Construction Smart Chair Using Arduino

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Abstract

Many workers spend lots of hours a day sitting down, which can cause bad posture and back problems. Therefore, sitting is a common behavior of the human body in daily life. It is found that poor sitting postures can link to pains and other complications for people. In order to avoid the adverse effects of poor sitting behavior, a highly practical design of a smart chair system was developed in this paper, which is able to monitor the sitting behavior of the human body accurately and non-invasively. A simple and inexpensive Arduino circuit based on an ultrasonic sensor attached to the chair's back was developed and put to the test while some individuals were sitting. The tiny device alerted them whenever they were sitting improperly and instructed them to adjust their backs in order to sit properly. Those who sit a lot and experience back pain can use the circuit in their everyday lives. These promising results suggested that the presented system is feasible for sitting behavior monitoring, which can find applications in many areas, including healthcare services.

Chapter One

Introduction

Scientific and technological advancements that have been made during the last decades have radically changed the lifestyle of most of the people living in post-industrial countries. Nowadays, machines have taken charge of almost all heavy occupations. As a result, jobs have mainly to do with office tasks in which personal soft skills are mostly required as opposed to hard ones, and sitting still in front of computer screens for extended periods of time is the more frequent habit (Aminosharieh Najafi et al., 2022). Poor posture can result in muscular imbalances in the body. It can reduce the amount of oxygen supplied to the brain, resulting in elevated levels of cortisol in the bloodstream and increased stress. Sitting for extended periods of time can affect mental capacity, sleep schedules, and vision (Meeks et al., 2013). Moreover, back health issues, including back discomfort, can result from poor posture while sitting down and infrequent breaks.

The Arduino is a freely available open-source platform that is simple to program and regularly receives new updates. In 2005, the first Arduino was released. Arduino is a microcontroller created by professionals and students to create devices that interact with the environment through sensors. Arduino microcontrollers have inputs and outputs that can be used to get information, and based on received data Arduino can send output. The Arduino platform can be divided into two: Hardware and Software. Arduino uses hardware known as the Arduino development board. Arduino software for developing the code is known as the Arduino Integrated Development Environment (IDE). Built up with the 8-bit Atmel AVR microcontrollers that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be programmed easily using the C or C++ language in the Arduino IDE (Ismailov and Jo‘Rayev, 2022).

In order to avoid the adverse effects of poor sitting behavior, the real-time monitoring of sitting posture has received particular attention. It has been used as a promising method in recent years. Research studies have been conducted using the pressure distribution measurement sheets placed on the seat pan and backrest to provide high-resolution pressure data for posture recognition (Tan et al., 2001, Zhu et al., 2003). Tan (Tan et al., 2001) used principal component analysis to address the issue of categorizing sitting positions. Zhu (Zhu et al., 2003) examined classification algorithms and discovered that Fisher-discriminant Rao's analysis could be applied to the classification of the seated posture. Andrew (Hwang, 2019) built the Smart Cushion with five strategically placed pressure sensors, an Arduino Uno circuit board, and custom software to capture and store data from the five pressure sensors. Mutlu (Mutlu et al., 2007) proposed a solution to detect sitting postures with fewer sensors using a near-optimal sensor positioning strategy and a logistic regression-based classifier. Xu (Xu et al., 2011) designed a textile-based sensing system for monitoring sitting posture and proposed an optimized signal compensation strategy to increase classification accuracy.

Most of the published research on static seated positions didn't give information about the costs. Arduino will be used to make a system for tracking seated positions. As preliminary research, this paper focused on the development of a system for smart chairs. The smart chair can monitor a user’s sitting posture and encourage the user to improve sitting behavior.

Chapter Two

Materials and Methods

2.1 Materials

The materials used in this study include an Arduino UNO board, buzzer, ultrasonic distance sensor-HC-SR04, and IDE.

Arduino UNO board

Arduino UNO (Fig. 1) is an electronic device that interacts with connected devices with processing power, memory, and IO ports. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno board is the first in a series of USB Arduino boards and the reference model for the Arduino platform; for an extensive list of current, past, or outdated boards, see the Arduino index of boards (Xu et al., 2011). The Arduino board can also be used to upload a new code to the Arduino board by using a USB cable to upload (Ismailov and Jo‘Rayev, 2022).

Fig. 1 Arduino UNO board.

The Buzzer

An Arduino buzzer (Fig. 2) is essentially a beeper. It is a device that generates sound when an electrical current flows through it. It can be directly connected to the Arduino to generate distinct tones by receiving electric pulses of varying frequencies. In the majority of systems, Arduino buzzers are utilized as beepers, alarm devices, timers, and security systems, as well as to produce sound upon affirmation of user input. The piezoelectric buzzer is most frequently employed with Arduino. There is no need for a separate oscillating circuit because it is lightweight, simple in construction, and typically a low-cost product that can generate distinct sound tones of different frequencies. It consists of two pins, positive and negative (Gabriel and Kuria, 2020).

Fig. 2. Arduino buzzer.

Ultrasonic distance sensor-HC-SR04

The HC-SR04 ultrasonic sensor (Fig. 3) uses echo to determine the distance of an object. The ultrasonic sensor uses the reflection of sound to obtain the time between the wave sent, and the wave received. It usually sends a wave at the transmission terminal and receives the reflected waves. The time taken is used together with the normal air sound speed (340 ms^{-1}) to determine the distance between the sensor and the obstacle. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1" to 13 feet. The operation is not affected by sunlight or black material, although soft materials like cloth can be difficult to detect acoustically. It comes complete with an ultrasonic transmitter and receiver module (Gabriel and Kuria, 2020).

Fig. 3. Ultrasonic sensor for ultrasonic wave production in motion detection.

Arduino Integrated Development Environment (IDE)

IDE is open-source and allows users to write, upload, and compile the code to any Arduino board. Arduino IDE is written in Java and is compatible with Windows, macOS, and Linux operating systems. The IDE environment mainly contains two basic parts: editor and compiler. The former is used for writing the required code, and later is used for compiling and uploading the code into the given Arduino Module (Fezari and Al Dahoud, 2018).

2.2 Methods

The ultrasonic sensor HC- SR04 is used to measure the distance based on echo. The sensor can detect the distance between the sensor and an object. The sensor consists of four pins (Vcc, Trig, Echo, and Gnd). Therefore, it was connected to an Arduino board, which was then connected to a computer. The Vcc, trig, echo, and ground pins were wired to the input voltage; pin number 9, pin number 10, and ground, respectively (Fig. 4). Codes are required to operate any Arduino circuits. Then the buzzer was connected as the buzzer's positive pin to pin number 11 and the negative one to the ground. Therefore, the code has been compiled and uploaded to the Arduino board. After connecting the circuit and running the code, the device was applied to a chair and tested.

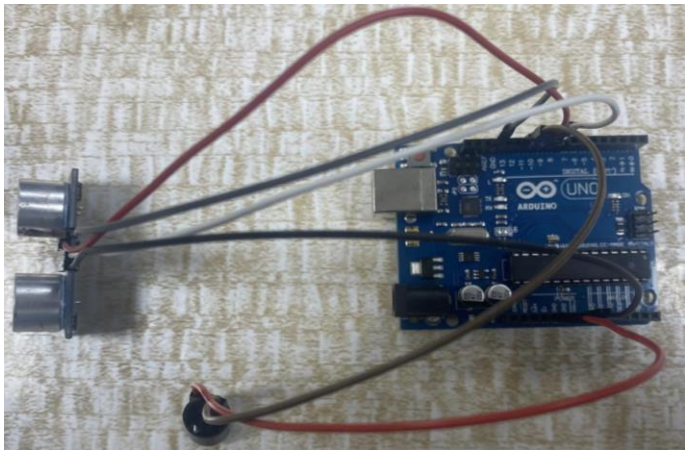

Fig. 4. Circuit connection consists of Arduino UNO, ultrasonic sensor, and the buzzer.

Chapter Three

Results and Discussion

Bad posture leads to all sorts of health issues, including back pain, limited circulation, and even headaches. To maintain health, it is essential to transform a standard chair into a smart chair that continuously detects your seated posture and sends an alarm for incorrect postures. Hence, this study proposed a portable, low-cost device for people who spend a lot of time sitting to alert them to sit correctly and avoid back trouble. This is possible with a programmed HC-SR04 ultrasonic sensor that is highly sensitive to the measurement of the distance (Fig. 5). Continuously measuring the distance to the rear of the seated individual. Any increase in distance is indicative of back bending. This will result in an alarm sounding. An Arduino board coordinates the entire procedure.

The participants who were subjected to the experiment reported that the buzzer sounded loud to warn them to sit properly whenever they attempted to adopt an improper posture. The distance between the sensor and the back was programmed to be less than or equal to 20 centimeters. The buzzer would sound an alarm if the distance was greater than 20 cm. This helps to minimize strain on the body from prolonged sitting.

Fig. 5 A chair was used to test out the building circuit.

Various studies were conducted on smart chairs employing various patterns of sitting postures to generate early warnings of potential back problems. One study (Hwang, 2019) developed a smart Cushing that primarily measured participant pressure to identify the sitting rather than the distance to correct poor posture. Another study (Huang et al., 2017) designed a smart chair using an artificial neural network classifier. In (Aminosharieh Najafi et al., 2022), a system of smart chair sensors was designed to identify and evaluate sitting postures using deep learning algorithms. These studies proposed alternative posture-correcting devices without mentioning costs; this research was conducted.

Chapter Four

Conclusion and Future work

In this paper, a smart chair system was constructed using Arduino to detect human sitting posture. The result indicated that the developed smart chair system could monitor the human body's sitting behavior and help in advocating better sitting habits for users. This is to reduce health risks by alerting the individual to correct his posture. The project is based on an ultrasonic sensor attached to the chair's back. In the future, more individuals will participate in experiments. Moreover, further studies regarding the relationships between posture and specific body regions are necessary to better understand the origins of back pain; however, the smart chair is sufficient for correcting sitting posture and preventing the development of additional back pain.

References

AMINOSHARIEH NAJAFI, T., ABRAMO, A., KYAMAKYA, K. & AFFANNI, A. 2022. Development of a Smart Chair Sensors System and Classification of Sitting Postures with Deep Learning Algorithms. *Sensors (Basel),* 22.

FEZARI, M. & AL DAHOUD, A. 2018. Integrated development environment "IDE" for Arduino. *WSN applications***,** 1-12.

GABRIEL, M. M. & KURIA, K. P. 2020. Arduino uno, ultrasonic sensor HC-SR04 motion detector with display of distance in the LCD. *International Journal of Engineering Research and Technical Research,* 9.

HUANG, M., GIBSON, I. & YANG, R. 2017. Smart chair for monitoring of sitting behavior. *KnE Engineering***,** 274-280.

HWANG, A. 2019. Arduino Pressure Sensor Cushion for Tracking and Improving Sitting Posture. *International Journal of Biomedical and Biological Engineering,* 13**,** 454-460.

ISMAILOV, A. S. & JO'RAYEV, Z. B. 2022. Study of arduino microcontroller board. *Science and Education,* 3**,** 172-179.

MEEKS, M., KNOTTS, T., JAMES, K., WILLIAMS, F., VASSAR, J. & WREN, A. 2013. The Impact of Seating Location and Seating Type on Student Performance. *Education Sciences,* 3**,** 375-386.

MUTLU, B., KRAUSE, A., FORLIZZI, J., GUESTRIN, C. & HODGINS, J. Robust, low-cost, non-intrusive sensing and recognition of seated postures. Proceedings of the 20th annual ACM symposium on User interface software and technology, 2007. 149-158.

TAN, H. Z., SLIVOVSKY, L. A. & PENTLAND, A. 2001. A sensing chair using pressure distribution sensors. *IEEE/ASME Transactions On Mechatronics,* 6**,** 261-268.

XU, W., LI, Z., HUANG, M.-C., AMINI, N. & SARRAFZADEH, M. ecushion: An etextile device for sitting posture monitoring. 2011 International Conference on Body Sensor Networks, 2011. IEEE, 194-199.

ZHU, M., MARTINEZ, A. M. & TAN, H. Z. Template-based recognition of static sitting postures. 2003 Conference on Computer Vision and Pattern Recognition Workshop, 2003. IEEE, 50-50.