MECHANICAL EXOSKELETON FOR THE DISABLED (LOWER LIMB)

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Abstract:
Robotics has supplemented humans and automated several facets of life and finds unprecedented scope for research and development in real time applications. Exoskeleton is a super specialized area of robotics for supplementing human movements. Exoskeletons can be mainly configured either as rehabilitative exoskeletons for medical rehabilitation (orthosis) and as augmentative exoskeletons for augmentation of human activities like in combat operations.

The proposed project focuses on research and development of a rehabilitative exoskeleton designed as skeletal frame to support and protect human limbs for orthosis which is distinct from prosthesis which does not work in tandem with human body movement. Exoskeleton is outside skeleton as against the endoskeleton which is internal skeleton of the human body. The rehabilitative exoskeleton presented in this research paper is a wearable mobile machine powered by a system of electric motors, pneumatics, levers, hydraulics, or a combination of technologies that allow for limb movement with increased strength and endurance.

The Automated Exoskeleton being proposed in this project is an automated lower limb exoskeleton to enhance the personal mobility of handicapped persons that facilitates walking standing and sitting/lifting. In our mechanical system based design, we attempt to construct a lower limb that assists human locomotion. The rehabilitative exoskeleton will improve the postural balance function of the human user to naturalize body movements specifically during tasks of standing and walking, in a clinical or otherwise real-life environment.

Introduction:
Robotics finds unprecedented applications in engineering to supplement human efforts and intelligence. Exoskeletons are the application of robotics and biomechatronics to provide physical support to human in their day to day life activities and adventurism.
Exoskeleton (also known as power armour, powered armour, powered suit, exoframe, hardsuit or exosuit) is a wearable mobile machine that is powered by a system of electric motors, pneumatics, levers, hydraulics, or a combination of technologies that allow for limb movement with increased strength and endurance.

The term “exoskeleton” refers to outer skeletal framework ready to fit human skeletal zone to supplement human locomotion to both disabled and able bodied individuals. Exoskeleton technology involves the use of an external wearable framework that fits over the human brawn to augments a
human’s natural physical ability. It transcends beyond the prosthetic support systems to incorporate mobility features to enable anthropomorphic features.

The applications ranges from physically challenged individuals to combatants in the field to adventurists. In our student project we propose to build exoskeleton for persons with cut or amputated limbs to make them standalone in their routine actions.

Objectives:
The objective of this project is to design, develop, fabricate and assemble a lower body limb exoskeleton. The exoskeleton is not only mechanized but automated to assist human locomotion without physical exertion.

- The exoskeleton is configured mechanically, commanded and controlled to synchronize the limb movement with natural body motion to enhance personal mobility of injured and disabled sections.
- To study the performance of the lower limb of the human body.
- To design and fabricate an exoskeleton for imitating the motion of the lower limb
- To develop a system that is portably easy and simple to operate and economically viable.

The aim of this rehabilitative automated designed with appropriate mechanization to provide 2 degrees of freedom to human lower limb extremity and commanded and controlled to synchronize with human body motion. The exoskeleton proposed is configured to withstand forces and body moments due to external loading on user during walking, sitting, and standing motions on one hand and operate with high positioning accuracy of motion on other hand.

Methodology & Result:
The working principle of the exoskeleton limb is depicted in the figures below by manual movement without a driver. The actual prototype under fabrication and assembly is first configured with alpha type prototype for testing and replacement.

Step 1: Initial position
Initially the upper thigh skeleton and the lower calf skeleton of the exoskeleton assembled with bolted joints are aligned in vertical posture and bears the full body load as shown in fig-1.

![Initial position of exoskeleton](image)

Step 2: Movement of calf muscle
The movement of calf skeleton controlled by the Arduino controller is programmed to generate the backward motion or retro swing of lower limb calf muscles generating a v-bent shape between skeleton halves during the forward motion of other limb as shown in fig-2. The speed and angle of movement is controlled by Arduino program.

![Movement of calf muscle](image)
Step 3: Movement of thigh muscle

The thigh skeleton is then actuated to perform a forward swing and concurrently the calf skeleton undergoes a forward swing twice the angle and arc length of thigh skeleton resulting in formation of straight shape of exoskeleton.

Step 4: Back to initial position

The thigh skeleton then leaps forward, that is synonymous to thigh muscles movement forward, to complete a cycle of movement to initial position.

The exoskeleton system is designed with appropriate mechanisms for human lower limb extremity and it operates synchronously as the human realizes. The aim of exoskeleton actuator system is to provide forces against external load carried by user during walking, sitting, and standing motions by using mechanisms that reduce the cost of the present commercial exoskeleton drastically which can
be afforded by the common man. The purpose of our design revolves around the concept of enhancing the human body and helping the paralyzed/handicapped to walk through the use of the exoskeleton.

**Conclusion:**
- The existing exoskeletons have a limitation are heavy structures and too intricate to operate and handle for populace of Indian sub continent.
- The present exoskeleton designed and developed has some of the novel features first of its kind. Most notably, simplicity of design operation and off course far economical.
- It enhances mobility of physically challenged individuals.
- The exoskeleton is mechanized and motorized to facilitate easy maneuvering to the walker in a naturalized way.
- The project is a inter disciplinary field and an extension of prosthetics and robotics.

**Scope For The Future:**
- Exoskeleton is emerging interdisciplinary field of engineering mech electrical, electronics & bio compatible material sciences & biomechatronics
- It holds unprecedented scope of applications for medically challenged & injured individuals function rehabilitation & for recreational & combat operations to supplement human adventures
- There is compelling demand for rehabilitative exoskeletons with automated controls which we have developed in this prototype
- Exoskeletons can be outfitted to any anatomical segment of human skeleton. But lower limbs exoskeletons have largest potential
- The prospective markets for these devices are quite large and promise
- Significant growth in the coming years, as product becomes available and affordable. Last January, ABI Research predicted the market for would reach $877 million by 2020 in US market alone