Design and Manufacturing of A Lower Limb Exoskeleton

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***Abstract*—Exoskeletons have several applications in various fields like industry, space and healthcare. Most of the research focus has been on load augmentation for soldiers, and workers in industries. There is a need to make better use of these technologies in designing a mechanism that makes people stand on their feet again, who imagined their life on wheelchairs and beds forever. They can be used in a variety of medical applications including assisting healthy senior citizens, enabling specialized training for sportspersons. We aim to produce a low cost lower limb exoskeleton that makes a paraplegic patient walk on their own. The design consists of a**

cage where the lower limb portion is operated by a linear actuator. Power supply is given by the battery and switch is used to control the forward and backward motion. Currently, there are various designs of lower limb exoskeletons used for gait rehabilitation. However, there is a lack of detailed information regarding the mechanical elements of these devices. This makes it troublesome for developers to design a device for a specific application. Research in this area is clearly shifting towards the ideas to overcome the main drawbacks of rigid exoskeletons, in terms of adaptability, comfort, safety, cost and efficiency. Thus, we aim to produce a device that delivers high quality treatment at lower cost and effort. These systems can also be used at home to allow patients to perform therapies independently, supporting the therapy program.

Keywords—Exoskeleton, rehabilitation, exercise, elderly

I. INTRODUCTION

Exoskeletons can be defined as a skeleton that provides support to the body externally. Exoskeleton is made up of two words exo and skeleton thus it can be said that it is a skeleton to be attached externally. Exoskeletons are wearable devices that work similar to the body part attached. The healthcare sector has many passive and rigid lower limb exoskeletons. These designs are lacking in comfort, safety and efficiency. To avoid this, robotic technology has been incorporated in the exoskeletons to make it user-friendly. Robotic exoskeletons also have great importance in the fields like industry and space. At present, there are various designs available in the foreign market. The previous researchers of the topic provide insufficient data of design considerations. So, it is difficult for users to select the proper model for a specific application. For this purpose, we made some efforts to collect and study the data of existing lower limb exoskeletons.

With a population of over 1 billion, the prevalence of disability is between 1.85% and 2.19%. The fig. Below shows that there are only five manufacturing clusters in India spread across six states. The contribution of medical equipment and instruments is 54%. Most of the medical equipment and instruments used in India are imported from foreign countries. Hence there is an urgent need to start manufacturing on our own.These various types of exoskeleton are used in various fields like military, industries, medical. Kenta Suzuki et al. developed intention-Based Walking Support for Paraplegia Patients with Robot Suit HAL (Hybrid Assistive Limb). T. Hayashi et al. have developed a robot suit HAL (hybrid assistive limb) as an assistive device for lower limbs. Hiroaki Kawamoto and Yoshiyuki Sankai have developed the power assistive suit, HAL (Hybrid Assistive Leg) which provide the self-walking aid for gait disorder persons or aged persons .Current product is a active one with one or more electrical components (actuators, motor).passive exoskeleton uses mechanical components to perform necessary motion or day to day chores. Generally product obtain in the market is quite expensive our goal is to reduce
the costing, thus making it affordable to common subjects

The main objective behind this project work is:

I. To facilitate movement of knee joint by providing
   - Torque
   - Power

II. To provide independency while exercising

II.SYSTEM DESIGN

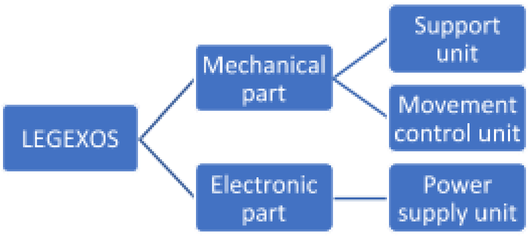
COMPONENTS

- Cage
- Actuator
- Battery
- Switch

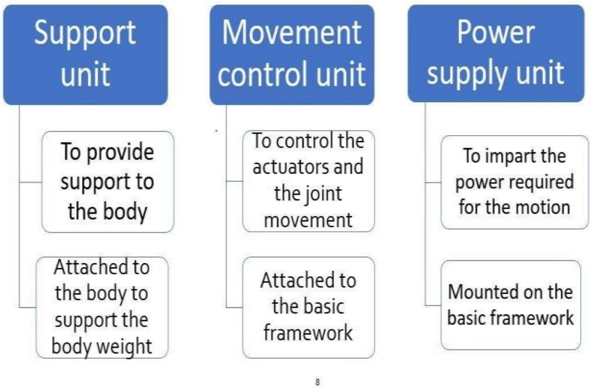
DESIGN REQUIREMENTS

- Torque at knee
- Leg dimensions
- Weight of body

SYSTEM ARCHITECTURE



Our model is simple and basically consists of two parts, mechanical part and electronic part. The mechanical part provides support and movement whereas the electronic part supplies the power to the movement control unit.



In our design the cage is of MS material which has been made as per the proper dimensions of a human leg. The actuator is mounted on the cage with a motor. The exoskeleton works on the principle of linear actuator which converts rotary motion into linear motion. Battery supply power to the motor resulting in rotation of the output shaft which drives the linear actuator. The switch is provided which has a forward and reverse button such that it can operate. After extension, the polarity is reversed and the motor rotates in the opposite direction which retracts the actuator.

ADVANTAGES:

- The structure is light in weight.
- The cost of the structure is less as compared to others.
- Any part can be changed as per the requirement.
- By some few changes in the structure it can be also used for hands.
- It is very easy to use and there is no need for any assistance to the user.
- The system takes lesser space and is portable.

CHALLENGES:

The challenges that we are currently facing in this design are

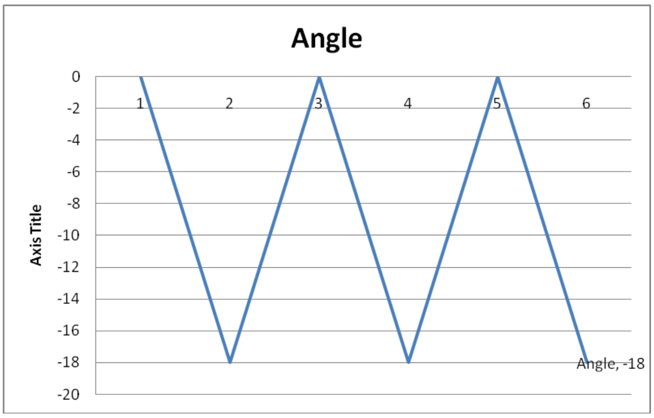
- There is no speed control i.e. the motor rotates at a constant speed.
- Currently, no power is given at the hip, power is provided only at the knee joint.
- The lighter weight battery can be used continuously only for 25-30 minutes.
- The Exoskeleton cannot be used by a patient to run.
- The overall cost of the exoskeleton could be reduced by making minor changes in the design.
- No muscle sensors or any other type of sensor are used incase sensors are used, the price of the exoskeleton would increase by a greater rate.
- The programming can be done in order to ease the use for patients but that would increase the cost.
- The usage of robotic systems allows precise measurement of movement kinematics and dynamics, which should be used for assessing patient recovery ability and progress. However, there is a need to develop standard protocols and procedures to obtain reliable assessment data.
- It has been shown that robotic rehabilitation can be as effective as manually assisted training for recovery of locomotor capacity, but a higher benefit should be desirable to spread its use in clinics worldwide.

FUTURE SCOPE:

- It can be made dynamic by using muscle sensors.
- The battery can be made more compact and lighter. ● Can be made adjustable as per the size of the leg.
- By providing power at hip paraplegic patients will be also able to use.

CONCLUSION:

In this research paper lower limb exoskeleton is developed which is based on a very simple mechanism. It has been developed for the elderly and people who need lower limb exercise to reduce the pain and gain recovery. The model can be operated manually without any assistance. This exoskeleton can be used by aged people, people suffering from lower limb injuries after an accident and need physiotherapy, exercising after knee surgery.



ANGLE (DEG) VS TIME(S)

SPEED VS TIME(SEC)

Angle is changed every 2 sec by 18deg in a continuous operation.

Speed remains constant throughout the cycle.

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