Upper Limb Exoskeleton

By: Atul Bhattarai (s4579219) To: A/Prof. Daniel Lai

Introduction

Exoskeletons are very fascinating. From Gundam to Power Rangers to Avatar, the conceptual use of a "Mecha", a humanoid mobile exoskeleton, that people control and fight with. That cannot be a reality yet, however a prototype of an Upper Limb Exoskeleton (ULE) is still a viability. The ULE is a supporting wearable mechanical structure overlaying the human arm, that can be used for amplifying power, rehabilitative assistance, and a support for the disabled. It is mimicked after the human arm; hence it can be divided in three broad segments, consisting of upper arm, forearm and palm. The upper arm usually takes support of the torso (could we do multiple ball-socket joint threads perhaps?), which is connected to the forearm in pivot joint, connected to the palm by wrist.

Things to consider

Actuators:

The ULE has actuators attached to produce torque. An actuator is any device attached responsible for controlling and moving parts of the ULE. The actuators can vary by types: electric servo motors, pneumatic and hydraulic pistons, linear actuator, etc. The most important thing in designing or choosing an actuator for the ULE is to look at the power-to-weight ratio, based on the application of target ULE. For the simplest understanding the number of actuators, and its type, can define the degree of freedom of the pivotal joints, and strength the ULE can produce with the torque.

Response Type:

The actual modelling and use of ULE has seen a steady rise over the past 2 decades. Since it cannot replace the human skeletal structure at the core, it has taken a shape not that different from a rehabilitative brace, except with actuators. Depending on the use of target ULE, it can have a passive, partially active role as a support. Does it always remain ready to support the user if the user is no longer applying force? Does its "muscle memory" passively mirrors the user's movement after syncing with a user, or does it track real-time the forces being applied from a mean/median test subject? Does the ULE restrain from making movement on its own during sync phase, or does it still provide emergency assistance in case a problem arises? The subject of ULE, and its response, varies depending on where the target ULE is most suited for.

Limitations:

Some of the most challenging aspect in the ULE are to do with its development. Besides the general problem of discomfort in wearing it (it may look cool but it is not as comfortable), and degree of freedom it provides, it is necessary to also keep in mind the sensors and control methods used, how good does it imitate human motion, and how does it read and respond to the electric signal fired by the central nervous system.

Control system and software:

The control system would use, a software to program the ULE, and a control board. The software can vary from using C/C++ to Python, depending on the type of PCB and controller used. The two mainstream ones in use are Arduino and Raspberry Pi. BeagleBone is one of the controllers based on Linux that can be coded through a multiple of programming languages like php, Java, JS etc. Out of newest models of controllers, Nanode, is an evolved Arduino microcontroller that can connect with the internet through a browser or API.

Research Objective

Considering all this information, our team has some major objectives to achieve during our capstone.

1. Design a prototype ULE based on research done.
2. Write a software code to program it based on control unit used.
3. Ensure that the design is practically applicable via testing onsite.
4. Reflect and prepare suggestions for what else could have been done.

Considering the points above we have to look into a lot of things, including materials, physics applied, cost-schedule management, which we will work on once we get a proper head-start into the project.

Conclusion

This project is huge on its own, and there are a lot of things to look forward to. Tom and I are working as a team, and the general consensus is that I will take charge of software part, while supporting when necessary in the hardware, and Tom will take charge of hardware, while supporting me in software. We look forward to working with you Daniel.