in 2020 from cancer (NCI, 2020). Medical professionals create RT plans to optimize treatment so that the delineated, image segmented, tumor receives the highest dose. Delineations segment computerized tomography (CT) scans to identify organs and tumors. To reduce errors in patients' organ delineations, software can be developed to detect errors through knowledge-based quality control (KBQC). KBQC can be used to decide when a delineation is extreme by comparing the delineation of an organ to known quantities such as size or location. Reducing these errors can help medical professionals to create better RT plans.

According to the World Health Organization (WHO), vaccines prevent 2-3 million deaths every year, and global coverage could prevent 1.5 million more (*Immunization*, n.d.). However, some organizations believe that vaccines' side effects are worse than the infections they prevent. Success in efforts to control infectious disease will require not only vaccinations that are safe and effective, but also public trust.

Quality Control in the Determination of Delineation Errors in Radiation Therapy

How can the software for automated delineation for radiation therapy be improved?

My partner Ms. Chomicki and I are working with our advisors, Mumtaz H. Soomro and Jeffrey Siebers, on a biomedical engineering capstone project to create a pipeline for use in RT planning. RT planning starts with CT scans which are used to make delineations that inform medical professionals where to apply and where to avoid radiation. The problem is many delineations are performed manually which is irreproducible at the millimeter level leading to a lack of consistency and allows for easy to detect contouring errors. For example, Lo et al. (2014) found that 23 percent of treatment plans submitted for multi-center peer-reviewed lung stereotactic radiation therapy study contained easy to detect major contour errors. These major errors alter the planned dose distribution potentially leading to more radiation dosage to Organs at Risk (OARs) than if the delineation were accurate. Increased radiation amount to organs can lead to more damage. Therefore, the pipeline aims to reduce gross delineation errors and determine the priority of delineated OARs potentially improving the RT planning process.

Currently, there are software that aid in radiation therapy planning, examples include Econtour and Therapanacea. The purpose of Econtour is to teach people how to improve conformance to a standard for manual delineation. Specifically, the program is focused on creating and visualizing delineations (Econtour, 2020). Another program created by Therapanacea performs delineations. This program can do a full-body delineation in two minutes and saves up to 90 percent of the time spent on contouring (Therapanacea, n.d.). While both programs improve delineation neither address the errors in delineations. This is where our project will improve the existing methods.

To improve error determination and efficiency in RT planning our pipeline will use knowledge-based quality control (KBQC) and determine if an organ is high or low priority. KBQC will be used to decide if a gross error has been made. A gross error will be determined by

comparing the measurements of the delineated organs to known distributions of parameters from historical priors such as size and location. If gross error is identified then the delineations will be remade and checked again. This way, when dose estimation is performed, it will be more accurate due to the correct determinations of each OAR. The second objective is to use dose estimation to determine if an organ is low or high priority based on the amount of radiation it receives. If an organ is exposed to more radiation than it can handle, then it is a high priority, which needs to be check by a medical professional. In contrast, if an organ is receiving minimal radiation then the organ is taking almost no damage so it does not need to be checked by a medical professional. Determining high and low priority effectively will reduce the time medical professionals will need to check the delineations. This will make RT planning more efficient. If these objectives are accomplished then errors, like the one Lo et al. (2014) describe, will diminish substantially. Both increasing patient health and reducing the side effects of RT.

Distrust of Vaccination in the United States

In the U.S. since 2000, how have social groups that distrust vaccines advanced their agendas?

Vaccines can be highly beneficial as they help to prevent harmful diseases. However, there has been an increasing mistrust of the benefits of vaccines as many groups argue that some substances in vaccines can cause detrimental effects such as autism and bowel disease. Furthermore, contradicting studies confuse the public and contribute to the spread of misinformation. Understanding anti-vaccination groups' motivations and rationales can help to better inform citizens on vaccines.

The motivation for many anti-vaccination groups stemmed from research by Wakefield et al. published in *The Lancet* in 1998. The researchers alleged that the measles, mumps, and

rubella (MMR) vaccine could cause autism and bowel disease (Wakefield et al., 1998). The autism link was particularly alarming; by 2002, 20-25 percent of Americans believed that the MMR vaccine causes autism (Lewandowsky et al., 2012). Many parents refused to vaccinate their children. In 2010 *The Lancet* retracted the study on grounds of falsified data and other improprieties (GIS, n.d.). In follow-up studies, researchers found no link between the MMR vaccine and autism or bowel disease (Buie et al., 2010), yet misinformation spread by the Wakefield article has continued to deter vaccination.

Many parents use Vaccine Adverse Event Reporting System (VAERS), a voluntary database for adverse reactions to vaccines, to better understand the frequency of side effects and sometimes conclude that vaccines are too risky (Healthline, n.d.). However, because VAERS is voluntary, there are invalid causal claims. For example, when a girl died after receiving the human papillomavirus vaccine, the case was recorded in VAERS (Healthline, n.d.). However, the girl was actually killed by a car crash (Healthline, n.d.). Some distrust of vaccinations is not ideological. Parents may simply be confused by the quantity and variety of information. According to Dr. Peter Hotez, "Most parents" are "just scared and inundated with misinformation" (TMC, 2019).

Through negativity bias, undesirable but extremely rare events, including adverse vaccination reactions, may draw undue attention (Müller-Pinzler et al., 2019; Housset, 2019). Housset (2019) found that much anti-vaccination publicity invokes fear. According to Lee et al. (2016) parents who distrust government are 2.11 times more likely to trust alternative medicine over vaccines.

Some advocacies oppose vaccination on grounds of safety. The Informed Consent Action Network (ICAN) alleges that "fewer than one percent of vaccine adverse events are reported" to

VAERS and that the measles vaccine can cause cancer (ICAN, n.d.). ICAN also alleges that people who contract measles are less susceptible to lymphoma (Montella et al., 2006, n.p). Age of Autism, another advocacy, claims that in the rush to develop a Covid-19 vaccination, medical professionals are willing to "take more risks," and that the U.S. Food and Drug Administration (FDA) evaluates only short-term risks (Age of Autism, n.d.). Age of Autism has also alleged an association between vaccination and ADHD (Age of Autism, n.d.). Physicians for Informed Consent (PIC) claims that though 22 aluminum-containing vaccines are recommended for children, FDA and the Agency for Toxic Substances and Disease Registry have found evidence that aluminum exposure can cause nerve damage that impairs motor skills and damage the nervous system (PIC, n.d.).

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