Exoskeleton Arm

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Abstract— **The exoskeleton is getting important to humans in many aspects such as power assist, muscle training, pneumatic functioning and rehabilitation. The research and development towards these functions are expected to be combined and integrated with the human intelligent and machine power, eventually becoming another generation of robot which will enhance the machine intelligence and human power. The designing of fully functioning motorised prosthetic arm with coordinating speed of response and strength is the aim of upper extremity prosthetics research. The current state-of-the-art prosthesis can be considered to be a tool rather than an upper limb replacement. The prosthesis is the device which can be worn as per will and can be removed when not wanted. The major factors limiting pneumatic prosthesis to tools are practical ones due to the heavy weight, less power, and size of the component as well as the difficulty in finding appropriate control sources to control the number of degrees of freedom. The exoskeleton also finds its application in physically weak people to regain their power they lost after stroke. This project reviews the upper extremity exoskeleton with different functions, actuators and degree of freedom (DOF). Among the functions, power-assist and rehabilitation have been highlighted In addition; the structure of exoskeleton is separated by its DOF in terms of Upper extremity. This paper reviews the upper extremity exoskeleton with different functions, actuators and degree of freedom (DOF). Among the functions, rehabilitation and power assist have been highlighted In addition, the structure of exoskeleton is separated by its DOF in terms of shoulder, elbow, wrist and hand.**

Index Terms: **Exoskeleton, Power-assist, Rehabilitation and Upper extremity.**

I.INTRODUCTION

An exoskeleton consists of structure and joints that are very much similar to the human anatomy. It will adjust with an individual and such that the physical contact between the administrator and the exoskeleton empowers an immediate exchange of mechanical force and data signals. Similarly, it gives a compelling interface between the mechanical structure and the upper limb of a person. The designing of fully functioning motorised prosthetic arm with coordinating speed of response and strength is the aim of upper extremity prosthetics research. Unfortunately, current prosthetic arms and collaborating techniques are still a long way from this aim. The current state-of-the-art prosthesis can be considered to be a tool rather than an upper limb replacement. Many efforts in this field are taken to make pneumatic prosthetic as an ideal upper limb replacement, however, current prosthetic arms are limited to be used as tools. The major factors limiting pneumatic prosthesis to tools are practical ones due to the heavy weight, less power, and size of the component as well as the difficulty in finding appropriate control sources to control the number of degrees of freedom. Of these the important drawback is the latter one. As a result, upper- limb prosthetics research is dominated by considerations of appropriate controls for controlling the degrees of freedom. Still, the importance of better pneumatic actuators and better multifunctional mechanisms cannot be ignored

Main Objective of our Project

- The major objective is to create an exoskeleton that enables the movement of the upper limb including the motions of the elbow, forearm and shoulder.
- To design and fabricate a motor powered human exoskeleton for one arm to assist the physically weak individuals.
- To reduce the size and weight of the device to prevent the fatigue of the user.
- To preserve the comfort of the user and to prevent any injuries or discomfort.
- To eliminate the external voice interfaces.
- To ensure that the arm is cost effective and available to the general masses.

- To manufacture an economic, portable, reliable, stable and ergonomic human exoskeleton arm.

The remainder of the paper was organized. Parts of the system include Chapter I: Introduction, Chapter II: Literature Review, Chapter III: Methodology, Chapter IV: Results and Discussion, and Chapter V: Conclusion. This section concludes the references section.

II. REVIEW OF LITERATURE

Z. Li, W. Zuo, S. Li., " Zeroing dynamics method for motion control of industrial upper-limb exoskeleton system with minimal potential energy modulationAccurate motion control of industrial upper-limb exoskeleton can provide efficient assistance for subjects to perform various industrial manipulation tasks. In most motion control scenarios of upper-limb exoskeletons, the variations of potential energy frequently reach to a high level of oscillations, leading to the reconstructed motion uncomfortable or dangerous. In this paper, in order to achieve minimal potential energy variation and accurate motion control of the upper-limb exoskeleton, we propose a novel motion planning strategy with minimal potential energy modulation. Such motion resolution scheme is formulated as an optimization problem and solved by the zeroing dynamics (ZD) to achieve elegant global convergence. Simulation and experiment results show that the potential energy variation range of the upper-limb exoskeleton can be significantly decreased by average 99.34 in both X-Y and X-Z planes, in addition to finishing tracking the desired motion path accurately. All of these demonstrate that the efficiency and superiority of the proposed method for potential energy minimization during achieving accurate motion planning and control.

M. A. Gull, S. Bai and T. Bak., "A review on design of upper limb exoskeletons".Exoskeleton robotics has ushered in a new era of modern neuromuscular rehabilitation engineering and assistive technology research. The technology promises to improve the upper-limb functionalities required for performing activities of daily living. The exoskeleton technology is evolving quickly but still needs interdisciplinary research to solve technical challenges, e.g., kinematic compatibility and development of effective human–robot interaction. In this paper, the recent development in upper-limb exoskeletons is reviewed. The key challenges involved in the development of assistive exoskeletons are highlighted by comparing available solutions. This paper provides a general classification, comparisons, and overview of the mechatronic designs of upper-limb exoskeletons. In addition, a brief overview of the control modalities for upper-limb exoskeletons is also presented in this paper. A discussion on the future directions of research is included.

Caraiman. S et al., "Computer vision for the visually impaired: the sound of vision system". This paper describes a perceptual displacement device for the sight handicapped based on computer vision. Its primary goal is to provide users with a three-dimensional depiction of the surroundings around them, which is delivered through the audible and tactile senses. One of the most difficult tasks for this network is to provide pervasiveness, or the ability to work in any inside or outside location and under any lighting condition. This paper explains the equipment (3D competitive bidding) and programming (3D processing pipeline) utilised to create this sensory substitution device, as well as how it can be used in different contexts. Preliminary usability testing with blind users yielded positive findings and provided useful suggestions for system improvement.

S. Alabdulkarim and M. A. Nussbaum., "Influences of different exoskeleton designs and tool mass on physical demands and performance in a simulated overhead drilling task". In this paper they compared different passive exoskeletal designs in terms of physical demands (maximum acceptable frequency = MAF, perceived discomfort, and muscular loading) and quality in a simulated overhead drilling task, and the moderating influence of tool mass (∼2 and ∼5 kg). Three distinct designs were used: full-body and upper-body exoskeletons with attached mechanical arms; and an upper-body exoskeleton providing primarily shoulder support. Participants (n = 16, gender-balanced) simulated drilling for 15 min to determine their MAF, then maintained this pace for three additional minutes while the remaining outcome measures were obtained. The full-body/upper-body devices led to the lowest/highest MAF for females and the lowest quality. The shoulder support design reduced peak shoulder muscle loading but did not significantly affect either quality or MAF. Differences between exoskeleton designs were largely consistent across the two tool masses. These results may be helpful to (re)design exoskeletons to help reduce injury risk and improve performance.

P. Maurice, J. Čamernik, D. Gorjan, B. Schirrmeister, J. Bornmann, L. Tagliapietra, et al.., "Evaluation of PAEXO a novel passive exoskeleton for overhead work". Work-related musculoskeletal disorders (WMSDs) are the first cause of occupational diseases in developed countries and represent a major health issue and an important cost for companies (Parent-Thirion et al. 2012). WMSDs develop when biomechanical demands at work repeatedly exceed the worker's physical capacity (e.g., extreme postures, high efforts). Overhead work has been identified as a major risk factor for shoulder WMSDs (Grieve and Dickerson 2008). Even without external load or force exertion, supporting the arms' weight imposes prolonged stress on shoulder muscles. Yet overhead work remains very common on assembly lines, especially in the automotive and aerospace industries. One solution to physically relieve workers while keeping them in control of the task execution is to assist them with an exoskeleton.

III. PROPOSED WORK

We can see how the approaches are employed to show the system's result in our proposed way. The mechanical design of the proposed methodology consists of Aluminium framework Mechanical design has been designed with the criteria such as with proper weight, easy replacement of parts and maintenance and easy assembly .The mechanical system is able to adjust its size and is portable .It is designed with a three sections including shoulder, elbow and wrist. Exoskeleton transmits torques to the joints by means of actuators allocated in its mechanical structure. The light weight model provides low mass and inertia to the system. The actual human arm comprises of 3 dof in the shoulder, 2 D in the elbow .Appropriate antagonistic torque has been produced by providing joint motion on the exoskeleton .Various hardware tools are embedded with mechanical model. It includes Arduino microcontroller, relay, fasteners, lead acid battery, DC geared motor along with the blue tooth module.

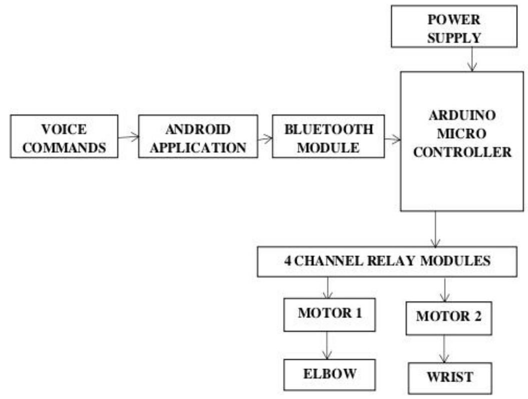

Figure 1 Architecture Diagram of Proposed method

In our project, we may use the six modules to display the system's results in an efficient manner. Modules are following as,

- Voice commands
- Android application
- Bluetooth module
- Arduino microcontroller
- Motor
- Power supply

Voice commands: The voice inputs are given through a microphone to the voice recognition module. The main aim of this project is that it can be very useful for paralyzed people or people with motor impairments. The appropriate words to be recognized are first trained by the user using the speech recognition module. The words are stored in numbers ranging from 1 to 9 which is displayed on the 7-segment display. During working, when the user says a particular trained word into the microphone of the speech recognition module, the words are recognized by it and the corresponding BCD of the number in which the word is stored is taken out as the output.

Android application:In this project an android mobile is used to control and communicate with arduino. Here the bluetooth module acts as an interface between our mobile and Arduino board.

Bluetooth module: Before getting into the execution process, the following procedure is followed

- First of all, the user should install an application called Bluetooth SPP PRO from the play store which is a free application.
- After installation, pair the bluetooth module to your mobile as like connecting one device to

other using bluetooth. The default pairing code is 1234.

- Upload the given program to the Arduino Uno board. After uploading the code, unplug the USB from the arduino.
- Now use external power adapter to power the Uno board.
- The Bluetooth SPP PRO has three types of communication mode. Here Byte stream mode is used to communicate. So select that mode and give the input as 1, as soon as the input has given the led will turn on and for 0 led will turn off.

Arduino microcontroller: The digital output corresponding to the voice command is provided to the microcontroller (it requires an external power supply of 5V). Microcontroller will generate the control signals to operate the four motors of the robotic arm. These signals are given to the motor drivers (to meet the additional power requirements of the motors). Motor drivers control the direction of rotation of the four motors.

Motor: Here in this project DC motors are used. After implementing the Project we will give the voice commands for the exoskeleton arm through the Bluetooth- Arduino Android Application the Bluetooth module HC-05 will get activated and sends a signal to the Arduino Micro controller, The Micro controller receives the signal from HC-05 transmitter according to the voice commands the relay will get activated and the motor in the elbow and wrist start working, here the relay will acts like a switch.

Power supply: For working of this system external 5V power supply will be required that will provided through the Battery.

IV. RESULTS AND DISCUSSION

The practical results acquired while carrying out the project are discussed in this chapter. The hardware structure of our proposed approach of the system is shown in Figure. It depicts the suggested method's hardware block diagram

Figure Hardware Diagram of our Proposed method

The working of the system is described in the following paragraph. The voice inputs are given through a microphone to the voice recognition module. The digital output corresponding to the voice command is provided to the microcontroller (it requires an external power supply of 5V). Microcontroller will generate the control signals to operate the four motors of the robotic arm. These signals are given to the motor drivers (to meet the additional power requirements of the motors). Motor drivers control the direction of rotation of the four motors. After implementing the Project we will give the voice commands for the exoskeleton arm through the Bluetooth-Arduino Android Application the Bluetooth module HC-05 will get activated and sends a signal to the Arduino Micro controller, The Micro controller receives the signal from HC-05 transmitter according to the voice commands the relay will get activated and the motor in the elbow and wrist start working, here the relay will acts like a switch. For working of this system external 5v power supply will be required that will provided through the Battery.

Controllability and accuracy of the exoskeleton prototype section presents the most important preliminary verification results obtained by testing the functional characteristics of the exoskeleton prototype in a controlled laboratory environment. The main objective is to gain a proof-of-concept validation of the described technologies integration, as well as a preliminary insight into the controllability and accuracy of the established hierarchical control architecture. The stability and reliability of the exoskeleton in all its aspects are correlated with patient safety and the potential feasibility of using this exoskeleton prototype in diagnosing and assisting.

The modular nature and architecture of the exoskeleton allow it to be adapted to different anatomies, making it a wearable system that is straightforward to attach or detach. Thanks to the materials used, the flexibility, and the attachment method, the exoskeleton can be put on and taken off several times without changing its mechanical properties. Figure shows the placement of the exoskeleton prototype.

Figure Wearing of the exoskeleton prototype

The test performed on the Autonomous Mode Controller (AMC) corresponds to the tracking of a sinusoidal waveform trajectory pre-programmed in the exoskeleton, where the amplitude range is between 0° (maximum extension) and 90°. The waveform is defined by a binary file, with a sampling rate of 120 Hz. The objective of this test is to determine the motion accuracy under two different speed settings, to measure the average response time of the actuation system, and to check the performance of the overall control architecture. The results are presented in the Figure.

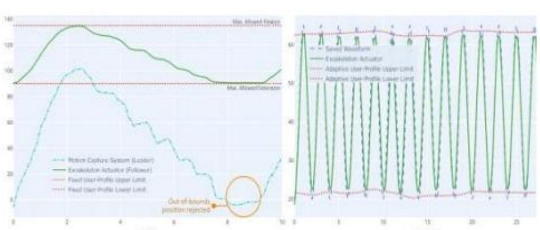

Figure Autonomous Mode Controller using sinusoidal wave

As a demonstration of the main safety system of the exoskeleton prototype, some tests have been carried out to show its operation. It should be noted that this system is always operational (unless otherwise configured) during any of the operation modes, as the control signals must be verified before continuing to the final joint driver. Figure shows some of the validations performed. For the case of the first test, the limits have been set in the user profile to allow for maximum flexion-extension between the ranges of 90° to 135°. After a training process, the system determines how to perform the transformation between the joint amplitude provided by the motion capture system and its correspondence between the limits set above. It is concluded that this system works correctly for all test cases.

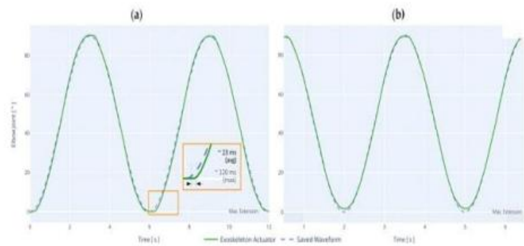

Figure Main safety system tests

The figure below shows the android application that is used to control the exoskeleton arm.

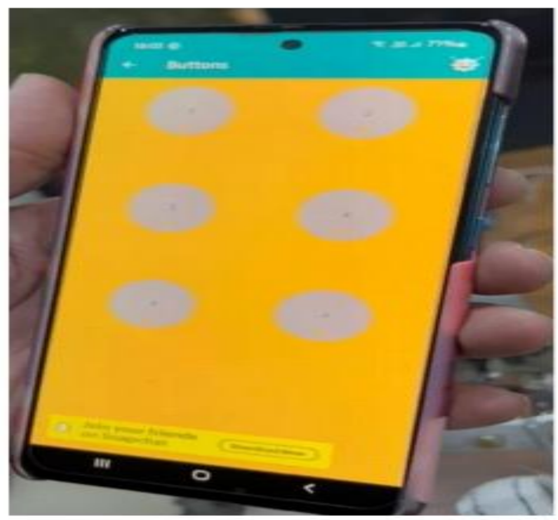

Figure Android Application

The circuit presented in Figure are the connections made for the fabrication of voice operated motorized exoskeleton arm.

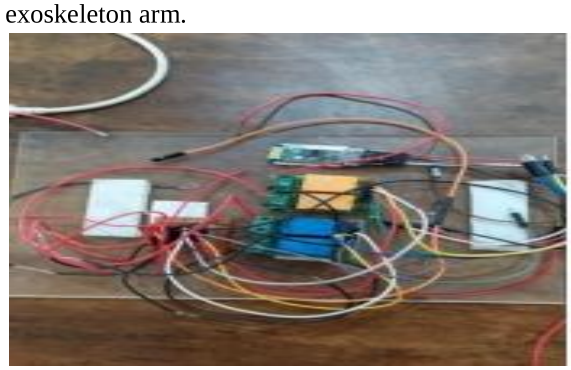

Figure Circuit connections

The Figure shows the fully constructed exoskeleton arm.

V.CONCLUSION

Thus in this project an exoskeleton is made which is used for two main reasons that is for rehabilitation and as mobility aid is created. The exoskeleton serves as an outer framework that can be worn on a biological arm. It is powered by actuators and can provide assistance or increase the strength of the biological arm, depending on the power of the actuator. They are also helpful in rehabilitation, training and therapy.

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