PosChair: Promoting Productivity & Health in Every Seat

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ABSTRACT

Sedentary behaviour, characterized by prolonged periods of sitting has become increasingly prevalent in modern lifestyles. It is an activity that has taken over most aspects of our days, both work and leisure. This way of life is shown to increase various serious health risks. This paper addresses the need for innovative solutions to combat these risks and introduces the "PosChair" – a novel interactive chair designed to promote user health and productivity by encouraging shorter sitting periods through intermittent standing. The paper offers an explanation on how the chair achieves this.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Interaction design*; *HCI design and evaluation methods.*

KEYWORDS

human-robot interaction, sedentary behavior, robotics, mechanical design, electronics

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1 INTRODUCTION

Imagine a typical day in the life of a student or an office worker – hours spent hunched over a desk rarely getting up. This is a scenario most people are familiar with, and it's affecting their health and productivity far more than imaginable. Sitting down has become one of the most common activities of modern society. People sit in chairs while studying, working, watching TV, using a smartphone at home, even around the dinner table. Sitting down has spread out to most parts of people's lives, it has become an inseparable act.

According to a study by Bauman A., et al., the median amount of time a person sits per day is 5 hours, with an interquartile range of 3-8 hours [1]. However, too much sitting time is shown to affect our physical and mental health. It can be regarded as the new smoking especially in a time dominated by screens and sedentary lifestyles. It is recommended by the WHO to avoid such a lifestyle as prolonged sitting postures cause increased rate for health associated risks such as all-cause mortality, cardiovascular disease mortality, cancer mortality, the incidence of cardiovascular disease, cancer, and type 2 diabetes [6]. Not only does this way of living cause physical health problems but it also has a negative effect on psychological health. According to a study by Kilpatrick M., et al., a significant association was found between prolonged sitting at work and moderate psychological distress [5]. This in turn can lower the efficiency, productivity and overall enjoyability of work and study.

However, based on research there are ways to counter the adverse impact of sitting. Some researchers say that frequent short interruptions of prolonged sitting with some walking can attenuate postprandial glucose (also known as post-meal glucose) and mitigate cardiometabolic disease (cluster of conditions and risk factors that increase the risk of cardiovascular disease and type 2 diabetes) risk [4] [2]. Another study done by Ekelund U, et al., says that 60-75 minutes of moderate-intensity physical activity per day seems to eliminate the increased risk of death associated with high sitting time [7]. For those who can't exercise or don't have enough time, avoiding sitting down for extended periods is one of the best ways to reduce the risks associated. Standing desks appeared as a means to prevent users from sitting for long periods. However, according to a study by Carvalho D, et al., replacing seated postures with standing for long durations would not be recommended [3]. This project takes on the challenge of transforming our 'everyday' into an interactive experience and provides an innovative solution that seeks to promote health and productivity for those who find themselves living this contemporary lifestyle. The proposed solution is intended for chairs that are used in working environments that usually involve long sitting hours, be it at the office, a home office, potentially schools. The PosChair not only addresses a societal problem but does so while fostering interaction with the user.

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2 POSCHAIR OUTLINE

In general, when people seek to improve seating solutions, their focus often gravitates towards enhancing comfort, allowing for the user to sit pleasantly for longer. Ergonomic design, breathable materials, built-in lumbar support are only few of many features that have been created to answer the sitting problem. While comfort is undoubtedly important, it does little to address the dangers of a sedentary lifestyle. The PosChair challenges this status quo. The design can be seen as a work friend, or buddy, it is built for the benefit of the user. After a designated amount of time the PosChair will gently remind you it is time to take a break and stand up and stretch. It blocks the user from sitting back down until the break is over.

3 INTERACTION SCENARIOS

Once the user sits down in the chair a timer starts counting down from a predetermined amount of time e.g. 40 minutes, after which the user is engaged with to leave their seat and take a break from sitting before being invited after the break has finished. The interaction sequences can be visualised through the following storyboard, which portrays the typical user experience. Below, are presented the key scenarios to showcase the PosChair functions and its impact on the user's experience.

Explanation: Figure 1 illustrates key moments in the interaction design of PosChair. Each subfigure is labeled for reference:

- **Subfigure (A)** The PosChair counts the time the user is seated, and when the predefined time is over, it emits a buzzing noise to make the user aware.
- **Subfigure (B)** If the user ignores the buzzing noise, the panel rotates to gently tap the user on the back to get the user's attention, and doesn't stop until the user leaves the chair.
- **Subfigure (C)** Once the user has stood up from the chair, the extension bends all the way forward, blocking the user from sitting back down.
- **Subfigure (D)** Chair notifies user that they are able to sit back down through different means (LED, buzzing, extension going back to original position) adaptable to user needs and preferences.

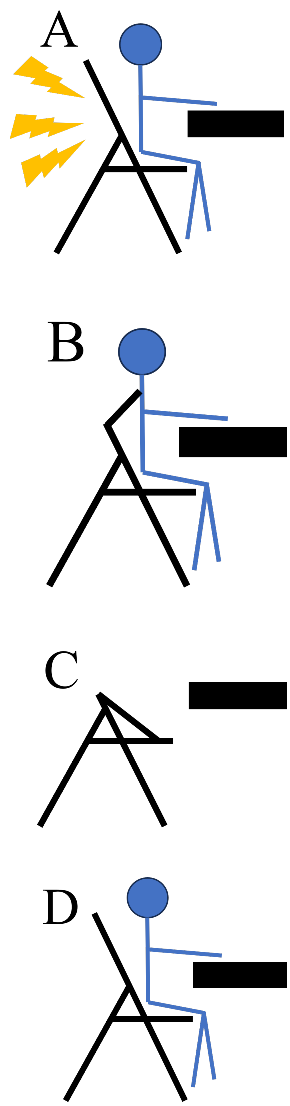

Figure 1: Storyboard of PosChair

4 DESIGN AND IMPLEMENTATION

The main ideas behind the PosChair design were for it to be straightforward and effective. On top of these main ideas, a constraint was added concerning the materials used. It was decided that the parts used for the project would be taken from various lab resources, with a strict adherence to taking only spare electronics already available. The only purchase for the implementation was the chair itself.

4.1 Electronics

The hardware/electronic design employs an ELEGOO Uno R3, a low-cost, broad use microcontroller board, used for processing and connecting external components. The ELEGOO Uno R3 has the sufficient power and memory to handle the execution of the software (written in the Arduino IDE, C++) utilized in the project. Its multiple GPIO pins allow connections to the other electronic components. This allows the design to execute the desired functionalities. The following components were selected for compatibility with the microcontroller.

For the sensing, the HC-SR04 ultrasonic distance sensor is responsible for the detection of the user's presence on the seat. It is important to note that this sensor was chosen due to its availability during the development phase and that the long-term goal would be to replace it with a weight sensor or a dual infrared sensor system. This is planned to increase the accuracy of the user detection. Once the person is considered seated the Uno R3 timer starts, the same happens for when the user gets up for the break (two different times recorded by one timer, one for the sitting period and one for the break).

For the actuation methods, the MG90S servo motor was used to control the speed, and rotation of the panel. The motor's characteristics (small size, torque, speed, ease of use) fit the project's requirements. The motor speed has been set so as to avoid any potential harm the repeated tapping could provoke.

For the communication/notification section of the project, a mini piezoelectric buzzer and two standard LEDS are used. The piezoelectric buzzer and LEDs work in pair. When time has run out, the buzzer emits noise and the red LED turns on until the user has stood up, after this point the buzzing stops unless the user tries to sit back down before the duration of the break is over. Once the break is over, the green LED turns on and noise is made by the buzzer to notify the user. The prototypes thus far have been powered using a nine-volt battery, which provides the project with enough power. It is in the long-term goal that we replace this with a more durable battery, so that they need less frequent replacements. Figure 2 shows all the electronic components with their specific wiring:

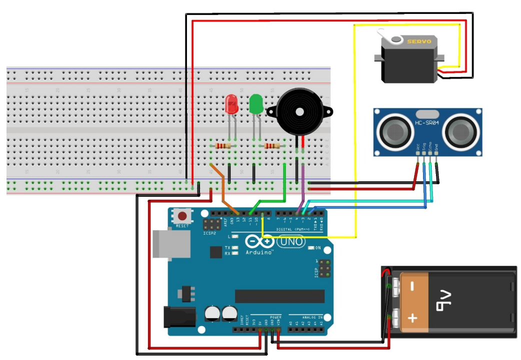

Figure 2: The Circuit (*made using Fritzing 1.0.1*)

4.2 Physical Components

Some parts of the design required to be customized as to fit the chair and electronics system in place. Computer-aided Design software system was used to make parts that would attach the motor to the chair and connect the motor to the panel as shown in figure 3. Sleeker and more visually pleasing parts are being made to offer an aesthetic solution. The panel in the prototype is a simple rectangular piece of cardboard. A big concern for the design was whether or not the panel tapping the user could cause any potential harm. This is why a light and soft material was picked. In the long-term another material may be used such as plastic or metal sheets covered with some cushioning, this is to be determined with further testing.

4.3 Integration

Most electronics are connected through a soldered prototype board. Others are connected using wires (the ultrasonic sensor and the servo motor) and carefully positioned to optimise their efficiency. A box regrouping most of the electronics (microcontroller board and prototype board) is attached underneath the seat, whilst the 3D printed parts are screwed into place as seen in figure 4 and 5.

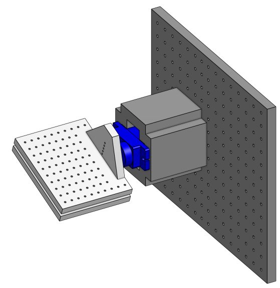

Figure 3: Model of 3D printed components with mounted servo motor.

Figure 4: The PosChair

Figure 5: The PosChair

4.4 Testing and Validation

Upon numerous tests with random groups of people found in the University of Genoa it was found that the chair executed its desired function perfectly. The groups all said that the tapping motion in no way caused any harm or discomfort while still remaining strong enough to be noticeable. On the other hand, it was reported that the noise emitting from the buzzer wouldn't suit certain quiet environments. Furthermore, depending on the subject's clothes the ultrasonic sensors had trouble detecting the person's presence.

5 FUTURE WORK

In the ongoing development of the 'PosChair', key improvements are planned. The final goal is to create a solution applicable to any chair. Finding ways to make the product modular to fit more chairs is constantly under revision. Future prototypes will see shifts in electronics, design and functionalities of the chair. These shifts should allow for more case specific electronics that could reduce costs and energy consumption and increase accuracy. It is planned to implement multi-sensor fusion with the likes of pressure, capacitive and infrared sensors. The latter paired with machine learning algorithms which will allow for the chair to better detect between a person and an object. Another aim is to increase the number of ways that the user can be notified. It is intended to include functionalities like poking and, chair folding. These additions will be developed to provide customization options for the user, so they may have full control over their work environment and their health.

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