Thesis Portfolio

Development of a Distraction Elongation Measurement Device for Use in Surgical Jaw Distraction Surgery
(Technical Report)

Precision Medicine and Machine Learning: Considerations Regarding Social Factors in Designing an Algorithm
(STS Research Paper)

An Undergraduate Thesis

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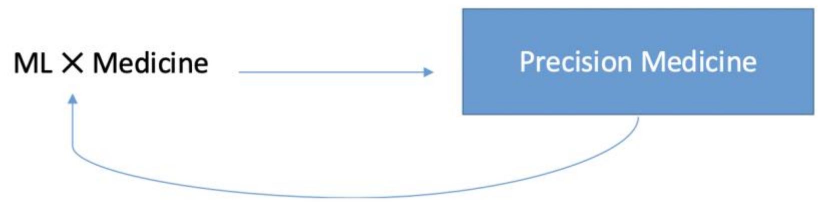
Children born with micrognathia or retrognathia are able to utilize distraction osteogenesis procedures to correct their condition, but it is still an imperfect process. After talking with Dr. Jonathan Black, my technical advisor, my team and I realized the application of some relatively simple engineering could make a world of difference for the 1/1500 children born with this condition (*The Fetal Medicine Foundation*, n.d.). Because the distraction osteogenesis procedure is carried out mostly at home, non-clinicians are the ones to carry out the lengthening of the patient's jaw. Current solutions do not easily allow clinicians to ensure that their patients verifiably receive even growth on both sides of their jaw, and do not give parents and patients the ability to verify that they are performing the procedure correctly, as doctors are currently limited to qualitative methods of elongation measurement. For my STS research, I used the knowledge of machine learning I have acquired in computer science classes and at my tenure with MIST, a company using machine learning to help doctors treat scoliosis. My STS research investigates the implications of equity and bias in algorithms, especially when applied to the field of medicine, and outlines a series of recommendations to help ensure that the advent of machine learning in medicine is one of equity, fairness, and maximal efficacy for all demographics. My technical project and STS research share the domain of medicine and surgery. Though my technical project takes a look at a specific surgical issue, I chose a broader STS research topic to explore what I have learned at MIST and through my experiences with machine learning, which I believe will ultimately impact all fields of medicine, including the context in which my technical project operates. In the future, it may be a machine learning algorithm that is designing solutions to problems like the one addressed in my technical report.

The technical portion of my project produced a screwdriver capable of outputting its own displacement. This screwdriver was designed and implemented to solve measurement issues associated with the elongation of the jawbone in mandibular distraction procedures for the treatment of micrognathia and retrognathia. The screwdriver my team and I designed uses an Arduino Nano, an MPU, and a display wired together with the help of soldering techniques. We utilized the I^2C protocol and used Autodesk Fusion 360 to create a custom body to host the components of the screwdriver. Using Stryker's pediatric mandibular distractor, we gathered device dimensions and incorporated them into our algorithm, allowing us to output the translational displacement of the distractor to the display. Using this translational displacement, patients, parents, and clinicians can determine how much the jaw has been lengthened with each turn of our screwdriver. Our device is currently being assessed for reliability and accuracy via testing verified by protractor and caliper and will be subject to durability testing in the future.

The STS portion of my thesis deals with how to mitigate the dangers of using machine learning in the medical field. Machine learning has already shown a capability for bias, including racism and sexism (Corbett-Davies & Goel, 2018; Kleinberg et al., 2018). Though machine learning in medicine is in its infancy, researchers are already exploring its potential for cardiac issues, cancer, spinal surgery, and medical prognoses (Adkins, 2017; Bihorac et al., 2019; Ho et al., 2020; Khan, 2020; Poplin et al., 2018). A lack of transparency and decipherability in algorithms, the use of poor datasets, and the exclusion of important protected factors (e.g. race and socioeconomic status) may lead to inequity and bias in the future of medicine; where only a few privileged demographics can benefit from the incredible power of machine learning. I use Thomas Kuhn's paradigm shift to first justify that medicine is undergoing a paradigm shift and use Sheila Jasanoff's coproduction theory second to assert that it is the coproduction of medicine with machine learning that is driving this paradigm shift (See **Figure 1**). Ultimately, I recommend that creators of algorithms include protected factors in their algorithms, use large and diverse training datasets to the extent it is possible, and encourage a culture of transparency when it comes to the algorithms they create.

Figure 1

The Coproduction of Machine Learning and Medicine, Driving the Paradigm Shift to Precision Medicine



Through my technical project, I have expanded my skillset to include soldering, working with Arduino and the I^2C protocol, and creating novel circuits. My STS research has taught me the vast potential of machine learning in medicine and about its dangers relating to bias and inequity, as well as techniques to mitigate the risks as I go forward in my career as an engineer in the healthcare space. The importance of considering the interaction of our engineering with the world around us cannot be understated. As engineers, it is imperative we work to design solutions to problems that help foster a world of equity and fairness.

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