Three-Dimensional Modeling of Lung Volume in Applications to Scoliosis

(Technical Paper)

Impact of Implicit Bias on Healthcare Outcomes for Women of Color in The United States

(STS Paper)

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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

The Influence of Social Groups on Reactions to Plastic Waste Reduction Campaigns

Introduction

Scientists agree that global warming is the chief climate risk in the next century ("Global Warming Timeline," 2013). Global climate change has already had observable effects on the environment. These effects include loss of sea ice, accelerated sea level rise, and longer intense heat waves (Jackson, 2019). Even with these obvious effects, climate change remains a controversial topic. In a 2019 survey conducted by the Yale Program on Climate Change Communication, 69 percent of American now say they are "somewhat worried" about global warming and 20 percent described themselves as "very worried," an 8-percentage point increase over last March and the highest level since the surveys began in 2008 ("Climate Change in the American Mind," 2018). However, only five percent of Americans said that "humans can and will successfully reduce global warming." The results of this survey show that most Americans don't feel empowered to tackle climate change. Additionally, most Americans don't realize the impact of plastic waste on climate change ("Plastic waste and climate change—What's the connection?," 2018). Democratic and Republicans social groups in the United States influence government policy on plastic waste reduction. The STS project aims to examine how membership in these social groups affects reactions towards plastic waste reduction campaigns in the United States.

The second project in this portfolio aims to model lung volume in patients with idiopathic scoliosis. Idiopathic scoliosis is an abnormal curvature of the spine that can cause visible deformity, emotional distress, back pain, and respiratory impairment (Konieczny, Senyurt, & Krauspe, 2013). To correct spine curvature and allow proper development of the chest wall, the main approach is a surgical procedure called "spinal fusion" that fuses the vertebrae to prevent further curvature of the spine and correct deformity (Kaas, 2013). The fusion of the spine's

vertebrae into a single, solid bone stunts the growth of lungs in growing children (Dimeglio & Canavese, 2012). For children with scoliosis that are in an intermediate age range in which they may have developed enough lung volume to have sufficient pulmonary function after spinal fusion, it is necessary to know the stage of lung development that the children have reached. Currently, total lung capacity (TLC) is measured through computed tomography (CT) scans (Tsiligiannis & Grivas, 2012). CT scan machines use 100 to 500 times more radiation than conventional X-ray machines ("How CT Scans Have Raised Kids' Risk for Future Cancer," 2013). Thus, there is a need for a method of gathering accurate TLC measurements from children with scoliosis without radiative effects so that physicians may determine the safest, and most effective, plan of treatment for these patients. The technical project aims to develop a method to calculate lung volume from X-ray scans. The two projects included in this prospectus are unique from each other and offer a diverse perspective on engineering education.

Technical Topic

Adolescent scoliosis affects approximately seven to nine million people in the United States (Haas, Hamm, & Niehues, 2014). This disease has complex effects on the anatomy of the chest, and consequently, can negatively affect pulmonary function. The most severe cases of scoliosis cause a reduction in total lung capacity (Grivas et. al, 2012). A surgical procedure called "spinal fusion" will significantly straighten the curve and fuse the vertebrae so they heal into a single, solid bone. This fusion is a problem for children with severe scoliosis because final fusion can limit their lung growth and lead to pulmonary paralysis and even death (Karol et. al, 2011). For children who are too young for final fusion, there is an alternative procedure called the MAGEC (MAGnetic Expansion Control) Spinal Growing Rod that allows the spine to continue growing until the child is old enough for spinal fusion ("Magnetically Controlled Spinal

Growing Rod—Conditions and Treatments | Children's National," 2015). Currently, the main metric used to determine whether a child receives spinal fusion or MAGEC surgery is age. This metric is used due to the assumption that age is a measure of lung volume and capacity. Lung volume cannot be measured from X-ray scans (Karol, 2011). While CT scans are a good tool for measuring lung volume, they have 100-500 times more radiation than conventional X-ray scans.

The goal of this project is to allow physicians to measure lung volume based on X-ray scans. To this end, the technical project aims to develop a user-friendly computational framework to enable lung volume calculation from X-ray images. A computational framework will be used on X-ray image sets to evaluate the accuracy of the computational model and reveal trends between spine curvature and lung volume. To accurately measure lung volume from X-ray scans, a novel algorithm will be developed to identify and calculate the mediastinal volume from CT scans of pediatric patients. This data will be used to determine a mediastinal volume constant for patients of varying age, sex, height, and weight. The constant allows the model to determine thoracic cavity boundaries and volume by identifying the ribs and spine on X-rays of the same patients. Subtracting mediastinum constant from thoracic cavity volume will be used to calculate lung volume. Lastly, a convolutional neural network will be constructed to automate mediastinal volume calculations and ribs and spine identification. The accuracy of automated calculations will be verified by comparing automated values with manual measurements of lung volume using computerized tomography (CT) scans. These aims will be implemented by developing and executing segmentation methodologies in MATLAB. Mediastinal constants will be generated for a wide range of patient demographics by manually establishing mediastinum boundaries in CT scans. Thoracic cavity boundaries will also be determined by manually identifying the ribs and spine in X-rays.

The result of this technical project will alleviate the problem of exposing children to unnecessary radiation from CT scans. Additionally, this method will provide a more accurate metric, compared to age, for determining when to perform spinal fusion surgery on children with scoliosis.

STS Topic

United States is the number one exporter of plastic scrap despite many efforts to reduce plastic waste production in the U.S. ("OEC - Scrap Plastic HS92," 2019). Six-times more plastic waste is burned in the U.S. than is recycled (Dell, 2019). Since 1950, the plastic waste recycling rate has remained constant at 9% globally ("A whopping 91% of plastic isn't recycled," 2018). Even worse, recycling rates are decreasing in the United States. In a report published by the United State Environmental Protection Agency (USEPA), recycling rates have decreased from 9.1% in 2015 to 4.4% in 2018. Researchers have studied social influences on people's opinions regarding climate change and political affiliation is amongst the top differentiating factors. In 1997, nearly equal numbers of Democrats and Republicans said that the effects of global warming have already begun. Ten years later, the gap was 34%: 76% of Democrats said the effects had already begun, and only 42% of Republicans agreed (Kamarck, 2019). Even as more evidence of global warming emerges, republican voters' concern about climate change keeps on falling. Share of GOP voters who are concerned about the issue has fallen to 44%, from 57% in September 2018 (*National Tracking Poll 180824*, 2018). The disconnect between the scientific consensus on climate change and voter opinions reveals a discrepancy that demands further attention.

Plastic waste reduction is a large and convoluted system with many key stakeholders and artifacts involved. Stakeholders include climate change activists, environmental scientists,

policymakers, producers of plastic goods, politicians, and consumers of plastic goods. Politicians play a major role in determining people's attitudes towards plastic waste reduction campaigns. In tweets, President Donald Trump blamed California's fires on water restrictions, while Interior Secretary Ryan Zinke told Breitbart News that "environmental terrorist groups" are responsible for blocking active forest management practices. In a 2018 survey conducted by the Morning Consult (*National Tracking Poll 180824*, 2018), 61 percent of all survey responders said that climate change contributed to the California wildfires, but broken down by party, only 39 percent of Republicans (compared to 79 percent of Democrats) agreed with that statement. This shows that political party affiliation has a significant impact on people's views towards the effects and importance of climate change. The artifacts involved in this topic can be physical or non-physical. Physical artifacts include plastic-replacement tools, such as metal straws or reusable shopping bags, whereas nonphysical artifacts include social media campaigns, climate change educational material and policies passed regarding climate change.

These stakeholders, artifacts, and social groups will be analyzed under the Social Construction of Technology (SCOT) framework to determine the effect of social group membership on people's reactions towards plastic waste reduction campaigns in the United States. SCOT argues that technology does not determine human actions but rather human action determines technology (Bijker, 1995). SCOT holds that those who seek to understand the reason for acceptance or rejection of technology should look to the norms of the society that is using the technology. In particular, they must ask who defines the technical criteria success is measured by and why technical criteria are defined this way. A key part of SCOT is relevant social groups which include: users, producers, users with different abilities, and users who neither use or produce the technology, such as journalists, politicians, and civil organizers. Landon Winner

published a critique of SCOT in 2003 called "Upon opening the black box and finding it empty: social constructivism and the philosophy of technology." In this piece, he argues that SCOT is an overly narrow research program that explains how technology arises, but ignores the consequences of technologies after the fact. Winner also states that SCOT ignores social groups with no voice in the process, yet those who are still affected by it (Winner, 2003). This critique is important to the subject of this project because many social groups with no voice in legislation are affected by climate change policies and plastic waste.

Under this framework, the technologies in question are various methods of plastic waste reduction. The social groups examined will be democrats and republicans, however, to address Winner's criticism, there will be an exploration of how people with disabilities can be affected by plastic waste reduction technologies even though they don't have a voice in the adoption process. As scientific evidence about the causes of climate change has mounted and as a consensus has evolved in the scientific community, the public has remained divided and large, important parts of the political class have been indifferent. This divide creates a problem where social group membership, as opposed to science, can determine attitudes towards the plastic waste campaign.

Research Question and Methods

The STS question that this project aims to answer is "How do political social groups influence consumer's reactions towards plastic waste reduction campaigns in the United States?" This paper will utilize the STS framework of Social Construction of Technology to identify and analyze the relationships between the previously noted stakeholders, artifacts and social groups. The methodology used for this research will involve case studies, surveys, and documentary research methods. Additionally, a literature review of relevant STS topics will be conducted to

further characterize the relationships between the different groups and stakeholders involved in the climate crisis. Through examining national survey results, this project will characterize the effect of political party affiliation on attitudes towards climate change. Further, case studies of previous plastic waste reduction campaigns will be used to characterize the influence of social group membership on public opinion. After this relationship is established, historical timelines, relevant literature, and documentaries will be examined to understand how and why political affiliation can change people's reactions towards climate change and plastic waste.

Conclusion

For the technical project, the deliverable is to develop a computational framework to enable lung volume calculation from X-ray images. This will allow physicians to measure lung volume and make accurate decisions about final fusion surgery without exposing children to unnecessary radiation from CT scans. Collectively, the new tools developed will provide a unique approach in tackling the surgical treatment plan questions outlined in the technical project. This work will yield a novel technology that incorporates both computational modeling and machine learning, as well as providing insights into accurate and efficient measurements of total lung capacities in adolescent idiopathic scoliosis patients. Furthermore, the proposed work is expected to create a safer and more cost-effective identification of TLC by limiting patient exposure to radiation by eliminating the need for CT scans.

The STS deliverable is to determine how social group membership, specifically political affiliation, affects reactions towards plastic waste reduction campaigns. This information can be used to improve future efforts for reducing plastic waste. In the end, climate change and global warming should not be partisan issues and this project aims to explore why it currently is and how that can be mediated.

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