Prospectus

# Three-Dimensional Modeling of Lung Volumes in Scoliosis
(Technical Topic)

# Pesticide Use in the Agriculture Industry and Immigrant Field Workers: A Case Study of Technological Politics
(STS Topic)

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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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**Introduction**

Scoliosis is a condition that affects 2-4%, or an estimated seven to nine million, of adolescents in the United States and has various detrimental health consequences including visible spine deformity, back pain, and emotional distress (Konieczny, Senyurt, & Krauspe, 2013). Scoliosis also constricts the chest wall and decreases lung compliance, leading to more serious complications like chronic respiratory impairment. Currently, the main approach to correct scoliosis and allow for proper development of the chest wall, is surgical in nature, and involves a procedure called spinal fusion; however, spinal fusion in young children who have not fully developed their chest wall, may result in stunted growth of the thorax, which ultimately stunts growth of the lungs and can lead to pulmonary paralysis later on the patient's life (Daniel Park, n.d.). Thus, to appropriately treat adolescent scoliosis, it is necessary to know the state of pulmonary function the child has developed in order to avoid performing a premature spinal fusion.

The technical solution to address this issue is to develop a computational framework to enable lung volume calculation based on X-ray images. In order for the technical project to succeed, it is also important to understand the ways in which technical artifacts have the ability to express and shape relations of power. To explore this idea, I will examine the use of pesticides in the agricultural industry, a technology that has further empowered large agricultural corporations while continuing to marginalize underpaid field workers and their communities.

Chemical pesticides were developed after World War II and were introduced to increase productivity and quality of food by controlling insects, plant pathogens, and weeds; however, human exposure to pesticides has adverse health consequences including seizures, infertility,

cancer, and skin conditions.(Nicolopoulou-Stamati, Maipas, Kotampasi, Stamatis, & Hens, 2016) Field workers are especially vulnerable to being exposed to pesticides, with an estimated 30-90% of adults in farm worker families having detectable levels of organophosphate pesticides in their urine (Grzywacz et al., 2010). In California, the leading state in pesticide use, ninety percent of field workers are immigrants, and over half are undocumented ("CDC - Agricultural Safety," 2019). A combination of long hours of labor that overexposes the workers to toxic pesticides and a poor socioeconomic position makes this group particularly predisposed to poor health, which further marginalizes them as a community while empowering large agricultural corporations.

It is not possible to separate the social and political aspects from the technical; thus, to complement the technical solution, I will use Langdon Winner's Theory of Technological Politics to elucidate the ways in which technologies like pesticides both privilege and empower certain groups over others.

**Technical Problem**

Scoliosis can be classified as either congenital, neuromuscular, or idiopathic, of which, idiopathic cases account for 85% of all diagnosed cases. Idiopathic scoliosis can be described as a spinal deformity that causes simultaneous curving and twisting of the spine (Genetics Home Reference, n.d.). Although a surgical spinal fusion will straighten the spine curve, it also fuses the vertebrae together, allowing the spine to heal into a single, solid bone, but also preventing further growth of the spine. This is a problem for young children undergoing final spinal fusion who have not yet developed their full lung capacity and, consequently, develop serious respiratory problems as a result of their stunted spine growth (Karol, 2011). A temporary alternative procedure is the MAGEC (MAGnetic Expansion Control) Spinal Growing Rod that is

surgically implanted into young children. This device is a magnetic rod attached to the spine that allows the spine to continue growing in a controlled manner by manual extension of the rod every six months (Philadelphia, 2016).

Currently, age is the main metric used to determine whether a child has enough lung volume to undergo spinal fusion or it is best to perform MAGEC treatment for a certain period of time, ultimately terminating in spinal fusion. Typically, age has been considered a good indicator of lung volume, however this is a precarious assumption since children differ in development based on a variety of both physiological and environmental factors. While computerized tomography (CT) scans are a good tool for measuring lung volume, they have 100-500 times more radiation than conventional X-ray scans, exposing young children to dangerously high radiation dosages (Chute, n.d.). Thus, there is a need for a method to calculate lung capacity and volume accurately without the use of potentially harmful technologies like CT scans. Therefore, the goal of this project is to develop a computational tool that will allow physicians to non-invasively measure lung volume based on X-ray scans.

To this end, the proposed technical solution is to develop and implement segmentation methodologies in MATLAB that will allow non-invasive thorax analysis. This will involve training and implementing a convolutional neural network to automate thoracic cavity volume calculations and ribs and spine identification from X-ray images. In addition, it will also involve determining a mediastinal volume constant for all patients based on various characteristics of a patient like age, sex, height, and weight. To validate and apply this computational framework, these automated values will be compared to measurements of lung volume using CT scans.

**STS Problem**

Bakersfield, California, is one of many productive agricultural cities in California. The most common crops produced in Bakersfield are grapes, citrus, almonds, carrots, alfalfa, cotton, and roses. In August, 2017, 167 field workers in Bakersfield were harvesting garlic when they were exposed to two highly toxic pesticides, Vapam and Vulcan. As a result, over ninety workers suffered skin abrasions and headaches, and two were transported by ambulance to receive hospital treatment. This incident was a part of various instances that year in Bakersfield where field workers were poisoned by exposure to pesticides (Sellen, n.d.). Over the last 80 years, pesticides have led to an increase in average corn yields by more than seven fold, and similarly, a fourfold increase in cotton yields (Fernandez-Cornejo et al., 2014). Heavy use of pesticides has put field workers in a state of continuous threat with pesticide exposure by direct exposure through application on crops or indirect exposure through dust or droplets in the air nearby agricultural farms, or contact with residues in crops and soil. Published research has linked occupational exposure to pesticides to limb-reduction birth defects, childhood leukemias, brain tumors, and adult lymphomas and lymphosarcoma (Rust, n.d.).

Because of the health risks associated with pesticides, the U.S. Environmental Protection Agency issued the Worker Protection Standard (WPS), which is the primary set of federal regulations aimed at protecting farm workers from the hazards of working with pesticides (Farmworker Justice, 2013). These guidelines have not been updated for twenty years, and furthermore, the EPA admits that complying with all guidelines within the WPS still poses excessive health risks to field workers. Field workers in contact with pesticides are regularly exposed to these toxic chemicals which predisposes them to serious health complications.

Furthermore, without proper training and safety equipment from the agricultural companies, fieldworkers and their communities are at a significant disadvantage. Many field workers have few financial resources, limited formal education, and an illegal working status; and although there are current studies that have focused on the health effects of pesticide exposure, few have addressed the circumstances specific to migrant field workers. (Shipp, Cooper, Donnelly, & Torey Nalbone, 2006) Circumstances like a lack of awareness about the health risks of pesticides, fear of deportation, and language barriers contribute to the lack of power of immigrant field workers. The large agricultural companies that take advantage of the inexpensive labor provided by immigrant field workers reap the most benefits of pesticide technology since they have minimal safety requirements to comply with, and a low degree of commitment to the health of their workers. Thus, it is indisputable that there is a power dynamic between immigrant field workers and large agricultural corporations that makes pesticide use a hazardous technology for workers and their communities.

To analyze this unequal power dynamic, I will use Langdon Winner's Theory of Technological Politics to understand how pesticides in agriculture have empowered large agricultural corporations while marginalizing immigrant field workers. Technological politics describes inherently political technologies which appear to require or to be strongly compatible with particular kinds of power dynamics that advantage certain groups over others (Winner, 1980). The Theory of Technological Politics will be a framework from which the reader can then understand that technological developments like pesticides, allow companies to meet the resource demands of a growing population; however, not all groups are benefited equally by these technologies. Specifically, I will investigate immigrant field workers in California who are

exposed to pesticides, and the consequential negative effects on their health. To do this, I will analyze reported instances of pesticide poisonings, the extent of regulations in place to protect field workers from pesticide exposure, and the accessibility of healthcare to immigrant field workers.

**Conclusion**

In this paper, the technical solution addresses a gap in the diagnostic ability to treat patients with adolescent idiopathic scoliosis, while the social solution addresses the ways in which pesticides as a technology in the agriculture industry both privileges large corporations and marginalizes field workers based on an unequal power dynamic. We propose the design of a computational framework model optimized for a clinical setting that identifies lung volume for use in scoliosis treatment. The computational tool will integrate existing and novel algorithms to automate the process of calculating lung volume, while maintaining accuracy. To complement the technical solution and help the reader understand that technical aspects have both social and political dimensions that are important to weigh in parallel, I will use Langdon Winner's Theory of Technological Politics to analyze pesticides as a technology in the agricultural industry. This analysis will elucidate the potential of technology to create and sustain dynamics of power. Although the inequalities and disparate power relationships may not be intentionally incorporated into the design of technologies, they are inherent consequences of the ways in which technology is used.

Fundamentally, we attempt to elucidate the ability of technologies to create, shape, and sustain relationships of power, specifically between large agricultural corporations and marginalized, vulnerable field workers. Without this critical understanding of the scope of

technology, and its effects on disadvantaged groups, it is difficult to ensure ethical engineering practices that promote equity.

Word Count: 1705

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