Mechanical Engineering Thesis Defense

Design of a Knee Exoskeleton for Gait Assistance

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abstract

The world population is ageing and age related disorders such as stroke and spinal cord injury are increasing rapidly and the patients often suffer from mobility impairment. Wearable robotic exoskeletons are developed that serve as rehabilitation device to these patients. In this thesis a knee exoskeleton design with higher torque output, is proposed, fabricated and tested. Series elastic actuator (SEA) is one of the many actuation mechanisms employed in the exoskeletons. In this mechanism an elastic element such as torsion spring is used between the actuator and human joint. It serves as torque sensor and energy buffer, making it safe and compact. A knee exoskeleton is developed using the SEA mechanism. It uses worm gear and spur gear combination to amplify the assistive torque generated from the DC motor. It weighs 1.57 kg and provides a maximum assistive torque of 11.26 N·m. It can be used as a rehabilitation device for patients affected with knee joint impairment. A new exoskeleton design is proposed as an improvement over the present exoskeletons. It consists components such as brushless DC Motor and planetary gear, that are powerful yet compact. All the other components such as bevel gear and torsion spring were selected to be compatible with the exoskeleton. The frame of the exoskeleton is modeled in SolidWorks to be modular and easy to machine and assemble fabricated using sheet metal aluminum. It is designed to provide and maximum assistive torque of 23 N·m, two times increase over the present exoskeleton. A minimal brace is 3D printed, making it easy to wear and use. The exoskeleton is equipped with encoders that are used to measure spring deflection and motor angles. They act as sensors for precise control of the exoskeleton. An impedance based control is implemented using Ni myRIO, a FPGA based controller. The motor is controlled using motor driver and powered using an external battery source. The exoskeleton is tested to accurately follow the desired reference. A walking experiment with human wearing the new exoskeleton is done and that proves it to be worthy improvement.

July 12, 2018; 11 AM; ERC 490