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SUPERNUMERARY ROBOTIC LIMBS FOR DISABLED HUMANS USING PNEUMATIC POWER SOURCE

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Abstract—The handicapped or old aged people are hard to sit in the environment. This project presents a new type of supernumerary robotic limbs (SRL) that supports the human body when performing tasks in dangerous environments or when taking postures that are fatiguing and uncomfortable against floors, walls, and surrounding structures so that the human can perform a task safely, comfortably, and stably. Robot is a machine that collects the information about the environment using some sensors and makes a decision automatically. People prefer it to use in different field, such as industry, some dangerous jobs including radioactive effects. Here a Robotic limb is attached in a human body. It has a free rotating joint helps for to sit them. This movement is usually driven by a pneumatic method. The SRL is worn around the waist and can brace the human body by making contact with a wall, grasping a rail, or being anchored to the floor.

***Index Terms*— Human support, Pneumatics, Wearable extra limbs.**

I. INTRODUCTION

There has been much investigation on the applications of automation and robotics in building structure. Robots can be used to substitute human works in a dangerous environment. One way to increase the efficiency of whole construction works is to support a single worker to complete a job that originally needs two or more workers to cooperate. Most of such manual works in the construction site require at least two people to cooperate each other to complete the job properly. In this circumstance, the main method is usually done by one person and the others perform supporting jobs. Thus, if robots are able to help the main process autonomously, the manual works can be carried out by one worker and the construction efficiency will be better. Many kinds of robots for different dedications have been investigated and among them, wearable ones have developed as one of the hopeful robots with diverse abilities.

A typical wearable limb which is normally used to support human in the part of power. In this project a new kind of robot named SRL (Supernumerary Robotic Limbs) has been proposed. The main difference between the exoskeleton and the SRL is that the SRL have capability to be operated independently of human arms. Therefore, the SRL can be applied to a work that needs multitasking rather than power supportive. With this fact, the SRLs are able to help a single worker to achieve the main process and supporting tasks concurrently which will result to enhancement in efficiencies of the construction works. In this project, in order to consider applicability of the SRL to construction works in terms of multitasking, pneumatic method to operate the limbs were designed.

II. RELATED WORK

2.1 Pneumo Algorithm

Pneumatics is a branch of engineering that makes use of gas or pressurized air. Pneumatic logic systems sometimes called air logic control)are sometimes used for controlling industrial processes, consisting of primary logic units like: And Units, Or Units, 'Relay or Booster' Units, Latching Units, 'Timer' Units. Pneumatic systems used in industry are commonly powered by compressed air or compressed inert gases. A centrally located and eletropowered compressor powers cylinders, air motors, and other pneumatic devices. A pneumatic system controlled through manual or automatic solenoid valves is selected when it provides a lower cost, more flexible, or safer alternative to electric motors and actuators. Pneumatics also has applications in dentistry, construction, mining, and other areas.

Advantages of pneumatics are Simplicity of design and control—Machines are easily designed using standard cylinders and other components, and operate via simple on-off control. Reliability—Pneumatic systems generally have long operating lives and require little maintenance. Because gas is compressible, equipment is less subject to shock damage. Gas absorbs excessive force, whereas fluid in hydraulics directly transfers force. Compressed gas can be stored, so machines still run for a while if electrical power is lost. Pneumatic logic is a reliable and functional control method for industrial processes. In recent years, these systems have largely been replaced by electronic control systems in new installations because of the smaller size, lower cost, greater precision, and more powerful features of digital controls. Pneumatic devices are still used where upgrade cost, or safety factors dominate.

Safety—There is a very low chance of fire compared to hydraulic oil. Newer machines are usually overloading safe.

Pneumatic actuators offer several advantages over electromechanical and hydraulic actuators for positioning applications. Nonetheless, pneumatic actuators are subject to high friction forces, which make fast and accurate position control to achieve. This project presents the process of controller identification, design, modeling and control for pneumatic actuator system. System Identification approach is used with the purpose to estimate the mathematical model of pneumatic actuator system and for controller design. Different control schemes such as PID and LQR (Linear Quadratic Regulator) have been applied for controller design. PID controllers with Ziegler Nichols tuning are enabled to provide good performance in various systems. Different external loads are added in order to investigate the effectiveness to the designed controllers in real time system. The tracking performance of this pneumatic system is satisfied which offers considerable robustness even on a slight increase in load.

2.2 Null-Space Stabilization Algorithm

Two control methods for stabilizing the body support system are considered: one is null-space stabilization using Hessian matrices, and the other is joint servo stiffness, based on the Jacobian. A prototype robot is designed and tested. Potential applications of the SRL in diverse fields are discussed. Using the parameter values and the specifications of the above prototype system, the body support stiffness is computed to verify the analytical results. The sticks can bear the human load with no actuator torque be- cause of the non-back drivable actuators.

To quantify the effectiveness of the null-space stabilization, the difference between the matrix norm of the gain matrix without the null- space stabilization and that with the null-space stabilization is evaluated for the following diverse configurations.

2.3 Rope Access Algorithm

Rope access is a form of work positioning, initially developed from techniques used in climbing and caving, which applies practical rope work to allow workers to access difficult-to-reach locations without the use of scaffolding, cradles or an aerial work platform. Rope access technicians descend, ascend, and traverse ropes for access and work while suspended by their harness. The Petzl Shunt, a recreational climbing device, has been used successfully for many years for the safety back-up because it is positionable by the user, allowing it to be high above them at the work site and thus providing optimum protection. Concern over potential misuse and lack of user instructions or support for its use by Petzl has led to the development of other devices, including the Petzl ASAP, the DMM Buddy Catch and the Safe Tec Duck-R.

Sometimes a work seat may be used. The support of the rope is intended to eliminate the likelihood of a fall altogether, but a back-up fall arrest system is used in case of the unlikely failure of the primary means of support. This redundancy system is usually achieved by using two ropes a working line and a safety line. The safety device usually relies on friction transferred to the safety rope by means of a cam.

2.4 System overview

The system, named supernumerary robotic limbs (SRL), consists of additional robotic arms worn through a backpack-like harness. The artificial limbs coordinate with the users and help them perform complicated or fatiguing tasks.

Unlike lower exoskeletons, where served joints are attached to the human joints, the SRL is not kinematically constrained to the human limbs. The robotic limbs can take an arbitrary configuration, independent of the human limbs. This opens up the possibility of optimizing body support performance with respect to support stability, reduction of human effort, and reduction of energy consumption.

III.PROBLEM STATEMENT

In existing method, robots are typically used for industrial automation and play in environments that are separated from the range of human lives and activities. In existing single robot arm is adapted to optimize its operating area to allow full movement in this desired workspace. Existing robot is strictly limited by the angles through which the joints can rotate. Exoskeletons can be divided into two groups: rigid and soft systems. Rigid exoskeletons replicate the jointed structure of human bones, reducing the loads on the wearer [12]. The drawbacks are their weight and the fact that they tend to constrain human motion. Soft systems, on the other hand, do not get in the way of the user and are lightweight but apply additional loads to human joints

Workers often make use of passive support tools, such as stools and ladders. These tools can compensate for the weight of the user, but must be manually moved where needed. Moreover, they cannot assist the stability of the workers and do not protect them from falls and slips. Passive safety systems such as body harnesses, on the other hand, protect workers from falls but cannot increase their stability or reduce their workload and have a limited range.

The main disadvantages are these robots are not safe for operation in proximity to workers, less mobility, Operating Dangerous tools is more difficult and Operates only angle method.

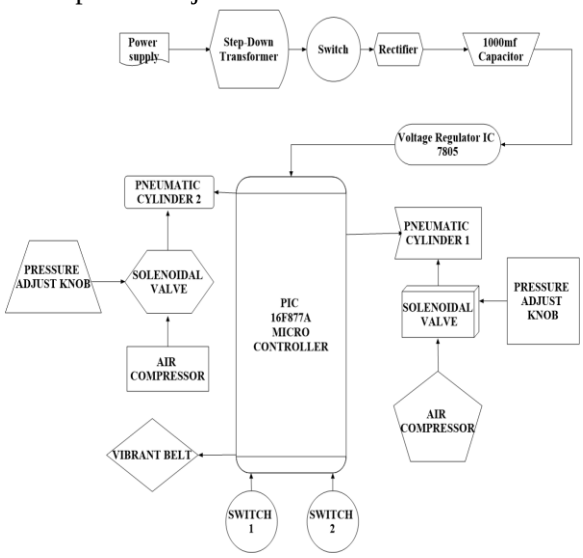
IV.SYSTEM MODEL

A.PROPOSED SYSTEM

Coming the increasingly aging humanities, robots that assist human activities in human daily environments such as in offices, homes and hospitals are expected. Especially, an emergence of human robots is strongly predictable because of friendly design,

applicability of movement, and so on. Human workers would greatly benefit from robots that are able to support and help them in the most fatiguing or dangerous tasks. Falls are the leading cause for injuries on construction sites and one of the major sources of risk in manufacturing facilities. Fatigue also results in decreased Productivity.

For all of these reasons, it would be highly beneficial if workers could make use of a wearable robot that is able to support them in the most difficult jobs, while also securing them to the environment in order to avoid falls. So in our project, we introduce a new kind of wearable robotic limbs designed to provide support and enhanced safety to manufacturing workers. The system, named supernumerary robotic limbs consists of additional robotic arms worn through a backpack-like join.



System Architecture

The proposed system consists of PIC16F877A microcontroller, power supply unit, pneumatic cylinders, air compressor, solenoidal valve and a vibrant belt.

There are 40 pins of this microcontroller IC. It consists of two 8 bit and one 16 bit timer. Capture and compare modules, serial ports, parallel ports and five input/output ports are also present in it. It also has 200 nanosecond instruction executions. The PIC16F877A features 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions.

Pneumatic cylinders also called as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, this piston rod transfers the force it develops to the object to be moved. It has two types, single acting and double acting cylinders.

Solenoid valves are the most frequently used control elements in fluidics. A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid in a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design. The plunger-type actuator which is used most frequently, pivoted-armature actuators and rocker actuators are also used.

An air compressor is a device that converts power using an electric motor, diesel or gasoline engine, etc. into potential energy stored in pressurized air (i.e., compressed air). An air compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank. When tank pressure reaches its upper limit the air compressor shuts off. The compressed air, then, is held in the tank until called into use. The energy contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is

released and the tank depressurizes. Compressors can be classified according to the design and principle of operation as Rotary screw compressor and Turbo compressor. It can also be classified according to the pressure delivered, High-pressure air compressors, which have a discharge pressure above 1,000 psi. Medium-pressure compressors which have a discharge pressure of 151 psi to 1,000 psi and Low-pressure air compressors, which have a discharge pressure of 150 psi or less

B.DESIGN CONCEPT

The system consists of a pair of robotic limbs, a harness, and a control unit. Each robotic limb has three degrees of freedom (DOFs), allowing the endpoint to reach an arbitrary position in space. The harness secures the robotic limbs to the hip bone of the user. As the primary objective of this robot is to provide support, it is reasonable to place the robot at the waist, which is simultaneously near the body's center of mass and will not interfere with upper body motion. Multiple straps are used for securing the harness that extends to the thighs and shoulders. One of the major functional requirements for the SRL is to bear a large load for a long time while using minimal energy. A prismatic joint with a high gear ratio is not back-drivable; hence, it can bear a load without consuming energy.

The input 230v AC voltage applied to the step-down transformer it step down into 12v AC. The switch is connected with secondary side of step down transformer. Bridge rectifier analog input is connected to the switch and positive and negative edge is connected to the 1000mf ceramic capacitor which is used to filter the harmonics in a power supply line. Capacitor is connected to the 7805 voltage regulator, which has 3 pins. First pin is 12v input pin, second pin is ground pin and third pin is 5v output pin is given to PIC16F877A microcontroller. Vibration belt is connected to human body, which is used to relax the muscles. Air compressors at the both sides are used to provide a compressed air to pneumatic cylinders 1 and 2 through solenoid valve. This compressed air is adjusted by a pressure adjust knob which is placed at both sides of human limbs. By using switches we can adjusts our limb positions at different angle levels. Once the prismatic joint is fixed at a certain length, it serves as a stick. Consequently, most of the load is borne in the longitudinal direction of each stick, the Orientation of which is varied with two revolute joints placed on the base of the robot closer to the harness.

The SRLs support the body from the floor to reduce the load on the knees and ankles. These body suspension applications can be found in various factory works, including aircraft fuselage assembly and automobile assembly, as well as in construction and field works.

CONCLUSION AND FUTURE WORK

The supernumerary robotic limbs (SRL) with high-force prismatic joints has been developed for supporting the wearer's body in taking fatiguing postures or working in a dangerous environment and for the disabled people who cannot sit and stand in the environment using pneumatic method. SRL system can support a human with tunable body support stiffness; therefore, the human can change the posture freely and stably. With the active joints, the SRL can also lift or lower the body for assisting the human in crouching and standing repeatedly.

In future, the system will implement the real time robotic limbs which operating through pneumatic method. Then we can lift or handle the task efficiently. It is important to overcome most difficult tasks for the disabled people and protect them from dangerous tasks like climbing stairs.

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