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Solar Powered Exo-skeleton (S-PEXS)

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Abstract - *A powered exoskeleton (also known as powered armor, power armor, 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.*

With the integration of a Solar power as an energy source, the Exoskeleton can be made eco-friendly and more energy efficient.

Key Words: S-PEXS, Exo-skeleton, Solar powered Exo Skeleton, Exo-Suit

1.INTRODUCTION

A powered exoskeleton (also known as powered armour, power armour, 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. With the integration of a Solar power as an energy source, the Exoskeleton can be made eco-friendly and more energy efficient. Exoskeleton, especially powered exoskeleton is a big energy consumption unit. Most of the exoskeletons are currently powered by batteries, and during the production of batteries, a huge amount of energy is consumed. Again for the benefits of nature we move our eyes on to the sun. However, here comes the question, is the solar cell enough for the big amount of energy consumption during the operation of exoskeleton? we can do some simple calculations here.
Single p–n junction crystalline silicon devices are now approaching the theoretical limiting power efficiency of 33.7%. In the extreme, with an infinite number of layers, the corresponding limit is 86% using concentrated sunlight. In September 2013, the solar cell achieved a new world record with 44.7 percent efficiency. let's say our solar cell can have 30 percent average efficiency over all time.
Solar radiation reaches the Earth's upper Earth's atmosphere with the power of 1366watts per square meter (W/m2). Since the Earth is round, the surface nearer its poles is angled away from the sun and receives much less solar energy than the surface nearer the equator, considering the fact there is difference between morning and afternoon, we can take the value of 200 W/m2 as an average. The total power of the solar system is about 200*0.3=60W/m2 .
To lift a person with battery and exoskeleton together to 1m height, the energy consumption m*g*h=100kg*9.81*1=981J, if we are going to charge the battery in the sunshine for 2h with 0.1m2 solar cell, we will store about 60*2*3600*0.1=43200J energy in the battery. which means we can have around the amount of energy of lifting one person to the height of 43.2m . This amount of energy is enough for normal exoskeleton, however for very high energy consumption powered exoskeleton, it seems rather difficult, alternative is probably using assistant normal battery.
In the inhibit mode, the robotic device would be used as an in-space exercise machine to supply resistance against leg movement. The same technology could be used in reverse on the ground, potentially helping some individuals walk for the first time.
The Project is designed to help the wearer of the suit to perform tasks which a normal person have difficulties in doing .The suit have three models, each to be used in different real world scenarios:

One model is a heavy lifter which will be implemented in the army for the wearer to carry weight more than his/her capacity .This model includes non- lethal weapon for self-defense of security personnel.

The second model is a light weighted and flexible one for the physically abled persons with different medical conditions.

The Third model is to be used in the industries so that the workers can do their work with more efficiency.

1.1 Brief History

The development of robotic exoskeletons already began in the second half of the 20th century.
Around 1965, General Electric (in the US) started to develop the Hardiman, a large full-body exoskeleton designed to augment the user's strength to enable the lifting of heavy objects. The first exoskeletons for gait assistance were developed at the end of the 1960s at the Mihajlo Pupin Institute Serbia, and in the early 1970s at the University of Wisconsin-Madison in the US (exoskeleton is second robot in the video below. It is shown after around 2 minutes).
Because of the technical limitations of their time, and the lack of experience and knowledge, it still took several decades until the technology matured and the first exoskeletons were ready for the market.With the beginning of the 21st century, the first exoskeleton products made their way to the market and are accessible to an increasing number of users. One of the first applications was gait rehabilitation in stroke and spinal cord injured patients. An early example is the gait rehabilitation exoskeleton Lokomat that was released in 2001 and is used in hospitals and rehabilitation centers worldwide. In 2013, the company behind the Lokomat (Hocoma AG) announced the shipment of the 500th device.

Development continued in the first decade of the 21st century at an increasing number of research labs and companies. Towards the end of the decade, several prototypes of military exoskeletons that aim to augment their user's strength and endurance were presented.
Examples are the Raytheon XOS exoskeleton, which is a full body exoskeleton, and Lockheed Martin's "Human Universal Load Carrier" (HULC) that supports its users to carry a heavy backpack.
Since 2010, several gait assistance and restoration exoskeletons have been presented and gradually introduced to the market. Most of them are designed to enable paraplegic users to leave the wheelchair and walk upright with the support of the device. Examples are the Rewalk device (ReWalk Robotics), and the Indego exoskeleton (Parker Hannifin) that is based on a research system from Vanderbilt University.
More and more of these exoskeletons receive certification (for example, CE in Europe or FDA in the US) for clinical use and also for use outside of medical facilities, which is an important step towards the home market. In September 2016, the company ReWalk announced the 100th exoskeleton delivered for home use.
Besides medical and military applications, several companies started developing exoskeletons for industrial use and just recently (around 2014-2015), the first systems were introduced.
Especially for this application, passive systems (not actuated) are increasingly popular, as actuators are not necessary to relieve the exoskeleton user of a payload or bodyweight. For certain applications, even single articulated exoskeletons (only one joint) are sufficient to provide support. This results in devices that are lighter and cheaper than their actuated counterparts.
In an effort to further reduce constraints that can be caused by the size, weight and rigid structure of exoskeletons, the concept of exosuits has emerged in the past couple of years. These soft, robotic devices are primarily made of textiles and can be worn like clothes. They provide support by actuated cables that are integrated into the textiles, or by soft and lightweight actuators (e.g., special pneumatic actuators) situated at the joints.
Pioneering work was conducted by the Wyss Institute at Harvard University that developed exosuits to support walking. Today, several research labs around the world are developing exosuits. In 2017, Rewalk Robotics announced that it licensed the Harvard exosuit technology and plans to release the first exosuit for stroke patients in 2018.
In addition to all the development efforts, exoskeleton producers started to promote their systems to a wider audience to demonstrate their capability and increase awareness. In 2012, Claire Lomas, who has paraplegia, used a ReWalk to participate in the London marathon and crossed the finish line after 16 days. In 2016, she participated in a half marathon and finished after 5 days.
In 2014, a paralyzed exoskeleton user executed a symbolic kick-off at the World Cup in Brazil. He was assisted by a 'mind controlled' (EEG controlled) exoskeleton that was developed as part of the Walk Again project
In October 2016, ETH Zürich in Switzerland hosted the first Cybathlon, a sporting competition for people with disabilities using robotic assistive aids. One discipline was an exoskeleton race on an obstacle course for people with paraplegia (called pilots). At this demonstration of pilot skills and technology, the exoskeleton users had to solve tasks such as sitting down on a couch and standing up again, walking up and down slopes, stepping on stones (like you would cross a shallow mountain river) and conquer stairs. None of the participating pilots was able to solve all obstacles, and it took the fastest teams more than 8 minutes to finish the 50 m long obstacle course. The next event has already been announced and will take place in 2020. It will show what progress has been made since. This look back shows that exoskeletons have been around for quite some time, but only recently the developments in the field of robotic exoskeletons really took off and the first systems became available outside of research labs. While today many systems are still limited in their performance, it will be very exciting to see where the technology goes and what opportunities it will present in the future.

1.2 Objective

- To increase the efficiency of a human being by increasing their overall strength and endurance.
- On a whole, this exoskeleton will be useful to develop the main three sectors of a country's development- Medical, Industrial and Military.
- These three sectors if developed properly, contribute to the overall development of a country.
- An easy and safe way of living will thus conclude to a harmonic lifestyle.

1.3 Applications

- **Medical**
- **Industrial**
- **Military**
- **Facial Recognition and Surveillance**
- **Non-Lethal Weapon System to tackle hostile situations**

2. Equipment Description

2.1 Solar Panels

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged, connected assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications.
Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 Watts (W). The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 W module will have twice the area of a 16% efficient 230 W module. There are a few commercially available solar modules that exceed efficiency of 24%

2.2 Sensors

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing.

2.2.1 Proximity sensor

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact.
A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive proximity sensor or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between the sensor and the sensed object.
Proximity sensors are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings.

2.2.2 Light sensor

A Light Sensor generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called “light”, and which ranges in frequency from “Infra-red” to “Visible” up to “Ultraviolet” light spectrum.
The light sensor is a passive devices that convert this “light energy” whether visible or in the infra-red parts of the spectrum into an electrical signal output. Light sensors are more commonly known as “Photoelectric Devices” or “Photo Sensors” because the convert light energy (photons) into electricity (electrons).
Photoelectric devices can be grouped into two main categories, those which generate electricity when illuminated, such as Photo-voltaic or Photo-emissive etc, and those which change their electrical properties in some way such as Photo-resistors or Photo-conductors.

2.3 Arduino control panel

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical and digital world. Its products are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form or as do-it-yourself (DIY) kits.
Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or breadboards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using raditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

3. CONCLUSIONS

On a whole, this exoskeleton will be useful to develop the main three sectors of a country’s development- Medical, Industrial and Military. These three sectors if developed properly, contribute to the overall development of a country. An easy and safe way of living will thus conclude to a harmonic lifestyle. All the research done in this field helped a lot in various aspects of designing and optimising the suit and finally a much easy to handle design was created. We took inspiration from the best features of all these suits and combined to form a totally different entity capable of doing various functions of these suits.

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