Assistive Exoskeleton for elderly

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Abstract:

The exoskeletal assistive device is a type of wearable robot that uses the synchronization of the human and the robot. Regardless of the application there are strict requirements for designing and producing exoskeleton suites. They must be durable but light weight and flexible, have reliable power control. The exoskeleton needs to be designed with natural and intuitive interface to be a true extension of human body. The exoskeleton should be designed to be self-sufficient between energy system recharge. Last but not the least, the exoskeleton should be comfortable and safe to wear.

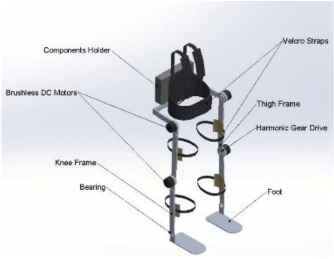
Introduction:

According to a study on gait in older adults, at age of 60, 85% of seniors have normal gait and this proportion drops to 18% by age 85. As society now has more elderly than ever, it will encounter the lack of young people who support them physically and financially. Robotic research will contribute to solve some of the problems of the aging society. The wearable robot may be a solution that helps elderly people to live without the physical assistance of young people. This project deals with the study of gait patterns in older adults and designing a suitable Exoskeleton for assistance while sitting, standing and walking of elderly. Individual study is made on different available designs to understand the advantages and the limitations of each design. Based on the study and the requirements that satisfy the problem statement an lower limb exoskeleton is designed. Static Structural analysis and modal analysis for the design was done to check whether the design is structurally safe. The final design is expected to solve the above gait related problems in elderly.

Method:

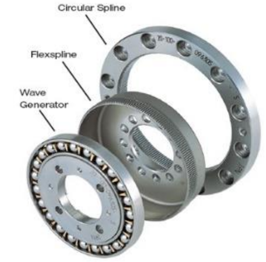
Reverse Engineering design methodology, the steps followed are:

- Clinical Gait Analysis
- Finding the Joint moments
- Selection of driving mechanism.
- Consideration of Anthropometric data.
- Ergonomic Considerations.
- Design of Exoskeleton.
- Stress and Modal Analysis of Exoskeleton.

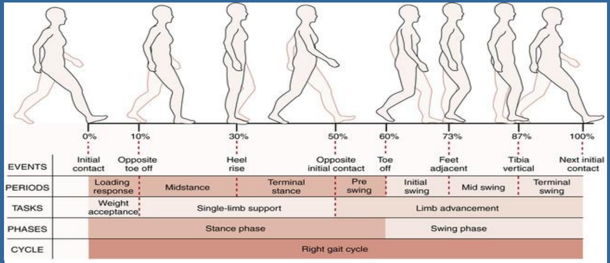


Simple and cost effective design considering only the vital functions of the elderly gait. Lower limb exoskeleton design with the elderly Anthropometric data consideration. Ergonomic and comfortable design. Usage of Aerospace material (Aluminium 7076 T6) made the design light in weight and robust in strength.

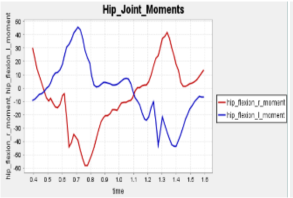
DC motors meet the criteria of necessary power with a compact and portable solution for wearable devices. Based on that, brushless DC motors coupled to a type Harmonic Drive gearbox were selected. . A 100 W motor (Maxon, EC60 Flat Brushless) is used in the hip, knee and ankle joints. This motor has a rated voltage of 24 VDC and nominal torque of 220 mNm.).

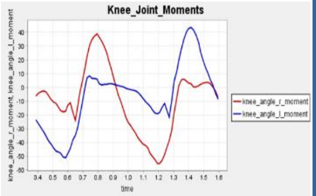


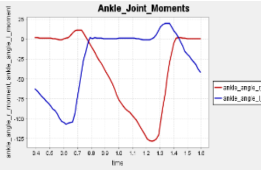
To obtain high gear ratio and zero backlash harmonic gear drives are used for exoskeleton. Harmonic Drive, CSD-20-160-2AGR) is coupled to the motor shaft in order to reduce speed and increase torque. Harmonic Drive gearboxes were selected to reduce the weight and size of the final actuators. A gear ratio of 160:1 can be obtained in a single stage with this gear drive. Dc brushless motor coupled with Harmonic gear drive produces a Nominal torque of 35 Nm and a Peak torque of 180 Nm.



For the elderly, walking, standing up from a chair, turning, and leaning are necessary for independent mobility. Gait speed, chair rise time, and the ability to do tandem stance are independent predictors of the ability to do instrumental activities of daily living. Walking without assistance requires adequate attention and muscle strength plus effective motor control to coordinate sensory input and muscle contraction.

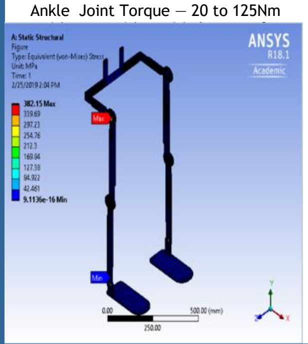






The experimental gait data that was considered for the analysis was collected by Jill Higginson and Chand John in the Neuromuscular Biomechanics Lab at the University of Delaware .The data consists of marker trajectories and ground reaction forces for an unimpaired adult male of height 1.83m weighing 72.6 kg walking on an instrumented split-belt treadmill at a velocity of 1.36 m/s. The motion data collected with the help of marker trajectories are used to compute the Joint angles using the Inverse Kinematics toolbox of OpenSim software. The Net Joint moments are computed by using the joint angles and ground reaction forces using the Inverse Dynamics toolbox of OpenSim software.

Hip Joint Torque – 45 to 60 Nm
Knee Joint Torque – 45 to 55 Nm
Ankle Joint Torque – 20 to 125Nm



Static structural Analysis is done by applying a load of 100 kg on the Hip joint and both the foot frames are made as fixed support. The Max.Stress is acting at the hip joint i.e 382.15 Mpa.

Results:

Payload of the exoskeleton is found by gradually increasing the load on hip joint.

Load on exoskeleton (kg)	Max.Deformation (mm)	Max.Stress (MPa)
120	0.59	411.95
150	0.63	514.16
245	1.01	820.78
305	1.26	1025.2

Modal Analysis is done by making both the foot frames as Fixed support.

Mode	Frequency (HZ)	Max. Deformation (mm)
First order	21.82	0.86
Second order	84.92	1.95
Third order	146.37	1.13
Fourth order	160.34	1.59
Fifth order	218.91	1.14
Sixth order	286.6	1.76

Conclusion:

The lower limb exoskeleton was designed considering the anthropometric data of the elderly in the light of cost and lightweight simple design. The approximate weight of the exoskeleton is 14 kg and still, there is a vast room to maneuver on this factor. The Static Structural Analysis results show that on using Aluminium 7075 T6 as the primary material for the Exoskeleton, the design can withstand a load of 100kg. . Modal analysis was done to find the natural frequency of the exoskeleton and the deformation of the exoskeleton with respect to mode frequency. This was done to find whether the selected motor will create a resonance, but the results show that the natural frequency vibration of the exoskeleton structure is not in the range of the forced vibrations created by the motorThe design satisfied both static structural Analysis and Modal Analysis substantiating that the design is structurally safe.