The Squat Bot: A Minimally-Invasive, Low-Cost Exoskeleton for Sitting and Standing

(Technical Report)

Ethically Sourcing Raw Materials for Technological Trends

(STS Paper)

A Thesis Prospectus
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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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General Research Problem: The price of “progress”

As battery technology rapidly develops, what fuels the development? Does this trend show up with Biomedical Assistance Technology?

The world is advancing very quickly and the rate that it will continue to advance is also going to increase. This is because as more technology becomes available, the same amount of people can accomplish the same amount of work that they did a year ago but in much less time. This applies to everything from STEM related topics to the rate of art being produced using generative AI. The problem with everything moving so fast is that progress is what gets optimized while some social problems will get covered up. Batteries have gotten significantly better in terms of capacity, stronger electromagnetic potential, safety, and rate of production. The volition in every consumer for a rechargeable device is the driving force behind all of this quick advancement. Sometimes, entities such as corporations use the fancy new battery tech to sell products that are supposedly better than their competitors, and then within a year the tech will be outdated. When people ask where the materials for batteries come from, a marketing manager will say something about ethical mining practices and environmentally friendly initiatives. A lot of these are just concrete lies.

The field relating medicine and technology is “relatively” new and I call it human augmentation. Human augmentation ranges from surface level plastic surgery to genetic editing with crispr for vaccines. Somewhere in the middle sits the field of biomechanics; applying technology to the extremities using technical analysis combined with scientific knowledge about organic substances. This has already applied to profitable industries like extremely advanced football helmets and robotics to replace human labor. Both batteries and human augmentation are advancing so quickly that I argue it would be a good idea to slow down and address the lack of awareness about how certain technologies are used.

There are more sustainable and ethical ways to utilize batteries whether it is related to recycling them or just changing how the raw material is collected. I also believe that with all the research done on

athletes and soldiers, a considerable amount of it could be applied to elderly people or people with neurodegenerative diseases. If private parties are willing to collaborate and not hoard their ideas behind patents, this tech could end up affordable or at least covered by insurance. Batteries and Human Augmentation are staples of the future and they will continue to advance rapidly. By looking at them from different lenses, they can advance and benefit the generally underrepresented classes of the population rather than hurt them like they do currently.

Technical Project: Stand up for what you believe

Some people do not have the ability to stand and sit; so we can help them

Throughout the world, some people don't have full motor control of their body. They might be getting old and their body just doesn't work the same way, or maybe they were born that way. Technology already exists to help when this happens, but it is too expensive. The technical research topic is the development of an exoskeleton to help people sit or stand. The first step of implementation is to help with rehab so it assists an individual in standing up and sitting down. The cherry on top would be to make it so cheap and minimally invasive that older people or anybody with a neurodegenerative disease could use it in everyday life. The individual pieces of tech are already here: High Torque Motors, Linear actuators, EMG Sensors, and of course all the new software for biomechanical analysis and mechatronic control. These pieces just need to be assembled correctly. By utilizing what we have learned so far, we will be able to create rehabilitation hardware for people who need it. We will build a system that works on one of our group members, and figure out how the different parts of the human body influence the design, and make it so that if somebody needed one, they could get a built exoskeleton to assist them in their everyday life. The International Research Board requires extensive paperwork to test on random people, however, this does not apply to the members of the research group, so we cannot legally test on anybody else, who is not on the research team.

There are many existing projects involving soft exoskeletons on the upper body. This mainly includes controlling the arms. However, there is not nearly as much work done on the lower body. Additionally, most of the existing work has to do specifically with gait analysis for walking. By looking at the published research, the plan is to apply the open source studies to this capstone project.

The novelty of our project comes from the fact that it doesn't do anything else but help people sit down and stand up. While doing research about existing technologies, we found a vacuum. Labs have conducted research to build exoskeletons that help people walk, but this is mainly about leverage the spring coefficient of a persons' calves as they absorb energy while walking. These exoskeletons cannot handle the high forces needed to control the weight of the upper torso during the transition from seated to standing or vice versa.

The project as it stands makes use of knowledge from earlier in the curriculum. This includes force analysis and video analysis for the geometry of the motion and making sure the motors and other components can withstand the force generated by the human body. Because mechatronic components are present, a large part of the project is going to involve controlling the motors with programming. The options on the table are parallax and arduino for motor control.

As the project moves forward, a better understanding of why this technology is currently inaccessible to so many people will rise to the surface. By comparing how our final product came out to what is already on the market, progress can be made in figuring out why this kind of technology is so expensive and hard to make. This is a technical problem because the project relies heavily on the accessibility of high torque motors. It is these motors that in previous times have not been strong enough for a design like ours to exist. One important part of the project is sourcing the correct motors that can output high torque without being too heavy.

STS Research Problem: Bad Batteries

Why are cobalt and nickel problematic for society?

Battery advancements come at an environmental and ethical cost. High GDP countries prioritize energy generation, but only batteries provide effective storage to transport that energy where it needs to go. China leads in electric vehicles (EVs), disrupting the conventional car market. India follows suit. The rush for batteries relies on cheap, problematic raw materials, particularly from Africa, where cobalt extraction harms the environment and uses slave labor. Spreading awareness may encourage ethical sourcing and reduce the impact on the planet.

India and China, two heavily populated nations, are shifting toward embracing electric and battery technology as part of broader sustainability efforts (IEA, 2019). Their motivation stems from the urgent need to combat air pollution and address climate change. Fossil fuels' adverse impact on their environment drives their commitment to reducing carbon emissions (Li Q, 2022). Electric power and advanced batteries are key solutions. Rapid urbanization has raised energy demand, making battery technology vital for efficient electricity storage, particularly in urban areas (IEA, 2019). Economic incentives drive the transition, with both countries aiming to lead the global clean energy market by investing in battery manufacturing, creating jobs, and reducing reliance on costly energy imports. Government policies, EV incentives, and international collaborations accelerate battery technology development in India and China.

China at one point owned seven out of eight cobalt mines. The eight cobalt mine in question was American owned, but it is being phased out because they cannot keep up with the Chinese mines in terms of rate of output and profit. China's involvement in African cobalt mining has raised concerns over labor practices, environmental impacts, and the ethical sourcing of minerals. Reports have alleged that Chinese companies operating in African countries may not always adhere to the highest labor standards (Kara, S. 2023). This has raised concerns about the use of forced or coerced labor. Cobalt is a crucial component in the production of lithium-ion batteries, which power many electronic devices and electric vehicles. China, as a major player in the battery and electric vehicle industries, has a vested interest in securing a stable cobalt supply (Li, Q. 2022). To meet this demand, Chinese companies have invested in cobalt mining

operations in African nations with substantial cobalt reserves, such as the Democratic Republic of Congo. Cobalt mining in the DRC has been associated with child labor and unsafe working conditions, leading to widespread concerns about unethical mining practices. Initiatives like the Responsible Cobalt Initiative are aimed at promoting ethical cobalt sourcing practices and improving working conditions in the industry (Kara, S. 2023). It is essential to keep in mind that addressing these complex issues requires collaboration between governments, corporations, and the people. This is about finding a balance which will not happen overnight.

Growing battery demand, particularly in electric vehicles and renewable energy storage, emphasizes the importance of proper disposal and reducing environmental impact (Zhao, G 2022). Battery recycling is on the rise due to valuable materials like lithium, cobalt, and nickel (Harper, G. 2019). Recycling conserves resources, lessens the need for environmentally harmful mining, and reduces the environmental footprint. It also mitigates hazardous waste and contamination risks. Investments in recycling infrastructure, driven by EV and renewable tech growth, are exploding in popularity in China and India (Singh, Y. 2022). Numerous regions promote recycling through policies, and companies work on extending battery life. Battery recycling is integral to clean energy and environmental sustainability.

The three previously mentioned paragraphs provide great examples of how society and technology mutually shape each other. Sometimes, technology influences the society, and other times the effect is reversed. For example, the destruction of farmland for mines is only really because more raw materials were needed. Then, it switched so that the low cost of labor practices encouraged political bodies to increase the rate at which they produce and use batteries. There is no sense in playing the blame game and deciding which came first. A better idea would be to change every party involved in the mutual shaping to encourage more ethical, fair, and sustainable outcomes for any network.

Conclusion

The wealth of progress should be shared with everybody, not just those who can afford it.

As time progresses, so does technology, but it does not have to be at the expense of the people in this world. Medical Technologies and Batteries are not going anywhere but they are already having negative effects on certain socio-economic groups. MedTech is often very expensive and hard to get access to, and only the best insurance plans will cover their cost. Sourcing raw materials is great for consumers in first world countries because they can get new electronics for a very low price. Unfortunately, this low price only exists at the expense of those in Africa who mine for the material. So the overlap in question is basically the idea that emerging technologies are not an objectively good thing for everybody. While it might be difficult to fix all the problems right away, I hope to at least clarify the situation because many people are simply unaware that this is going on. Once this is spread around, in theory, most of the readers are actors in the network as a consumer and so more consumers will understand their role in the supply chain. Some may be engineers, some may be in other fields like art or public policy. Artists could convey their message through media, and policymakers could directly influence the international supply chain. In the future, I would like to see cool new battery tech that doesn't rely on unethical labor practices, and anybody that is handicapped from the hips down can get the help they need, regardless of how much money they have.

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