Assistive upper-limb exoskeleton controlled by multi-modal interfaces for rehabilitation

The Ethical Impact of Body Enhancement Technology

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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

In this essay, I will be discussing the manufacturing of exoskeletons to be put on and used by humans, and their ethical and technical problems. In this topic, there is potential for serious technical problems, such as how to best manufacture these exoskeletons for rehabilitation and what movements need to be focused on. There are also widespread social problems. Imagine being able to lift two times the amount of weight you can usually lift. Or be able to jump off higher planes and not be injured. Or see your loved ones who have trouble moving get the support they need. All of that sounds beneficial, but I am addressing the underlying social problems that the access to these types of abilities may have.

"The focus here is on the threats to domestic law and order from the misuse of exoskeletons and exosuits by rogue users such as for creating havoc in public spaces, willfully endangering civilian live(s)…" (Burton, 2020, p.371). In her journal, Dr. Burton talks of the dangers of misuse in any type of human/body enhancement, especially those readily available for public consumption. Another example is of the Cochlear Implants and how they affect the Deaf community. "Many Deaf culturalists are deeply offended by what they perceive to be the inherently negative implication of cochlear implants: deafness is a medical disability that should be cured rather than a cultural identity that should be celebrated and respected." (Cooper, 2019, p. 470). In this entry, Cooper, a sophomore at Washington University, discusses how this technology that was made for the deaf community, was actually an acknowledgement of what many people thought of the deaf community.

As you can see, technologies enhancing the human body have a variety of social discussions about them, and how they could change the world. As engineers, before we continue

to build and innovate, we must take into account all communities and all perspectives. Our job is to help build a better world, and for that, we must include everyone in the conversation.

Technical Topic: *Assistive upper-limb exoskeleton controlled by multi-modal interfaces for rehabilitation*

My technical topic as planned is to build an exoskeleton for medical rehabilitation. This research will aid the rehabilitation process for stroke survivors and other criteria. With these exoskeletons, the goal is to create a way for human limbs to have more support, as well as keep them healthy. This problem is interesting because of how intricate human body pains and diseases can be in the world. Studies from Hunter and other researchers explain that people who have muscular dystrophy (MD) lose functionality in many of their limbs and hinders their day-to-day life (Hunter et al., 2019). Not just diseases, but accidents and pain from work can also be a large part of people's lives. This pain can encourage dangerous habits in terms of painkillers shown by statistics given from the well-known CDC, "Since the 1990s, when the amount of opioids prescribed to patients began to grow, the number of overdoses and deaths from prescription opioids has also increased. Even as the amount of opioids prescribed and sold for pain has increased, the amount of pain that Americans report has not similarly changed" (WONDER, 2021). These are just a few examples of how circumstances in the human body affect quality of life.

Engineers continue to study the wearing down of the human body, and have theorized that exoskeletons could support the solution. "Muscle activity reductions up to 80% have been reported as an effect of active exoskeletons. Exoskeletons have the potential to considerably reduce the underlying factors associated with work-related musculoskeletal injury" (de Looze et al., 2016, p. 673). Not only in labor focused jobs, but different studies have shown that

exoskeletons can be very beneficial for improving quality of life for neuromuscular diseases. (Gandolla et al., 2020; Cruz et al., 2021). The study led by Professor Gandolla (Politecnico di Milano) mainly focuses on upper limb assistive devices (ADs) and its effect on diseases. Nevertheless, it continues to prove that assistive technology, which includes exoskeletons, can be beneficial for rehabilitation for all circumstances of human muscle pain or disease and should be explored.

My technical research will consist of creating a new and cheap exoskeleton specifically for rehabilitation. My team and I, with support from the Professor, plan to use new sensors that can identify when a muscle contracts and use them to activate our exoskeleton. The research will also include 3D printing structures for the general exoskeleton body, as well as using motors to create rotational movement. Our end goal is to create an exoskeleton that can be easily used, bought, and learned by consumers for rehabilitation and workload pain relief.

STS Topic: *The Ethical Impact of Body Enhancement Technology*

My STS topic will be about body technology and ethical implications of releasing more readily available technology into the world. The general talk of medical rehab with exoskeletons can be exciting for many individuals, and inspiring for engineers. The thought of having a loved one be able to fight a muscular disease or bounce back from a stroke gives hope. But, convenient advances in technology can create unfavorable environments. MD Gary W. Small and other authors discuss the correlation between brain health and digital technology usage (Small et al., 2020). They find that there are benefits to new digital technology, but many hindrances to the brain including addiction, social isolation, reduced attention and sleep, etc. Small does not give insight to how these problems affect communities or how to fix them, even so, the result remains

the same. No matter the intentions of a technology, they can produce negative/opposite effects on a community.

What values do you want to express with your work? What makes a technology inherently "good", and what should we make of the negative effects of a "good" technology? These are questions that must be answered, especially in terms of technology that directly affects the human body. This brings us back to the topic mentioned at the beginning of this section. Ethical implications also include who these advances of technology truly benefit. MD Kenneth Jaffe and MD Nathalia Jimenez address in their paper the fact that there are inequalities for access to rehabilitation and insurance, especially for racial and ethnic minorities. (Jaffe & Jimenez, 2015). They discuss that not just race and ethnicity, but also geographic distribution, gender, and age all play a part in the equity of rehabilitation for communities in America. Even though their point is overall proven, there are many nuances in the environment of health care that they do not expand upon. Unlike Jaffe and Jimenez, Dr. Rodolfo Bulatao and other authors of their book dive more into the nuances of the relationship between the medical insurance establishment and minority communities (Bulatao et al., 2004, ch.10). Bulatao and co-authors explain that some minorities in America have an insurance rate very close to the white population, while others are very far from it. However, we can conclude from both sources that there is an unbalance of insured communities in many countries, especially when it comes to income gaps between these communities. Being insured includes what medical technology is given to you and how it is paid for. We cannot claim a technology is readily available, when those who need it the most don't have access to it.

Considering these scenarios and circumstances, what makes the advancements in body technology inherently "good"? How do we as an engineering community, but also as a general

community make sure these advances are ethical, safe, impactful, and are not used to alienate and separate communities? What are the effects of low-cost body technology on communities, and how do we make sure this technology is not used to inspire criminal activity? These research questions will be discussed in my STS paper.

In my research, I plan to use the theoretical framework of Social Construction of Technology (SCOT). The well-known STS Professor Bijker explains that SCOT is a research approach to study technical change, and a theory about development in technology relative to society (Bijker, 2009). Using this theory, I plan to relate the need/innovation of body technology to society and explore the idea that society will eventually shape body technology. I also plan to use SCOT to review the impacts of body technology on society, and how we as engineers must change our way of thinking to include every community in this innovation. This framework will be used to start a conversation of manufacturing, selling, and the politics that goes into body technology. I plan to use articles and studies written by medical/engineering professionals and social groups, as well as group studies on the effects of using body technology. I also plan to interview professors, students, religious leaders, and personnel around the school to receive more information about the public perception of body technology. Dr. Silverman in his book discusses qualitative research and how this type of method plays a significant role in obtaining open ended data (Silverman, 1998). Abdullah, a lecturer of English language at University of Jeddah, continues in this path explaining that interviews are vital for assessing thoughts, views, and perspectives to present information collectively (Abdullah, 2019). Using interviews and asking questions, I plan to dive deeper into the thoughts of those around me, and those who will be most affected.

Conclusion

In conclusion, with my team, I plan to build an exoskeleton that will assist in the rehabilitation of stroke patients. With this technical objective, I plan to explore the ethical values and implications of technology that directly impact the human body. Through research, I will be able to engage in communities that have lower representation in the decision of these issues. My goal in this paper is to further the conversation surrounding this technology, and bring to the forefront issues that have been buried. Through my research, I will be able to understand these issues more, and present them to the world in the hope that my message will be acknowledged.

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