Thesis Portfolio

Soft Upper-Limb Exoskeleton for Shoulder Joint Control

(Technical Report)

Potential Applications of Exoskeletons in the Armed Forces

(STS Research Paper)

The Overlap of Exoskeleton Technology and its Moral Implications

(Sociotechnical Synthesis)

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Sociotechnical Synthesis:

The Overlap of Exoskeleton Technology and its Moral Implications

Introduction

Broadly, an exoskeleton is an electromechanical structure worn by a person that matches the shape and function of the human body. There are dozens of different types all with different functions, but at its core every exoskeleton is essentially a wearable robotic system that helps a user complete a task or motion. While the roots of this technology can be traced back to 1969, most significant developments in this field have only occurred in the last decade. This is because only recently has the true potential of exoskeletons really started to become realized, with practical applications ranging from medical rehabilitation in hospitals, to enhancing physical strength and endurance for laborers and soldiers. But as with any rapidly improving technology, it is essential to consider both the positive and negative effects it can have on society. This fact is demonstrated by the engineering capstone project I have completed on exoskeleton technology, as well as the STS research conducted on its potential applications. The goal of my capstone was to create a novel design of an upper-limb exoskeleton to be used for the benefit of patients with muscular dystrophy, to help them achieve a greater range of motion than they otherwise could. While this represents a category of the potential good exoskeletons can bring about, my STS research focused on the negative consequences exoskeletons could have when adapted to a military context.

Soft Upper-Limb Exoskeleton for Shoulder Joint Control

Most traditional exoskeletons are composed of rigid braces that encase a user's arm and are actuated by DC motors. This not only results in the overall system being bulky and heavy but is also generally uncomfortable for the user. This is especially problematic when considering an

exoskeleton for everyday hospital or home use, where comfort is a top priority. The most novel idea in exoskeleton technology that seeks to address this issue is the soft actuator. This involves using soft, pneumatic artificial muscles in place of rigid components, to adapt to the human contour more naturally. The goal of my capstone project was to pursue this novel idea in practice. My project sub team was specifically tasked with trying to replicate the abduction degree of freedom of the shoulder, which we were able to achieve with moderate success. While the range of motion was less than originally anticipated, the model was a successful first step in proving the novel concept that the shoulder joint could be actuated using artificial muscles.

Potential Applications of Exoskeletons in the Armed Forces

Up until this point in time, our society has not seen a mass adoption of exoskeletons in military use contexts. But with the recent boom in exoskeleton technology, this may not be the case for much longer. In the past decade, the United States Army has partnered with several military contractors to research and design exoskeleton suits to be deployed in the field. Most of these suits have focused on passive improvements to army personnel, such as reducing the fatigue felt while travelling or increasing the load a soldier can carry. But a small number of these suits have been designed explicitly for improving the combat performance of soldiers, which has the potential to revolutionize the way ground combat is conducted. In my research paper, I examined the current state-of-the-art military exoskeleton technology and determined the likelihood that we ever would see a mass adoption of exoskeleton suits in the army for combat purposes. Additionally, I took into consideration other effects that exoskeleton use may have on our society, including the dehumanizing nature exoskeletons can have, as well as the potential cognitive stress they may have on a user. There has been very little research into the potential

moral and ethical issues that increased societal use of exoskeletons may cause, which is what this paper intends to highlight.

Conclusion

Whether an exoskeleton is a full body suit used for armed conflict, or just an arm used to help rehabilitate a patient recovering from a stroke, the core principles behind the technology are the same. While the structure or method of actuation differs greatly among different models, all exoskeletons seek to mimic a human's intention of motion. Researching this growing field in tandem with the construction of a prototype helped to demonstrate that fact, as I was able to experience firsthand how the model my team developed could be used in a number of different contexts. It is a surreal feeling to realize something that you are developing could be used for the benefit of patients in the hospital, or to improve the warfighting capability of an army. While the prototype we developed is more of a proof of concept than an actual workable prototype, it still made it very apparent why it is so important to consider *all* the potential consequences developing an innovative technology could have, both positive and negative.