This Novel Approach New Blend Assistive Accessory

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***Abstract* -** The Hybrid Assistive Limb (also known as HAL) is a powered exoskeleton suit or cyber-type strap-on robot suit developed by Japan's Tsukuba University and the robotics company CYBERDYNE. It has been intended to sustain and expand the physical capabilities of its users, particularly people with physical disabilities. Professor Yoshiyuki Sankai's robot suit, dubbed HAL™ for "Hybrid Assistive Limb", is a major feat in science and technology, which enables elderly people to perform everyday tasks with which they would otherwise struggle, such as walking, climbing stairs or lifting heavy objects**.**

I. INTRODUCTION

The third HAL prototype, developed in the early 2000s, was attached to a computer. Its battery alone weighed nearly 22 kilograms (49 lb) and required two helpers to put on, making it very impractical. CYBERDYNE's newer HAL-5 model weighs only 10 kilograms (22 lb) and has its battery and control computer strapped around the waist of the wearer. Cyberdyne began renting the suit out for medical purposes in 2008. By October 2012, over 300 HAL suits were in use by 130 medical facilities and nursing homes across Japan. The suit is available for institutional rental, in Japan only, for a monthly fee of US$2,000.In December 2012,

II.PHYSICAL MAKEUP

It consists of four limbs, a spine, and a battery pack. The limbs of HAL trace the human's body and are strapped onto the human's limbs. The battery pack is located in the back of the device, on the waist area. As of now, HAL does not come in a variety of sizes. It is produced in two sizes; medium, for people of height 150 cm to 165 cm, and a large size for people of 165 cm to 180 cm. Weighing only 23 kilograms, HAL is rather light for a robot its size not to mention, HAL was designed to support its own weight as well as the user's weight; so HAL causes no strain to the user in terms of load. HAL also has a battery life of 120 minutes. While that may seem insufficient for a person with sufficient locomotive capabilities, 120 minutes of independent movement for a disabled person can be regarded as sufficient, if not long. The most recent version of HAL can be viewed in Figure

III.BASIC WORKING MECHANISM

When a person attempts to move their body, nerve signals are sent from the brain to the muscles through the motor neurons, moving the musculoskeletal system. When this happens, small biosignals can be detected on the surface of the skin. The HAL suit registers these signals through a sensor attached to the skin of the wearer. Based on the signals obtained, the power unit moves the joint to support and amplify the wearer's motion. The HAL suit possesses both a user-activated "voluntary control system" and a "robotic autonomous control system" for automatic motion support. without the usage of a powerful CPU to process the information, motors to actuate its elements or a battery power source to energize the entire system.

Fig.1 Basic Working Mechanism

IV.DETAILED WORKING MECHANISM

Evaluation of a control system is an intricate process including the input, the processing, the output, and the feedback. The most basic idea is that the control system is the basis for the partnership between the human user and the machine, or in this case, HAL Furthermore, the control system is intermediary between the brain and action by sending the messages akin to a nervous system. For example, when a human is walking, there is a certain plan already formed. The plan is formed and the decision of where the plan is to be sent is initiated in the cerebral cortex. Then, the plan is sent from the base of the brain, hippocampus, to the corresponding limb via the human's nerves. These nerves give off something that is analogous to a motor giving off heat: biosignals. Biosignals are weak biological signals that can be detected just on the surface of the skin. These signals send the message to the limb that is preplanned to move. The evaluation of the control system for this component of HAL is broken down into the basic sequence of Control Theory.

V.VOLUNTARY CONTROL SYSTEM

The Cybernic Volunteer Control System is the user dependent control system. With this in mind, we are going to evaluate the Voluntary Control System being more dependent upon the biosignals produced by the nervous system. The nervous system of a human is based upon sending messages throughout the body for regulating, controlling, and maintaining the human's system. The Voluntary Control system utilizes this aspect of the human. For example, we will evaluate the simple motion of a leg. The human forms the idea and plan to move the leg within their motor sensory cortex. The motor sensory cortex sends this plan to the cerebellum through neurons. The cerebellum takes this plan and processes the information. The cerebellum then takes the processed information and sends it to the correct location; for our purposes, the leg. HAL's EMG sensor picks up on the weak signals on the surface of the skin. These signals occur during muscle activation of the muscle 20-80ms prior to the actual muscle action beginning. Therefore, HAL has the information to analyze the signal before the action begins, enhancing its overall efficiency.

VI. AUTONOMOUS CONTROL SYSTEM

The Cybernic Autonomous Control System provides support for the user, independent from the user. When utilizing the Autonomous mode, it uses movements that have already been calibrated within its database. The main highlight the Cybernic Volunteer Control system is that it can rely on the weak biosignals sent from the cerebellum.

However, some disabilities are based off of gait disorders where signals are no longer able to be received by the corresponding limb. In this case, HAL must use what has already been programmed in. The human body relies heavily on its nervous system for all messages to get across, especially in regards to movement. The Autonomous mode works off of mechanical sensors and torque. Autonomous systems must be able to adapt to system and environmental changes through their own knowledge. This adaptive personality is based off of software with preprogrammed information on such adaptations. First, the exoskeleton must obtain information on the environment. Second, it must process the information from the environment.

VII.MECHANICAL DETECTION

HAL uses three types of mechanically-based detection sensors. For the purpose of this paper, the acceleration sensor and angular sensor are defined as motion sensors while the floor reaction sensor is categorized in both motion and environmental sensors. The main difference between the mechanical sensors and the bioelectrical sensors is that the mechanical sensors are not contingent upon the biological values of the human user. Therefore they are independent from the disabilities of the user; meaning that they are utilized within the autonomous control system, heavily. Furthermore, the mechanical sensors are built into the joints or on the bottom of the foot. Accelerator sensors, accelerometers, are technical devices that measure acceleration of the two systems: the dynamic system and the static system. The dynamic system is contingent upon the user and HAL working together. The static system takes the factor of gravity into account. The main reason for an accelerometer is to factor in the g-force, or the vertical force on the entire system. Angular sensors, gyroscopes, are sensors that detect and measure angles. Gyroscopes measure the rate of rotation around an axis.

VIII.RELATING THE MUSCULOSKELETAL SYSTEM TO HAL

Like the human musculoskeletal system, HAL is made up of parts that function in various ways. The combination of these functions into one system creates motion. HAL is made to function very similarly to a human's body, in terms of degrees of freedom. HAL is said to have a motion range of 90 degrees on its ankles, 210 degrees on its leg (from the upper thigh), and 165 degrees on its knee. HAL performs motion using one of two methods. In the first method, the angle of motion for a joint is computed, and then produced with a torque amplifier-actuator pair. EMG signals sent from the brain are picked up by HAL's sensors, and pre-calculated motion algorithms are combined to match the motion patterns sent from the brain. The second method consists of HAL detecting very slight forces that result from the intended motion of the wearer. As in the previous method, HAL calculates, and amplifies the torque of the wearer. This way, when HAL applies the torque to its joints, the wearer does not have to exert as much, if not any force in order to move.

A. Hal's Motion

In order to imitate a normal human's motion patterns, HAL is built very similarly to the human body in terms of limbs and joints. For a human to move, a combination of forces is applied to the joints through the contracting and relaxing of muscles. This creates a torque on the joint and leads to movement. Once HAL receives an electrical message from the brain, it computes torque estimation for the joint to perform that motion .A system of many mechanical elements is required For HAL to move. Because the scope of these mechanical elements is too vast, only the most crucial elements are discussed in this paper. The next sections describe the purpose of HAL's actuators, torque amplifiers, mechanical limiters and strain gauges.

B.Calculating and Performing the Motion

An actuator is a device that modifies the mechanical state of a system where the mechanical state of a system is the amount of energy that a system has. One way to change the mechanical energy of a system is by active interaction such as the application of force on an object to accelerate it to the point where motion occurs. An actuator can be seen as a system that establishes a flow of energy between an input (electrical) port and an output (mechanical) port. Basically, an actuator operates in the form of a mathematical function. The input or electrical signals is modified within the function, in other words, the actuator. The output (electrical input), is in the form of mechanical energy. The goal of this function is to change the input form of energy (not always, but generally electrical) into mechanical energy. The actuator then effectively dissipates the net mechanical energy of the system,

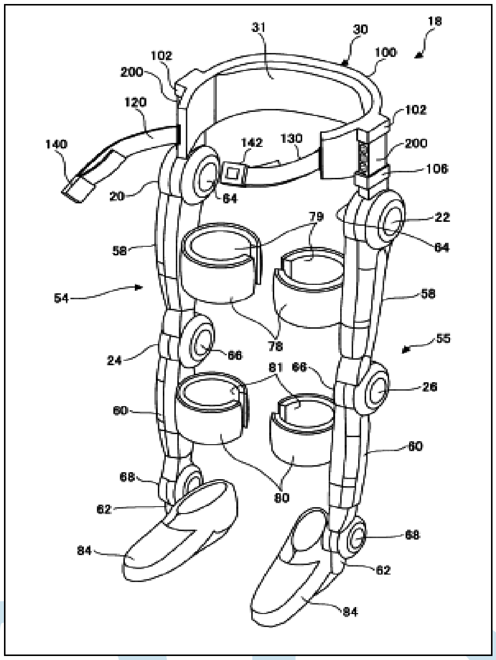

Fig.2. Torque Amplifiers

IX.APPLICATIONS

The major application of HAL is in the medical field. Most patients with thoracic ossification of the posterior longitudinal ligament (OPLL) exhibit delayed recovery of gait dysfunction after spinal injury.HAL controls the knee and hip joint by detecting very weak bioelectric signal on the surface on the skin .Likewise HAL has been used for many major medical applications.

X.CONCLUSION

In conclusion, our goal was to evaluate a piece of technology that would enhance the life of those with gait is orders and for other applications. We did so by breaking down both the Electrical and Mechanical aspects of the robotic exoskeleton and evaluating each functional piece. In the end, we can conclude the overall enhancement using HAL.

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