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DESIGN OF LOWER-LIMB EXOSKELETON FOR WHEELCHAIR PATIENTS

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ABSTRACT

Persons with spinal cord injury (SCI) suffer impairment in lower extremities of the body causing a condition called paraplegia which leads to the loss of mobility. This immobilization limits their ability to access the world as they knew it. The extreme inactivity imposed from paralysis leaves these individuals at risk for many secondary medical conditions, such as adverse body composition alterations, increased risk for insulin resistance, diabetes and cardiovascular disease, and difficulty with bowel evacuation. In this project we aim at developing a device of a powered lower limb orthotic to aid walking in paraplegic individuals providing assistive torques at both hip and knee joints along with a user interface and control structure that enables control of the powered orthotic via upper-body influence which offer the possibility to adapt the paralyzed person to the existing environment, rather than adapt the environment to the wheelchair. Powered exoskeletons may permit the individual with paralysis to perform functional/vocational standing, and walking tasks. We aim at developing an exoskeleton with intelligent power management, lighter weight and low cost with improved mechanical design.

Keywords – Spinal Cord Injury, Paraplegia, Powered Lower Limb Orthotic, Exoskeleton

INTRODUCTION

The number of patients experiencing mobility impairment caused by spinal cord injury is increasing because of accidents and diseases, and patients with complete SCI lose motor and sensory functions in their lower limb In addition, patients who have various diseases and injuries such as cerebral paralysis and orthopedic injuries have a dysfunction in the lower extremities. Impaired mobility would significantly reduce life expectancy, and thus rehabilitation training is needed to help these patients recover and regain mobility. Therefore, it is necessary and impactful to develop assistive devices that utilize state-of-the-art technologies to help disabled people regain the ability to stand and walk, and release therapists from the heavy work of rehabilitation training.

An exoskeleton is a wearable bionic device that is equipped with actuators that act as the working of the human joints. It can apply external force to the wearer’s limb under control, and hence provide user initiated mobility.[6] Exoskeleton type assistive device have been developed in order to achieve the patient's dream of walking, whereas wheelchair only help them to move.

MATERIALS AND METHOD

A rectangular pipe has been selected for the links due to its advantage of lightness and its ability to hold the patient with better strength in shear and bending movement for unit mass[6]. Aluminium has been selected as the material of the link on the basis of low cost. The power for the exoskeleton has been provided by 12V DC motor with 250rpm[1]. This motor is connected with the sprocket that has been aligned with the roller chain attached to the rectangular frame of the exoskeleton. The method of applying cable driven method at the joints helps in overcoming the robotic therapy that has been used to fill this gap, cost and performance has been the difficult optimization.

The sprocket attached at every joint which is driven has been connected to the spring actuator that enables the movement of the shank and the foot region with some less effort from the user. The exoskeleton additionally consist of the custom distributed embedded system, this component is connected to the hip joint that regulates the actions of the motor that in turn coordinates for the movement of the device. The microcontrollers are programmed in C using MPLAB IDE and the MP32 C Compiler (both from Microchip Technology, Inc.). A control tether connects the microcontrollers on the orthosis to a laptop computer via an RS-232 interface, such that the orthosis control can be supervised by the laptop host via the real-time interface provided by MATLAB Simulink RealTime Workshop. The two microcontrollers drive the brushless motor.

DESIGN AND DEVELOPMENT

Design is one of the most important stages in the manufacturing and it influences all the subsequent stages of any product development. The design methodology involves many evaluations and improvements to the solutions chosen in earlier stages.[7] The block diagram of the project is shown in the fig.1., the joint-level controllers consist of variable-gain proportional derivate (PD) feedback controllers around each joint, where at any given time, the control inputs into each controller consists of the joint angle reference, in addition to the proportional and derivative gains of the feedback controller. This feedback is calculated based on the torque and force sensors from the hip and foot.

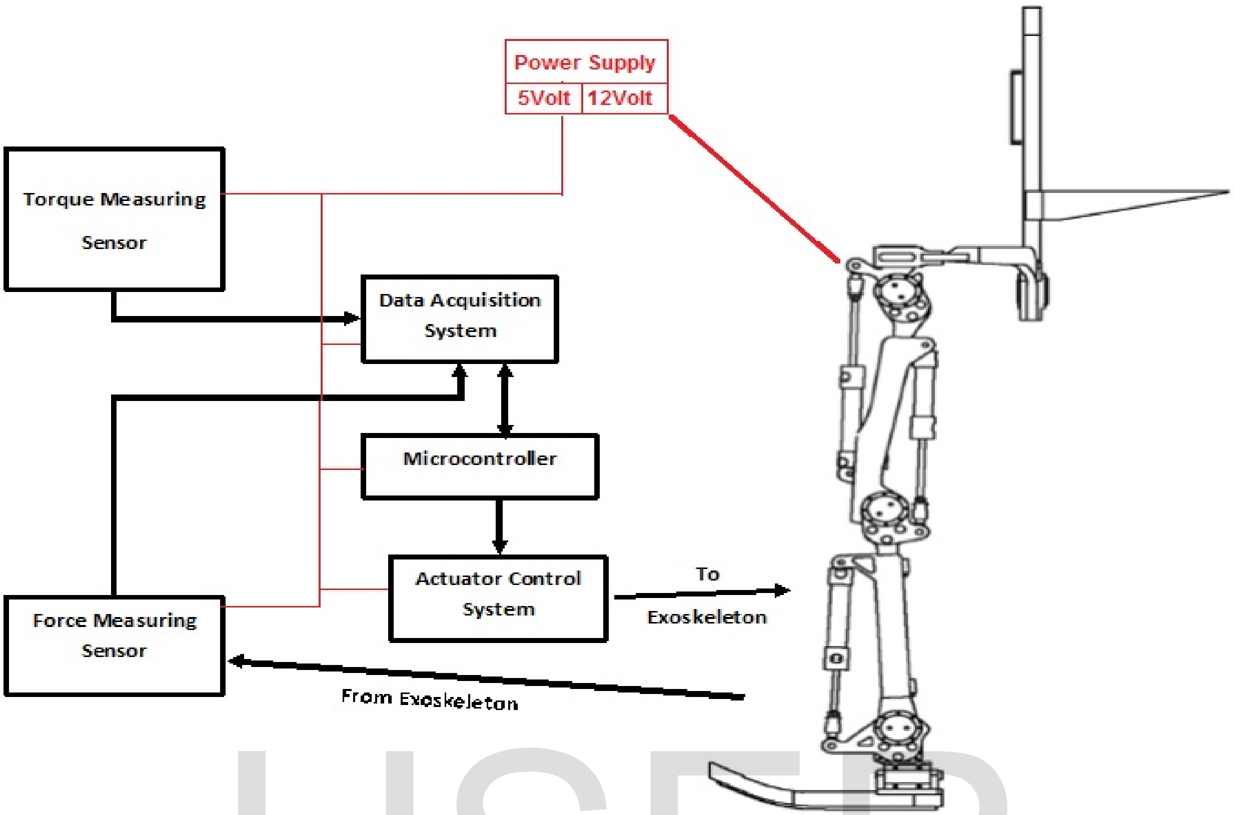

Fig.1.BLOCK DIAGRAM

The control given at the hip joint based on the motor speed and the degree of rotation which has been programmed having the reference of the gait cycle of the person for whom the exoskeleton is being designed or the possible average gait cycle of the male/female has been taken into consideration based on these details the motor is controlled and simultaneously controls the whole set up attached to the patients lower limb.

HARDWARE SETUP

The torque sensor is located downstream from the chain drive, enabling the controller to mask any friction occurring on the chain and the motor. The diagram of hardware setup of the motor aligned with the frame is shown in the fig.2.where the motor is placed parallel to that of the sprocket that simultaneously rotates figuring out the movement of the hip and thigh frame.

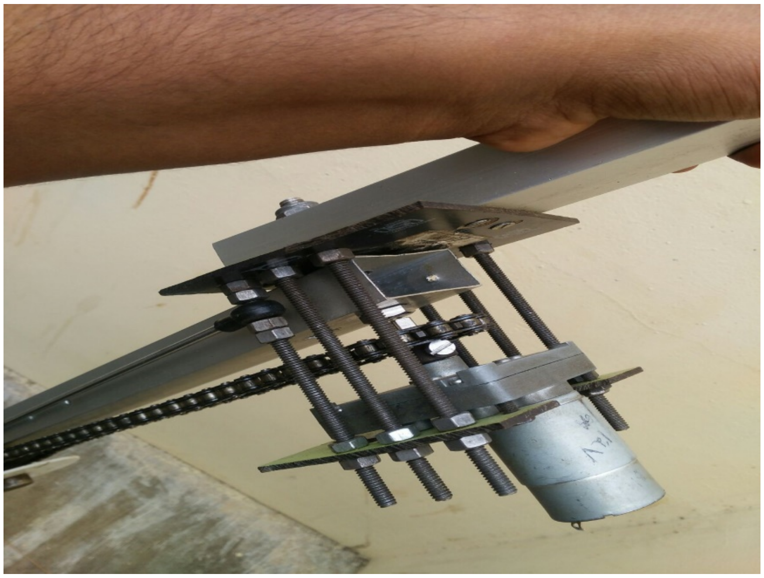

Fig.2.Motor aligned with sprocket chain drive

The joint between the upper thigh and the shank part is being correlated with the internal rubber bolts in order to ease the movement of the joint and the fig.3. shows the knee joint and upper joint juncture.

Fig.3.Knee joint junction with the lower chain drive

The controller used for programming the movement of the motor has been shown in the fig.4.where the controller will connected to the laptop that is used for programming the code onto the system that in turn is connected to the exoskeleton.

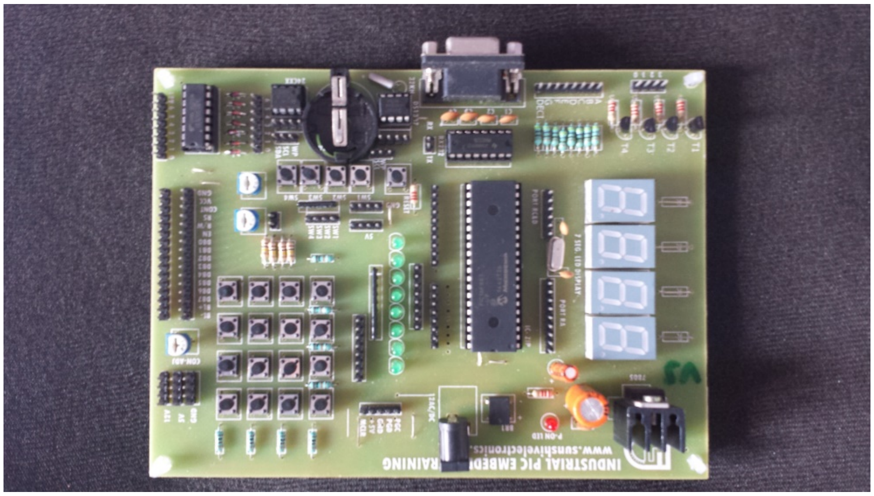

Fig.4.embedded controller

RESULTS

The overall setup of the exoskeleton for the lower limb has been designed and been strapped to the patient that will enable him to move and perform the functional walking when developed into a product. The prototype designed is shown in the fig.5.

Fig.5.Developed Hardware Setup

CONCLUSION

This paper describes the implementation and control of a new powered lower limb orthosis prototype developed to assist gait in spinal cord injured individuals.The developed hardware can be well adapted to individual patients as the intensity and range of the therapeutic practice are actually under control by patients. This feature leads to a reliable, easy-use and patient-self guided rehabilitation scheme for the spinal cord injured individuals. In future, this project can be continued by improving the type of material and using additional motor at the knee joint will help in reducing the load at that juncture. Currently, flexion and extension movements only are provided and rotation, abduction, adduction movements can also be included by providing individual control units for each action of the limbs.

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