DESIGN AND DEVELOPMENT OF DUAL MOTOR-POWERED WAIST ASSIST EXOSKELETON AND ANKLE EXOSKELETON

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ABSTRACT

An exoskeleton is a wearable electromechanical structure that is intended to resemble and allow movements in a manner similar to the human skeletal system. Military tasks often require lifting and carrying of heavy loads from one place to another, which can cause strain and fatigue on the joints and muscles of soldiers. This can lead to reduced performance and cause chronic musculoskeletal injuries, especially in the lower back and limbs. Apart from this, soldiers need to walk long distances during battle to get to strategic zones, which can cause fatigue on their calf muscles. The use of an exoskeleton to assist soldiers during such tasks can lead to a reduction in the burden felt and in the energetic cost of their muscles.

The project intends to cover detailed Literature survey about the exoskeleton, Identification of problem statement, 3D CAD Modeling, Calculations and Modifications, Simulations, Selection of Components, Material Selection, Manufacturing, Control Systems Design, Coding and Integration of Control System with the Exoskeleton Assembly.

PROBLEM STATEMENT

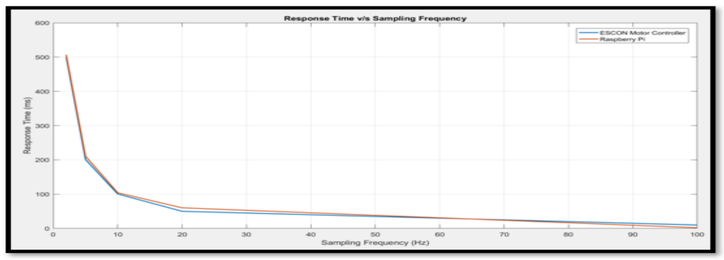
Design and Development of Dual Motor-Powered Waist Assistive Exoskeleton and Passive Ankle Exoskeleton.

The purpose of this project is to conceptualize, design, analyze and build a wearable waist assistive exoskeleton to provide back and thigh support for army personnel and industrial workers during repetitive lifting and long-distance walking tasks and to assess reductions in back muscular activity.

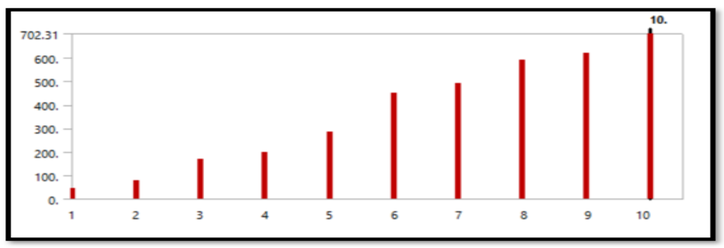
In addition to the waist assistive exoskeleton, an ankle mounted module is to be developed to reduce the stress on lower legs and feet. This is a passive mechanism with a rack and pawl clutch, spring based integrated system.

RESULTS

- On solving by hand, a rough estimate of torque and current draw was made. Torque values were 0.5Nm and 3.5Nm respectively for No load and Load. MATLAB &Simulink produced similar results which were 0.39 and 3.2Nm respectively
- The Real time results were acquired through CSV through the ESCON Studio. The values were 0.32 and 2.769Nm
- Theoretical and Simulation values showed an Average Error of 10%, while the Theoretical and Actual values showed an Average error of 31.8%.
- The time lag found between the sensors was in the order of milliseconds.

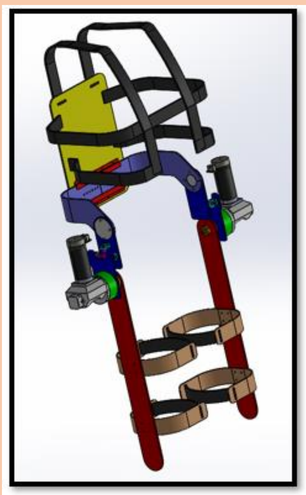


Response Time v/s Sampling Frequency

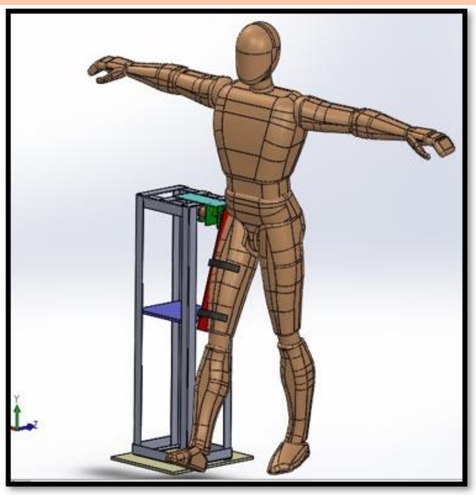


Modal Frequencies at various Modes

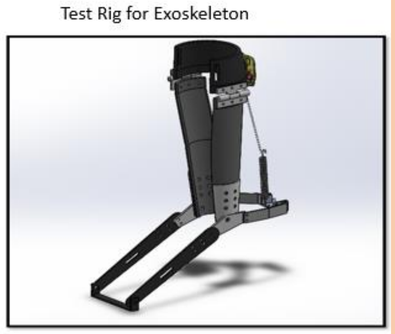
CAD MODELS



Waist Assist Exoskeleton



Test Rig for Exoskeleton



Ankle Exoskeleton

MANUFACTURED COMPONENTS

Test Rig for Exoskeleton

Clutch Mechanism

Ankle Exoskeleton

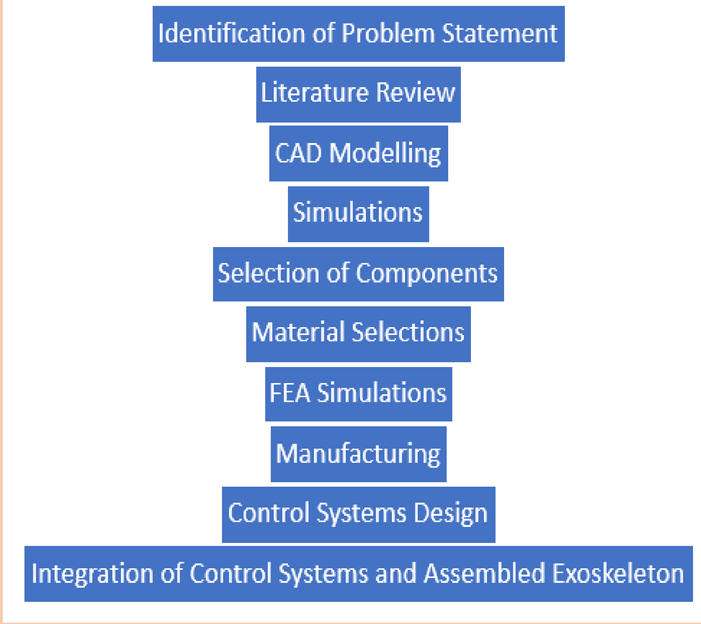
CONCLUSION

The Capstone Project was aimed at designing a Waist Assist Exoskeleton and an Ankle Exoskeleton for aiding our soldiers. During our designing process, many design iterations were made for Waist and Ankle Exoskeleton, with each iteration solving the problems raised in the previous iterations. After the completion of designing work, we focused on Electronics and Control Systems Design part. After the completion of Control Systems Design, our group was ready to proceed for prototyping and testing phase. FEA Simulations using ANSYS were also performed to check the safety of the design.

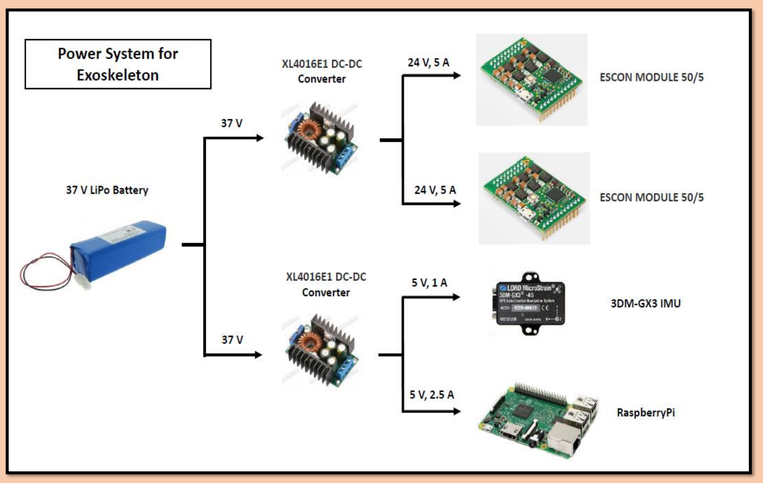
OBJECTIVES OF THE PROJECT

- To reduce the overall metabolic cost of human locomotion and lifting activities.
- To reduce stress on Lumbar Muscles during long term lifting work
- To prevent progressive function loss in patients with muscular dystrophy.
- To prevent work-related musculoskeletal disorders in dynamic heavy lifting or static high-precision work (medical surgeons).

METHODOLOGY



POWER DISTRIBUTION SYSTEM



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- Steven H. Collins, M. Bruce Wiggin & Gregory S. Sawicki, Reducing the energy cost of human walking using an unpowered exoskeleton, doi:10.1038/nature14288