

SpiMO - Sitting Posture Monitoring System

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ABSTRACT

Back pain is among the most common causes of missing work and contributes to about 93 million lost workdays and \$5 billion in health care costs every year. Sitting in an office chair for long periods of time can create lower back pain and can worsen problems that already exist. There are a number of factors that affect back pain, including level of movement, schedule, and desk set-up. Posture is a key factor that can induce pain over time; this includes sitting in the same position for too long or leaning too close to the screen. One may be able to avoid back pain or prevent its recurrence by improving the physical condition and learning and practicing proper body mechanics. We propose an efficient and time-effective tool to support the maintenance of a healthy position - a smart pillow. This pillow will track one's sitting posture on the chair, provides alerts when you don't have a right posture, provide you tips for exercises based on your posture, allow you to set up goals regarding your position and remind you when to take a break and sit-up.

The current paper offers development details related to the proposed innovative product, both from the hardware point of view (the pillow with sensors) and from the software point of view (the mobile application gathering signals from the pillow and providing learning alerts to the user), in the context of other similar applications available on the market and useful in learning how to have a healthier lifestyle.

Author Keywords

healthy lifestyle; smart pillow; body posture; prevention

ACM Classification Keywords

H.5.m.

General Terms

Design

INTRODUCTION

Posture is very important both at home and on the job especially if your jobs requires lots of hours of sitting at the desk. A back-friendly posture will prevent one from getting back and neck pains. Not only office chair sitting posture, but also driving posture to and from work can have a bad influence on one's health if the body position is ignored.

An important tool to support and maintain a good posture while sitting could be an ergonomic office chair. However, simply owning one is not enough - it is also necessary to adjust the chair to the proportions of one's physique in order to reduce the aggravation to the spine and improve personal comfort. There is no single type of office chair that is optimal for all patients, and people should determine their individual preference for comfort while following some simple steps of maintaining a proper posture.

The above mentioned are the main reasons we decided to develop SpiMo, a posture monitoring system which tracks the moves of the body. In this study, we investigate the use of mobile sensing technology to monitor spine stress in real-time during daily activity. [1]

Our proposed solution provides feedback with the use of a phone application and real-time notifications. SpiMo is a suitable solution for your spine health since this monitoring system could fit everybody's needs unlike the traditional ergonomic chairs.

The first part of the article consists in presenting the importance of a good posture to one's health, followed by some similar applications and the general, functional and technical description of SpiMo.

POSTURE MONITORING SYSTEM

The use of sensor technology in monitoring the spine position and health in real-time has been rather limited. However there are similar solutions based on sensors or Kinect. One example would be Lumo Lift.

Lumo Lift [5] is a fitness wearable able to track your posture. How does it work? By resting against your décolletage, using algorithms and hardware sensors in order to measure the body's alignment. Every time you put Lumo on, you need to calibrate it and you also tell Lumo what posture you want to try to maintain (whenever it is slightly slouchy, or upright).

After that, during the day, Lumo tracks how often you stay in that right posture and when you start deviating from it. There is also a smartphone application, in which you can see your progress, but also the step count and distance.

The Lumo uses magnets in order to stick it on you, instead of clipped to clothes, so you actually wear it with a magnet. All the components are inside a polycarbonate tracker, while the plate holds the device in place on your clothes. The tracker acts like a button that you press to use it and program.

The device is smaller, more or less like the size of two quarters side by side, and just some centimeters thick. The magnetic configuration offers the user the possibility to personalize it, which most of the fitness trackers doesn't give. The user can create his own magnet clasp by using a strong one and, also decorate it.

Lumo is charging via a magnetic cradle with 2 pins that connects to the tracker in order to charge it. A full charge is about 2 hours and lasts five days. Unfortunately, Lumo does not have a LED display, but has a LED charging light.

The device is meant to be worn every day, in order to track your steps and posture. You simply attach it on your clothes, finding the right spot and, keep the posture you want. Calibrate the device by pressing twice on Lumo and in this way will enter in a Align mode. The device will vibrate in order to tell you that is recording your desired posture. The Lumo can be recalibrated as often as the user wants.

Once it is calibrated, the device tracks your posture and your motion all day long. Lumo has also a coaching mode that vibrates when you slip of your desired posture. The device has inside a microcontroller, a rechargeable battery and accelerometer, gyroscope and a Wi-Fi chip, used to send all data to a smartphone. With all these components, Lumo is raising the quality of life of many users, not only by making them more confident because of the straight posture, but also because can prevent users from developing back pains or other diseases caused by a bad posture.

Another example of spine monitoring system is **eCushion** which is designed for both clinical use as well as daily home use. A smart phone application gives real-time feedback on the distribution of sitting pressure on the cushion.

The implementation of eCushion consists of a textile sensor array, signal sensing and transferring unit and a computation and display terminal. A 16 by 16 textile sensor array is used to monitor the pressure distribution on cushion when users are sitting on it. The footprint of the sensor is 5/8 inch by 5/8 inch, and adjacent space is 1/8 inch. An Arduino based unit is used to sample and transfer the sensing data via bluetooth protocol. For sitting posture monitoring application, the sample rate is set as 10Hz. [7]

SPIMO – SITTING POSTURE MONITORING SYSTEM

A good posture means your bones are properly aligned and your muscles, joints and ligaments can work properly. Poor sitting postures are common among adolescents as well as employees who work for prolonged hours. Spinal injuries are second only to the common cold as a cause of absence from work, with many of these problems emerging from poor posture habits. Since more spinal problems will inevitably lead to higher health costs and lower productivity, helping people maintain healthy spinal habits and reduce spine stress during daily activity is of considerable benefit. Some studies have showed that the some common sitting postures can lead to lumbar flexion and higher compressive forces in lumbar joints [2, 3].

Trying to avoid the adverse effects of bad sitting postures, the real-time monitoring of sitting posture received a particular attention and was used as a promising way in recent years. Increasing person awareness of bad posture means that the person can use her own back muscles to correct the spine, instead of using external support devices which could cause physical and psychological discomfort [4].

You may be able to avoid back pain or prevent its recurrence by improving your physical condition and learning and practicing proper body mechanics, but sometimes you do not have time for exercises. This is why Smart Pillow comes to help you. Smart Pillow is a smart pillow that will track your sitting posture on the chair, alerts you when you don't have a right posture, provides you tips for exercises based on your posture, allows you to set up goals regarding your position and reminds you when to take a break and sit-up.

General Description

SpiMo is a smart pillow designed for both clinical and daily use at home, where the user can be remotely monitored. The system monitors sitting postures and provides real time feedback to the user for poor sitting posture but also monitors increased pressure on the back due to undesirable positions such as standing or sitting in a fixed position for a long period of time.

The system measures the weight of the user and detect which would be the right sitting posture. Furthermore, a daily summary report is automatically generated and it provides an account of the amount of time during the day that the user is sitting, to enable her to track her progress. The report also provides daily information related to posture angle and severity of poor posture. Data from the

sensors is acquired and transmitted to a database using a wireless module.

SpiMo is also able to suggest different type of exercises, for improving your health condition, based on user's height, weight, age, genre and report of the sitting postures. Basically, SpiMo is a virtual coach that analyzes your sitting posture on the chair and suggests you exercises for your health condition, but also sends a gentle vibration and sound alarm when imbalance is detected or you have sit in same position for a long period of time.

The feedback for the user must be presented in a smarter way. This is done in two ways, implicitly or explicitly. In the explicit way, the user is notified (for example with a pop-up message on his computer or mobile phone) of an incorrect posture, urging him to adjust his position accordingly. In the implicit way, the system stimulates the user in using a correct posture by vibration and sound feedback.

SpiMo is able to learn which are the good postures of a person and with an algorithm predicts your future sitting postures. For the cases when the user is spending more time than normal sitting, SpiMo uses the pomodoro technique [6] for the alerts: after each 50 minutes spent on the chair, the user should take 10 minutes break and sit up, doing some exercises or simply walking from a room to another.

Functionalities

Inside the pillow are some thin sensors able to detect your sitting position. An Arduino Uno board was used in order to read the data from the sensors and via Bluetooth, sends your status to the mobile application. In this way, you will get notification whenever your posture is good or bad. Smart Pillow application is not only notifying you regarding the sitting posture, but also offers you some other features:

- **User profile** module allows you to personalize the application with your details (name, email, weight, height, date of birth, genre).
- Set **Goals module** allows you to set your good sitting goals, in terms of hours, minutes.
- **Track posture:** one can see in real time whenever your posture is good or bad.
- **Track progress:** the Smart Pillow app offers your statistics regarding your posture, in order to know what would you have to do to correct your posture.
- **Exercises:** based on your profile information (age, height, weight and genre) and your posture progress, Smart Pillow offers you tips and tricks, exercises of how to improve your posture.
- **Coach ON/OFF:** with your coach ON, you will always receive alerts, tips and tricks and exercises regarding your posture. Smart Pillow coach uses pomodoro technique, that will also ask you to take a break and sit up at each 50 minutes. Smart Pillow together with

Pomodoro Technique will help you increase your work productivity.

Technological description

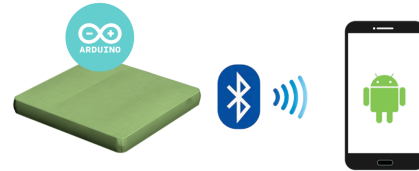


Figure 1, Smart pillow architecture

Smart Pillow improves your postures, because sitting too much on the chair and also in a bad posture, increases the chances to develop different diseases (type 2 diabetes, cardiovascular diseases).

The pillow is collecting data from the pressure sensors that are further establishing if the sitting position of the person is good or bad. The person is receiving a feedback directly on the phone, as long as the pillow is connected via Bluetooth to the mobile.

The overall system architecture is illustrated in Figure 1. The method of detecting postures includes pressure sensors that are connected to an Arduino board that computes the pressure distribution of the sensors, in order to establish if the sitting position is good or poor. All the data is sent to a database via Bluetooth and an mobile application is showing the user status, reports, suggestions for improving the health condition and more. There have been some technologies used for developing SpiMo prototype: Java, MySQL, C++, Bluetooth Low Energy.

Besides the sensors and Bluetooth component, to the Arduino there are also connected some other components: a battery for energy, a piezo speaker for sound notification and a vibration motor.

There have been used eleven pressure sensors in the following manner: 9 in the pillow (placed in a squared matrix of 3) and 2 for the back. The sensors in the pillow are calculating the weight distribution of the person, while the other 2 from the back are detecting if the user is sitting with the back right. Depending on all sensors, we detect if the user is sitting right and we send via Bluetooth the data to the mobile application that is further storing the values in a database and sends notifications. In the mobile application, there is a Boolean variables that is changing when the posture is changing too and depending on it, the application is sending notifications.

Validation

A posture experiment has been conducted to characterize the performance of the system. At the moment, the prototype consist in the smart pillow (that has an Arduino, sensors, battery and Bluetooth module) and a mobile application which is sending you push notification

regarding the sitting posture, shows you reports and is giving you training exercises.

The experiment was conducted with 8 subjects (4 males and 4 females, age 20-50) and for each we have calibrated the pillow and measured different sitting postures. The testers were alerted each time they have changed the postures from good to bad ones or otherwise. As it can be seen in Figure 2, one that tests the smart pillow has a good posture and receives a pop up on the mobile application with the notification. From the one that participated in the testing phase, 65% of them said that SpiMo is a key for a healthier lifestyle, while 35% were not delighted with the idea, because they considered that are too many notifications and in time they can get stressed because of them.



Figure 2, SpiMo prototype

CONCLUSIONS

Comparing with some other devices that have the same purpose, the good posture of the user, like Lumo Lift for example (a device that you stick it on your body in order to track your activities and posture), SpiMo is a product for people who are working in offices, are spending too much time on a chair, children from schools that are spending time on chairs in classes (they still are in the growing process, so a bad posture might affect their spine later) or simply at home.

SpiMo smart pillow can be used by anyone who would like to take care of their spine and back, provides a pleasant solution, cheap, handy and non-invasive, based on recent technologies, with a great impact on enhancing the quality of life and increasing user's microlives (a unit of risk representing half an hour change of life expectancy) gets improvements, while the micromorts (mortality risk) are decreasing.

Smart Pillow takes care of your, of your health, of your mind and helps you be more productive. It is portable, can be used on any chair.

While people's health is getting improved, money for treatments will be less, Romanian's GDP is increasing, not only because of the less money used on health treatments, but also for increasing the productivity in the IT sector.

The smart pillow is able to teach people how to keep in shape, how to be healthy. Learning how to prevent diseases is the key to a healthy longer life.

As further improvements, the research period will have an important impact of the product, as long as we will aim to develop a helpful product but at lower cost, in order to be affordable for everyone. Another important aspect would be to improve the lifetime of the battery by optimizing the processes in order to not overload the processor and use a wireless technology that is not consuming much.

Machine learning is also a step forward in the development of SpiMo, learning if a keyword that should not be missed in a smart pillow, by making the system learn which are the good posture, which are the poor ones and learning to adapt by itself depending on person which is sitting on the pillow.

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