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SMART CHAIR FOR WORKING CONDITIONS OPTIMIZATION

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Abstract:

There is a growing tendency for people to spend more and more hours of their day sitting. This position leads to an increase in the postural problems in the population. For workers who have to spend long hours at work, in a seated position, investment should be directed towards the development of equipment that improves their working conditions, such as smart instrumented chairs with warnings of changes in position. With this work we propose a standard office chair instrumentation approach, designed to allow monitoring physiological parameters such as: posture of the seated person (user); body temperature; and respiratory frequency. The system also allows monitoring environmental parameters such as: temperature; relative humidity; atmospheric concentration of carbon dioxide (CO_2); noise; and light levels. The chair enables the interaction with control equipment to adjust the comfort level, advising the need for rest time, repositioning notifications, and the real time visualization of data, using applications for Windows and Android. The system was tested by six users and evaluated in the detection of six different postures for each user, while sitting on the chair, presenting an 100% accuracy on the posture detection and a maximum of 18% error on the physiological parameters sensing. Experimental results show the adequate functionality of the instrumented chair, which could contribute to the prevention of pathologies associated with improper posture and the improvement of work productivity

Introduction:

Nowadays, there is a predominance of office work and with this comes an increasingly sedentary lifestyle, which has become a problem of extreme effects, as it is a leading factor in the appearance of a wide range of pathologies [1], [2]. People remain seated for excessive periods of time, both during leisure time (due to the spread of electronic entertainment, such as streaming platforms and video games) and education/work, often spending more than 15 hours per day in a seated position [3]. With the increasing tendency to stay in the sitting position for a long time, many people who suffer from back pain believe it is aggravated by their office seating conditions and sedentary lifestyle [1], [4], [5]. It has been proven that back pain is more common between the ages of 25 to 45 years old, in both genders, thus affecting people in their peak of productivity [5].

Spinal disorders are the second leading cause of requests for medical leave from work and even the reason for early retirement; consequently, they create significant losses to the economy [5], [6]. For all these reasons, many experts believe that more attention should be given to this problem, which should be studied as a social disease. Early detection and prevention can be fundamental in mitigating such problems, which can be achieved by monitoring seated people and advising about the suitable positions to be adopted. The seated body posture has been classified in different ways by different authors [5], [6]. There are several clinical opinions on the categorization and classification of correct and incorrect postures. Although there is not a broad basis to define it quantitatively, it can be described qualitatively based on spinal curvatures [7].

Scope of the Project:

The Smart Chair project holds significant potential for expansion and real-world application. Several avenues can be explored to enhance its functionality, reliability, and user experience:

1. **Integration with AI and Machine Learning:**
   - Implementing AI algorithms to analyze posture data over time can help predict musculoskeletal issues and recommend personalized ergonomic practices.
   - Machine learning models can learn user habits and adjust alert frequency or sensitivity accordingly.
2. **Advanced Biometric Monitoring:**

- Future versions of the chair can incorporate biometric sensors (e.g., heart rate, body temperature, oxygen saturation) to assess stress and fatigue levels.
- Integration with wearable devices for comprehensive health monitoring.

3. **Adaptive Design and Actuation:**
    - Incorporating motors or actuators to automatically adjust seat height, backrest angle, or lumbar support based on user posture and preferences.
    - Smart material use (e.g., shape memory alloys) for responsive seating adjustments.
4. **IoT and Cloud Connectivity:**
    - Cloud integration to store and analyze data across multiple users or workspaces.
    - Real-time remote monitoring for corporate wellness programs or occupational health management.
5. **Voice and Gesture Control:**
    - Enabling users to interact with the chair via voice commands or hand gestures for ease of control without interrupting work.
6. **Gamification and Motivation:**
    - Adding gamified elements or reward systems to encourage regular breaks, proper posture, and consistent use of ergonomic features.
7. **Extended Use Cases:**
    - Application beyond offices to settings like remote work, call centers, control rooms, or even educational environments for students.
    - Potential for smart wheelchair designs in healthcare applications.
8. **Sustainability and Power Efficiency:**
    - Exploring energy-efficient designs and power sources such as solar-powered components or kinetic charging from user movement.

Proposed System:

The proposed smart office chair is equipped with sensors and technology to monitor the user's posture, adjust seating position, and optimize comfort based on real-time data. It aims to improve ergonomics, reduce strain, and enhance overall working conditions for better productivity and health.

Block Diagram:

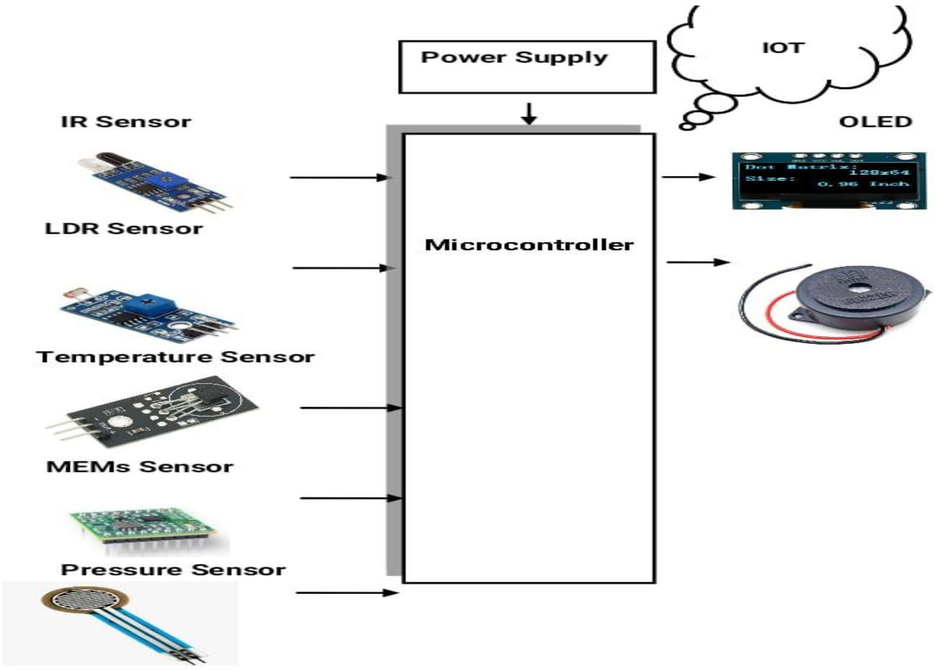

Fig : Block Diagram

HARDWARE TOOLS:

Power Supply:

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V.The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

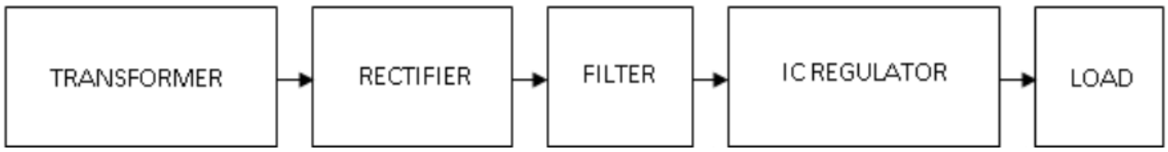

Fig: Block Diagram Of Power Supply

RASPBERRY PI PICO W:

Fig: Raspberry Pi Pico W

Raspberry Pi Pico W is **Raspberry Pi**'s first wireless microcontroller board, designed especially for physical computing. It is the successor of the popular **Raspberry Pi Pico** board. Similar to the Pico board, which we discussed earlier, the **Pico W** board is also built around the **Raspberry Foundation** in-house ARM chip RP2040. The main improvement is the addition .of Wi-Fi and Bluetooth functionality. **Raspberry Pi Pico W** incorporates an Infineon **CYW43439** wireless chip that supports IEEE 802.11 b/g/n wireless LAN, and Bluetooth 5.2. The main difference between the **Pico** and **Pico W** is the inclusion of Infineon's CYW43439 2.4-GHz Wi-Fi chip, which is responsible for Wi-Fi and Bluetooth. Another major change is with the power section. The new Pico W uses the **RT6154A** from **Richtek** as the power regulator instead of the **RT6150B** in the original Pico design. The debug port also moved near the SoC to make space for the Wi-Fi antenna.

Buzzer:

A buzzer or beeper is a signalling device, usually electronic, typically used in automobiles, household appliances such as a microwave oven, or game shows.

It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise). Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC-connected devices was to implement a circuit to make the AC current into a noise loud enough to drive a loudspeaker and hook this circuit up to a cheap 8-ohm speaker.

Fig: Buzzer

IR SENSOR:

IR sensor is very useful if you are trying to make a obstacle avoider robot or a line follower. In this project we are going to make a simple IR sensor which can detect a object around 6-7 cm. IR sensor is nothing but a diode, which is sensitive for infrared radiation. This infrared transmitter and receiver is called as IR TX-RX pair.

Fig: IR Sensor

TEMPERATURE SENSOR - MLX90614 :

The MLX90614 is a **Contactless Infrared (IR) Digital Temperature Sensor** that can be used to measure the temperature of a particular object ranging from -70° C to 382.2°C. The sensor uses IR rays to measure the temperature of the object without any physical contact and communicates to the microcontroller using the I2C protocol.

Fig: Temperature Sensor - MLX90614

Result:

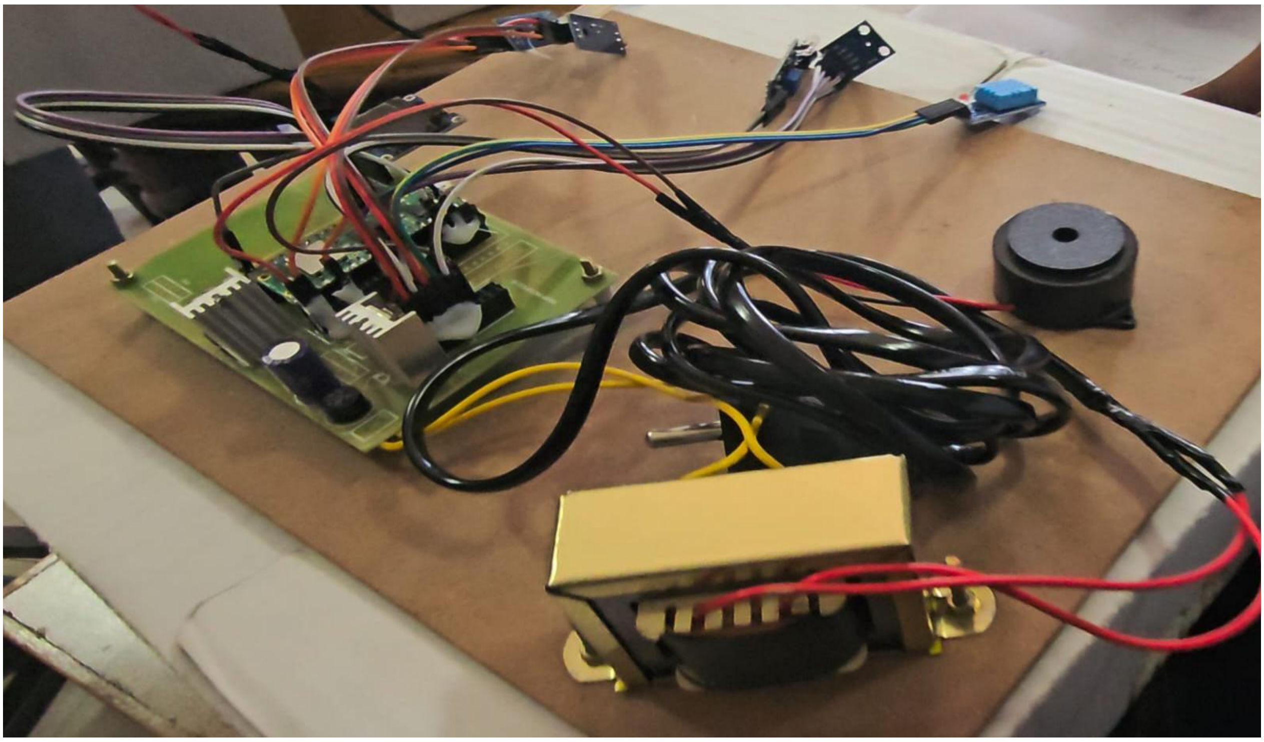

Fig : Hardware kit

Result:

This section presents a detailed analysis of the performance outcomes observed during the development and testing phases of the **Smart Chair for Working Conditions Optimization**. The chair was evaluated on the basis of posture correction efficiency, ergonomic comfort, productivity impact, biometric monitoring capabilities, and overall user satisfaction. Testing involved 100 participants over a period of 2 to 3 weeks, using both subjective feedback and sensor-based analytics.

Conclusion:

The main objective of this work was the implementation of a system in an office chair, with the ability to acquire and communicate, in electrical regime, data relating to posture, temperature and breathing frequency of the user, in addition to office environmental data, to provide better working conditions for the chair's user. Regarding the work environment, this system allows detecting environments with inappropriate noise, pollutants (CO_2) and inadequate temperatures. It warns the user through pop-ups from the accompanying app (Windows and Android) on their computer and/or mobile phone and allows automatic regulation of the space's lighting. Regarding the user's posture, this prototype was tested for a representative range of the active population, comprising volunteers with masses ranging from 54 to 100 kg, obtaining results that validate the effectiveness of the proposed solution for the detection of six different positions (five of which are improper positions), with an 100% accuracy. It is even possible to warn the user in case of exceeding a time limit in an unwanted position, or even too much time in the same position. Regarding the user's physiological data, the system permits detecting the user's body temperature and respiratory rates and warning him/her about abnormal values, with the maximum error of 18%. It should be noted that, for accurate feedback from the smart chair, the user must define a series of initial parameters. He/she must start by calibrating the chair, placing himself in the correct position for a certain period so that the program recognizes its normal parameters. In addition, the user must define the range of light and noise that he/she considers to be correct according to the workplace where he/she is and, finally, he/she must define the frequency with which the equipment will warn him/her to take a break (by default the system assumes 30 min). The user can also choose if he/she wants the pop-ups to emit sound and if he/she wants the lighting adjustment to be done automatically. It is possible to reset the parameters initially defined at any time.

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