DEVELOPMENT OF AN UPPER-BODY EXOSKELETON

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RESEARCH

This thesis includes a comprehensive literature review on exoskeletons, mainly focusing on active upper-body models including many industrial and academic research projects. The current international standards related to exoskeletons with relation to robots are also examined. The interaction between human and exoskeleton is investigated by focusing on kinematics and physical interaction. Powering the exoskeleton and the communication plans are also explored for this specific device. A certain design is proposed including selection of materials, cross-sections of rigid parts, and overall joints. The control approach to the developed exoskeleton is described with chosen components as well as functional diagrams and algorithm charts.

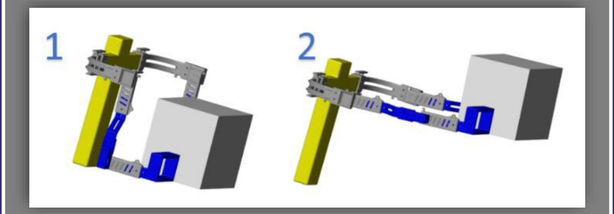
BACKGROUND

In general, an exoskeleton is a multipurpose robotic device which can be used in various applications like military, medical, industry, and so on. Most common way of exoskeleton classification is by the body parts; full-body, upper-body, and lower-body. Examples can be found in both academic and industrial domains. The exponential growth on the published material on exoskeletons indicate a bright future for their development

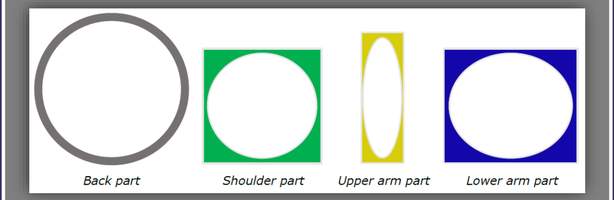
International standards regarding exoskeletons are still a very young concept. Currently, they are mainly considered as service robots and most of them are studied as restraint type physical assistance robots under personal care robots. However, with the standardization reforms of organizations like ISO and ASTM, exoskeletons are getting to the industrial levels they deserve starting from the terminology.

Regarding the scope of the industrial usage of this exoskeleton, the focus of this study is dynamic physical interaction. Therefore, the factor of safety is decided to be 2 as a development criteria. Also, appropriate materials are examined during design phase.

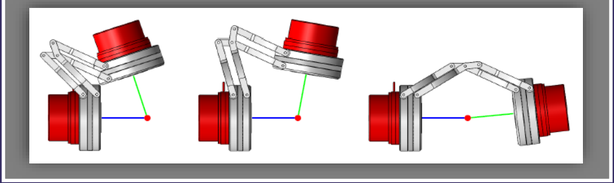
To have an idea on the motion of the exoskeleton, a motion simulation was conducted with the preliminary design.



The cross-section study was conducted with four pieces of the exoskeleton as back, lower arm, upper arm, and shoulder parts each simulated separately.



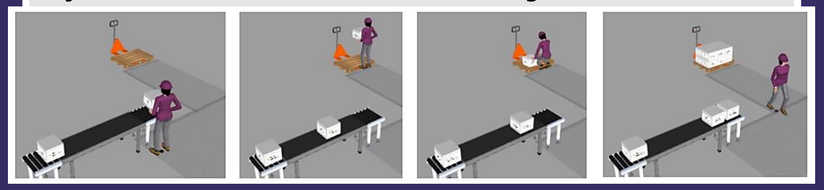
A good solution to the shoulder joint is the hybrid mechanism with two revolute joints connected via a double parallelogram linkage (DPL) structure.

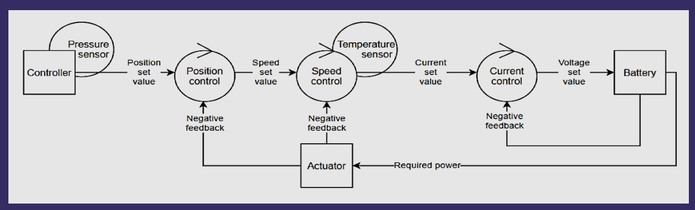


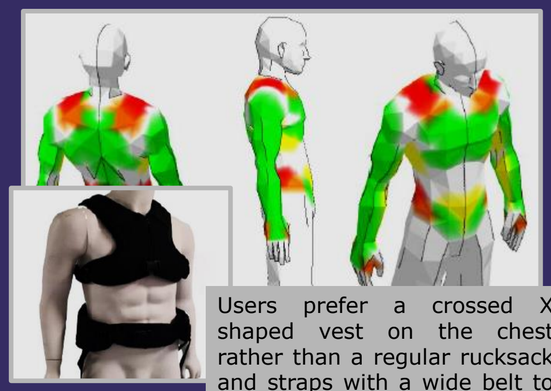
RESULTS

- Rechargeable Lithium-Ion batteries for power
- Bus network topology for communication through the device
- Wired CAN technology with CORC software for control and monitoring
- Series elastic actuators including DC motors with drivers for joint motion
- Position (absolute encoder), speed (tachometer), pressure (capacitive), temperature (resistive) transducers for data acquisition
- Arduino Mega microcontroller to control elements
- PID controller to include in the system

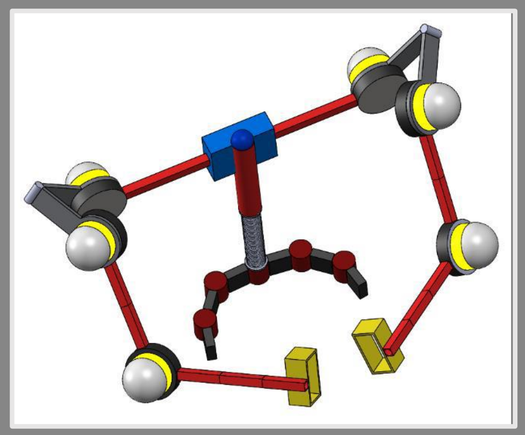
There have been many reports and studies examining the work process and worker disorders. Other than optimizing the exoskeleton design for the job description, in this case heavy lifting operation, the work environment can also be adjusted to be more suitable for working with one.

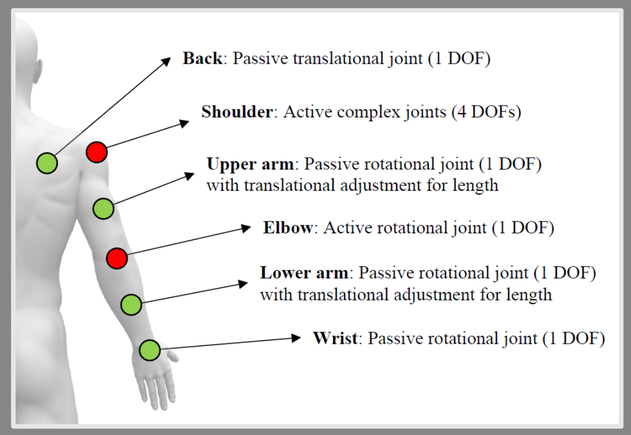






Users prefer a crossed X shaped vest on the chest rather than a regular rucksack and straps with a wide belt to unload the assistive forces on a larger body area.





The mechanical draft was analyzed including gravity and 30kg load with static and fatigue simulations. An elastic piece added between the belt and rigid parts which requires more maintenance than other parts.

CONCLUSIONS

This lightweight electromechanical exoskeleton shall not have connection to anywhere for energy except when it is charging. The sensors and actuators will work with a controller to ease the work process of the wearer. It should handle loads weighting 15-25 kg and the device itself must be maximum 10 kg.

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