Enhancement of ergonomic wearable chair with voice controlled using Raspberry pi

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Abstract. Ergonomics is the designing of products and systems that suit a range of people who use them. The Ergonomically designed wearable chair ensures the ability of the user to sit and stand anywhere. It provides the convenience and required posture for their workplace thereby overcoming disabilities caused due to long hours of standing and sitting. This device increases the efficiency of the user by reducing tiredness, pain in the lower back, leg and ankle region. Enhancing the wearable device with voice control will facilitate the operation of the system and provide automatic control over the device. The chair is wearable due to its exoskeleton-like design and portable due to its lightweight arrangement. This paper elaborately explains the design, mechanism, and application of the wearable ergonomic chair with voice automation. Future developments and challenges are also discussed in this paper.

Keyword: ergonomic, wearable, chair, voice, control, raspberry pi 3

1. Introduction
It is a known fact that necessity is the starting point for all inventions. Energy is the fuel for productivity. In today's fast-growing world, a person spends most of their energy at work. Sometimes they tend to work overtime. Putting for long hours in their work tends to cause physical as well as mental problems. Sitting and standing postures for long periods come under sedentary behaviors. This behavior leads to health issues like back pain, musculoskeletal disorder, cardiovascular diseases, etc.; also It is a proven fact that sitting and standing for too long can reduce life expectancy. Such kind of problems affects the productivity of the organization where they are working. A recent survey among the workers shows that 61 percent of them are working below their energy level; this is mainly due to prolonged standing. Many industries have been trying to solve this, by replacing the human force with machines. But with this replacement, the industries faced even greater problems such as maintenance, power shortage, etc.

It nearly took 20 years for researchers to seek a solution to solve the productivity problem in industries. Many solutions were brought forward by them but the problem still exists. So the engineers paved a way to an invention i.e. an intermediate device that helps the workers in both sitting and standing hence resulting in increased productivity. With the introduction of this invention, the purpose of conventional chairs has been rendered null and void. In this paper, we had renowned our invention with more sophistication by incorporating the voice module which enables the person to sit/stand easily. This device
is useful for surgeons who have to perform surgery for a long duration of time where both their hands will be busy. It is also useful for factory/industry workers who perform most of their tasks in a standing position. Since it’s an exoskeleton device it doesn't occupy much space like our conventional chairs. This device is power efficient, lightweight portable and walk able. In this paper, we have enhanced our base model [1], to further increase the features of the ergonomic device to adapt to the current trends of the society. Some of the health disorders and the proposed idea have been explained in detail below.

2. Musculoskeletal disorder
Operation Theater is a terrifying experience not only for patients but for surgeons too. They also experience a dreadful situation during surgery time. Out of 10, 9 surgeons experience musculoskeletal disorder shown in Fig 1; this is due to a continuous standing position during the surgery time [2]. There are cases where the surgeons have to perform surgery for more than 12 hrs. This leads to many health and mental illnesses. Since our energy is directly related to our production rate, to work efficiently one needs energy, decreases in time, lower the energy rate that in response lower the productivity. When it comes to surgeons it is very important to maintain the energy level, because they are lifesavers. They play a Nobel position in this society.

![Figure 1: Musculoskeletal disorder](image)

They are given a status next to god, so as a citizen and as an engineer it’s everyone's responsibility to find a solution for their problem. So this device that we have designed will be used for the people who stand for a very long time especially for the people who want to switch their positions between standing and sitting. It’s pretty much helpful for the surgeons because most of the time they have to use both their hands to perform surgeries in such circumstances since our device is voice automated it will be very useful for them. The main advantage of our device is that it doesn't occupy much space and it is a wearable, portable device so the user can walk easily. By using our device an individual’s energy expectancy can be maintained so that the productivity and efficiency of a person will be high for example if person works on an average of 8 hrs per day without our device will work for more than 2 hrs by using our device because their energy have been saved by using this device.

3. Varicose Disease
It is a disorder which happens in the vein near the superficial surface of the skin shown in fig2. This type of disorder is mainly due to high blood pressure Blood flows to the heart through a valve, when this valve becomes weak the blood will start accumulated in the vein which in turn swells the vein. The valve becomes weak when a person sits or stands for a very long time. This poolls the blood which is flowing through the leg. This type of disease affects your day today activity [3].
3.1 Symptoms of varicose disease

- Rashes
- Change of skin color
- Inflammation on the leg
- Burning sensation on the leg
- Aching of leg etc...
- Itching on the areas around the leg

3.2 Prevention

One can prevent varicose vein by improving the circulatory system and muscular tone. It’s very difficult for the blood to flow against the gravity. Which consequently pool the blood around the affected areas? There are some other ways in which we can prevent this disease.

- Regular exercise
- Changing the sitting and standing position often
- Avoid wearing heels and high shoe

Figure 2: Varicose veins [11].

4. Base Model Working Principle

Our base model is a flexible, portable, wearable device which covers the hip, back of the leg to our foot. User has to wear the device and shoes then they have to adjust the belts that are tied tightly, once all these process are done the person have to give a physical pressure to supporting rod that is placed in the butt region shown in Fig3.
There will be a piston attached to the leg like structure which is made up of stainless steel to sit, so while applying the pressure the piston will be compressed and the person will be able to sit, and for standing the person has to release the pressure from the supporting rod which is placed in the butt region so that the piston will expand and the person will be able to stand. With a support of our earlier designed model, we taught of enhancing the model with voice automations and other stuffs, the idea and working principle of our enhanced model is discussed below.

4.1 Working Principle of Enhanced Model
The enhanced version of our base model is also an exoskeleton, wearable, flexible device with voice automation to make it more easier and useful for the people who are standing for a very long time especially this voice automated chair will be useful for the surgeons [4], because there are situations where both their hands will be busy during the operation, so voice automated ergonomic chair will be helpful in such circumstances.

Once the device is booted by the battery, analog input i.e. (a continuous signal with a time varying feature) is given to the voice recognition module, this analog input is then converted into digital signals (in the form of 1’s and 0’s) These signals are then transmitted to the raspberry pi via a USB TTL module, it is a protocol converter which is used to convert the data to other communication standards. The signals are processed inside the raspberry pi (a versatile single board computer) and then the motors are controlled accordingly, using the relay controller, with respect to these the ergonomic device will be able to sit and stand according to the user’s desire.
5. Construction of the Ergonomic Wearable Chair

The construction of the ergonomic wearable chair consists of three parts:

I. The skeletal design
II. Voice recognition System

5.1 The Skeletal Design

The strength and balance of the wearable chair rely on the skeletal design of the device. The base of the skeleton is constructed with graded aluminum alloys used in aircraft. These alloys are light in weight and provide rigidity and durability. The positioning of the aluminum rods is very significant because of their major role in balancing the whole model. The skeletal design comprises two legs each containing two aluminum rods connected with the help of nuts and bolts. The connection between the two rods will bend exactly in the human knee position, making the device operate like an exoskeleton. So, when the user wants to sit or stand the rods are arranged in such a way it bends and straightens like the user's leg [5].

The linear actuator is the main component of this ergonomic wearable chair. The design consists of a linear actuator which has only two movements forward and backward, this is controlled by giving the DC power supply to the polarities of the motor.

The linear actuator is placed right behind the skeletal structure. When the actuator is energized forward the rod arrangement is expanded to make a person stand and when it is energized backward the arrangement is contracted to make a person sit. The linear actuator can carry up to 120kgs of load and requires a 12v DC power supply [9]. The belts are the next component in the design that is attached to the skeletal structure of the wearable chair to keep the device intact to the user's body. The belts are placed at the hip, thigh and ankle region to create a steady balance. The hip region's belt holds the whole device to
the body and contains spaces to place the batteries to run the actuators and electronic modules to automate the device with voice control. The ankle region's belt support will keep the device intact to the user by not letting the lower rod arrangements to leave away from the user's circumference. If required extra straps or belts can be attached from the lower body to the shoulders providing extra support.

5.2 Voice recognition System
It is a compact user-friendly device, it depends totally on a speaker to recognize the voice, and all types of sounds can be incorporated into the kit. Before recognizing the voice the user has to instruct or train the kit, the commands that we are instructing will be stored in a large set of the library [6]. It consists of the USB TTL module, which is just a USB (Universal Serial Bus) to serial TTL (Transistor Transistor Logic) converter which is built based on IC PL2303. This module can be used in all types of the operating system [7]. It can be used in all type of development boards to serially transmit through USB; this device does not require any external power source because it pulls the power from the pi itself.

The next component is the Raspberry pi which is manufactured in two ways they are A and B, A type of pi doesn't have an Ethernet port and it consumes less power whereas B type pi has an Ethernet. It is a minicomputer in series, it does all the functions that a computer does, it requires a SD card in which we have to install the NOOBS/RASPBEIAN and the pi is powered up by a USB it consumes a power of 3-5 V. CPU which is the brain pi is responsible for carrying the instructions through operations, it uses ARM11 processor [8]. GPU is a chip present in pi which speeds up the image calculation. A connection with raspberry pi to detect voice command is shown in Fig 5.

6. Comparison of Base and Enhanced Model
There are some major changes that have been implemented on our base model, which improves the efficiency and comfort of the user. Hence, the difference between the base and enhanced model are explained in the following table 1.
Table 1: Comparison of base and enhanced model.

| CONTENTS                   | BASE MODEL         | ENHANCED MODEL          |
|----------------------------|--------------------|-------------------------|
| Type of device             | Mechanical         | Electrical              |
| Weight                     | 6 Kgs              | 4 Kgs (excluding batteries) |
| `Material Used            | Stainless steel    | Aluminum graded alloy   |
| Compressing component     | Hydraulic piston   | Linear Actuator         |
| Accessibility              | Can walk up to few meters | Can walk easily        |
| Compressing type           | Physical pressure  | Automatic               |
| Balancing material         | Painters belt      | Lase like straps        |
| Shoes                      | Customized shoes are required | Can use their own shoes |
| Power consumption          | No power required  | Up to 12 v              |

7. Applications
- Doctors/Surgeons
- Factory Workers
- Applicable for patients suffering from Spastic Diplegia
- Can be used in Physiotherapeutic Exercises
- Industrial Employees
- Useful for people working in assembly lines and distributed systems
- Applicable in the field of hair-care services
- Designers and Artists
- It is also helpful for people working in the food industry such as chefs, etc.

8. Challenges
There are not many challenges in this proposed model. The main challenge is the cost of the device since it will be more expensive than the conventional chairs. In this model, the fame will be light weight but with the inclusion of batteries it will get little heavier. Finally, the most basic challenge is the stability of the model, due to the placement of the linear actuator the balancing capacity of the device will be less.

9. Conclusion
"Too much of anything is good for nothing" is a quote that suits the condition where people work long hours standing or sitting. This proposed model will ensure that the above criterion could be managed. Invention is the key to change; this proposal can bring a change in every possible workplace by increasing the efficiency and convenience of the worker.
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