PAUSE-ture Head Posture Correction System*

Final Course Project for INFO 4120†

Charles Yu
Cornell University
Ithaca, NY, USA
ccy27@cornell.edu

Chelsea Chan
Cornell University
Ithaca, NY, USA
cc987@cornell.edu

ABSTRACT

This paper explores the design and implementation of a cheap-to-implement, minimally obtrusive posture-correcting wearable device. Previous research has indicated that bad head and neck posture has become increasingly common with the rise of personal computers and smart-phone usage. The decline in head posture among desk workers can lead to many health issues such as tension headaches and chronic neck pain. Solutions to this growing problem are generally expensive or cumbersome to use. We leverage key principles of ubiquitous computing and calm technology to describe a cheap-to-implement system that allows for a minimally obtrusive way of correcting head and neck posture. We provide a prototype of this design and conduct a user study to highlight our preliminary results.

CCS CONCEPTS

• **Ubiquitous Computing**;

KEYWORDS

ACM proceedings, LaTeX, text tagging

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1 INTRODUCTION

As computer and smart-phone use has rapidly grown over the past decade, so has the prevalence of poor posture. Forward head posture has become a common symptom among office workers and students today. Previous research has found that the decline in proper posture has negative health effects among adults and is strongly linked to symptoms such as tension headaches and severe neck pain [1]. There have been many proposed solutions and commercial products on the market which target this problem space; however, many of them are expensive or cumbersome to use due to unnatural routines or clunky hardware. Ubiquitous computing and calm technology provides a fitting solution to this issue since the posture problem directly stems from technology usage and thus should be seamlessly integrated into a users daily technology use. In addition to being easy to ingrate into day-to-day life, an effective solution to head posture should be designed to lie in the user's periphery and only enter the center of attention when needed. This avoids information overload and creates a better user experience [3].

This paper introduces PAUSE-ture, an effective head and neck posture correction system that is cheap-to-implement and minimally obtrusive, and conducts a preliminary user-study that produces promising results for future work. The system is designed as a wearable device that attaches onto over-ear headphones. The system operates by providing subtle audio and visual feedback to notify the user to correct his or her posture when poor posture is detected. The system specifically aims to improve the posture of users who spend extended periods of time working at their desks; however, can easily be extended to include more active settings in future work.

In addition to the description of the system, this paper also finds negative auditory feedback to be an effective form of reinforcement for posture correction.

2 RELEVANT WORK & MOTIVATION

Current posture-correcting systems on the market require users to wear physical devices. For example, the Marakym Posture Corrector requires the user to wear a strap-on harness, and the Upright GO Posture Trainer, which is a wearable that sticks onto the user's back. Requiring users to wear physical devices do provide immediate feedback, however it impedes natural activity of the user and is more troublesome since the user would have to remember to wear this extra device. Furthermore, most posture correcting and training devices are mainly focused on correcting upper back posture. There is less emphasis placed on head and neck posture which is increasingly becoming prevalent among office workers and college students who spend prolonged hours working with computers [2].

3 THE PAUSE-TURE SYSTEM

In this section we introduce the key design goals of the PAUSE-ture system, and detail our prototyped implementation of the system.

Design Goals

Existing research in this field has not delved into the different types of feedback being transmitted and how this affects the usability and comfort of a posture correcting system. We feel that we can use the characteristics of ubiquitous computing and peripheral attention to enhance the user experience of a posture correction system. We have set out to create a corrective and minimally intrusive wearable device designed for long-wear use.

To achieve this, we have set some design goals for our project:

(1) Firstly, The PAUSE-ture system uses lightweight and cheap sensors that are easily available. This makes our system easy to implement and more accessible to a wider audience.
(2) Secondly, our system aims to minimize the level of intrusiveness towards a user. Since our target audience is people that work for extended hours at their desks, we choose to implement feedback in the form of audio that is already incorporated into their working habits, in this case, music playback through their personal computer.

Prototype

To evaluate the effectiveness of the PAUSE-ture system, we implemented a prototype using infrared time-of-flight distance sensors combined with a Raspberry Pi as a processing unit. We developed several types of minimally intrusive audio feedback and evaluated the effectiveness of these forms of feedback in a user study.

Prototype System Architecture & Implementation. The prototyped PAUSE-ture system consists of three key components: 1) a pair of sensor-mounted headphones, 2) a Raspberry Pi control unit, and 3) a Web-based UI. The headphone accessory is mounted with two Adafruit VL6180X Time of Flight Micro-LIDAR Distance Sensor, one on either side,

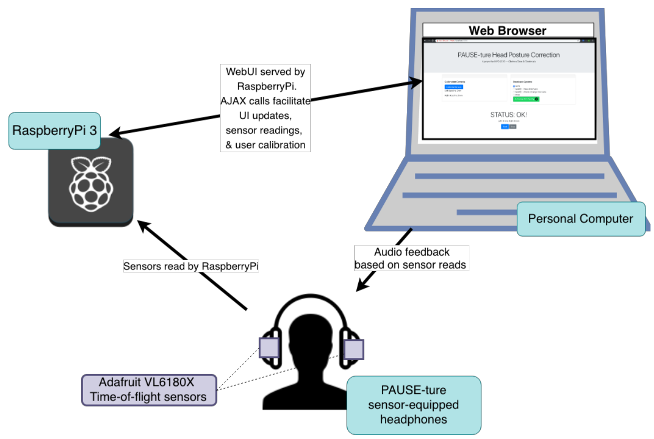

Figure 1: Schematic of the PAUSE-ture system architecture. This diagram details the interactions between the three key components of the PAUSE-ture system.

which measure the distance from the sensors to the user's shoulders. The Raspberry Pi control unit polls sensor reads from the wearable unit, and stands up a web-server to serve the Web-UI to the user. A user communicates with the control unit through the Web-UI to calibrate the sensors, set their preferred method of audio-feedback, and start or stop the system. Figure 1 illustrates the interactions between the key system components.

Hardware Specs.

- 1 x Raspberry Pi 3
- 1 x Adafruit TCA9548A 1-to-8 I2C Multiplexer
- 2 x Adafruit VL6180X Time of Flight Micro-LIDAR Distance Sensor
- 1 x Koss KPH7 Lightweight Portable Headphone
- 1 x Personal Computer

Software Design. We implement a lightweight back end web-server hosted on the Raspberry Pi using the Python Flask framework. The server serves a Web-based UI written in JQuery which facilitates all audio and visual feedback to the user based on the received sensor reads it gets from the Raspberry Pi. The UI communicates with the Raspberry Pi web-server via AJAX calls to request sensor reads and perform authorization for certain services, like the Spotify Web Playback API.

To detect bad posture, we introduce a simple heuristic that leverages the read distances from each of the sensors. If either of the sensors reads a distance that is outside of a tolerable range of distances, the system reports that the user has bad posture.

UI/UX Design Choices.

Web-UI Dashboard. The Web-UI has a simple interface that allows the user to calibrate the system to their desired head posture, select their feedback preference, and start or stop the system with just a few clicks.

Sensory Feedback Options. For our prototype, we implemented several types of audio-feedback that the user could select from. Visual feedback via the Web-UI was paired with each of these types of auditory feedback. The implemented feedback options are as follows:

(1) No audio feedback
(2) Spotify Streaming with Pause Interrupts
(3) Spotify Streaming with Volume Change Interrupts
(4) Beep Interrupts

We selected these forms of feedback to experiment with a breadth of reinforcement stimuli. Our rationale for choosing these forms of auditory feedback is as follows:

Following the principles of calm and ubiquitous computing, we wanted the system to remain in a user's attention periphery and come into focus only when necessary. We observed that many desks workers listen to music as they work, and using this observation we thought that the maintenance of user freedom to listen to whatever they chose was integral to such a system. To accommodate for this freedom, we integrated our application with Spotify to produce two types of auditory feedback. We believe that an appropriate and effective type of feedback to integrate with this observation is negative feedback, or the removal of pleasurable stimulus. To do this, we created two feedback options: One in which a user's music is paused on poor posture and another in which a user's music volume is decreased significantly on poor posture. We also created a feedback option that used positive feedback, producing stimulus on undesired behavior, via a beep that is sounded whenever posture is to be corrected. Finally, we maintained a baseline option that does not give auditory feedback.

4 METHODS AND EVALUATION

User Study and Data Collection

We performed user studies on five different users of different height, age and gender. For the scope of this class, we think it would be easiest to test on college students. Testing on people of different height and gender is a key factor to take into account because this might affect how well the positioning of our sensors on the wearable perform, due to how the distance sensors are affected by factors such as hair length and body form.

The goal of the user study and data collection procedure is to determine the effectiveness of our different feedback options and to find the optimal position of the IR sensors. The

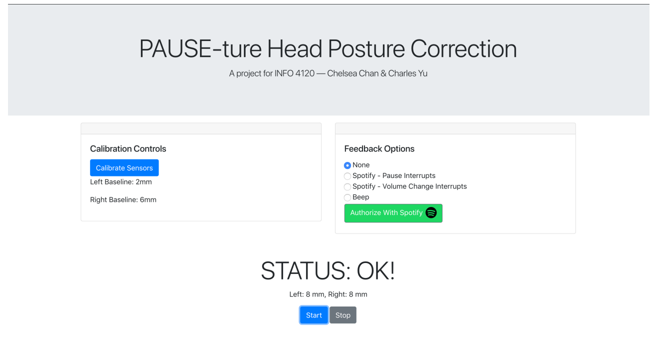

Figure 2: Screen shot of the WebUI interface. This UI dashboard provides the user with a way to control and interact with the PAUSE-ture system.

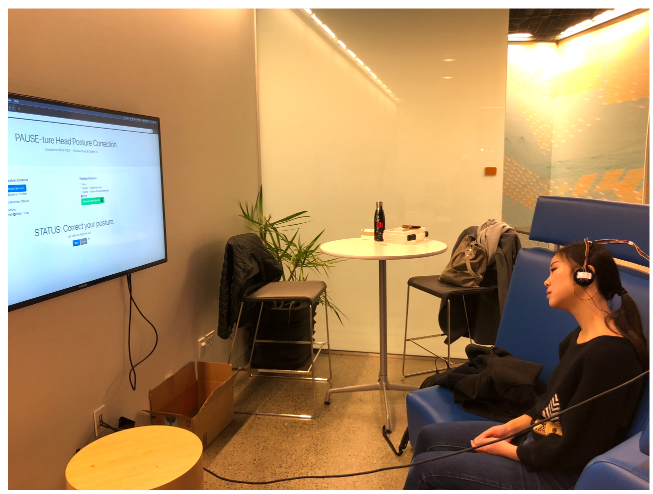

Figure 3: Photograph of one of the participants in the user study testing how different angles and side to side movements affect the feedback given.

first part of the study involves varying audio visual feedback in each test. The user will wear the PAUSE-ture device for 1 minute each in four different feedback modes:

- Purely visual feedback
- Beeping indicating bad posture
- Pausing music playback
- Volume changes

The second part of the user study involves varying the sensitivity of the IR sensors attached on both sides of the

Figure 4: Photograph of a user demo for the PAUSE-ture system.

headphones. The sensors will be tested at 3 different sensitivity levels: low, medium and high. At the end of these tests which should take about 7 minutes to complete, we ask users some questions to obtain more information about our design and feedback system. Figure 3 shows one of the participants in the user study testing out different head angles and sensitivity levels.

Left-Right Audio Panning. After incorporating feedback from our poster presentation and live demo, we decided to test out a different type of feedback that was not implemented as a working option in our original user interface. For this last part of the user study, we test out how left and right audio panning affects the head movements of our users. During the study, we introduced this mimicking effect as an extra feedback option in our user interface. User's are told to move their head in any direction they choose. When leaning towards the left shoulder, we then manually pan the audio into the left ear, and vice versa for the right side. There was no change in audio feedback implemented for forward and backward head movements.

5 DISCUSSION

User Feedback

Most users found that the beep was too annoying to be implemented in real life situations. The visual feedback was effective but would be better implemented as a notification since most users would be working on other screens while using the device. Another recurring point of feedback that we received through our user studies was that the pauses and volume change were too abrupt. One user suggested to have the volume be more gradually mapped to the extent of how bad the angle of head posture is: As a user's head posture gets worse, the music gradually lowers in volume until it reaches a threshold angle which triggers the music to pause entirely. Besides having the severity of head posture being a factor to be mapped to our music feedback, we also received user feedback that the persistence of head posture is another important factor that should be better incorporated into our overall design.

In particular, by combining our existing types of feedback options into a more cohesive unit, we can create a better user experience. Furthermore, one user said that mixing in how different sensitivity levels react to different types of feedback could be another possibility. One user commented that there should be a feature that allows you to adjust the level of volume change from low to medium to high. There is more room for fine tuning here, as we noticed through the studies that the left/right head posture detection was much more sensitive than our forwards/backwards head posture detection.

We also received feedback from users that it would be a great idea to incorporate the PAUSE-ture system into existing devices. For example, Apple's Airpods have built in dual optical sensors, microphones and dual accelerometers. The possibility of developing the PAUSE-ture feature onto Airpods would help us reduce our hardware load immensely.

Lastly, users were also particularly interested and surprised by the panning feedback introduced in the last stage of the user study. We think there is a lot more room for experimentation here. One user commented how it was a very effective and unobtrusive way of returning her head back to a neutral position, which ties into how our device can incorporate ideas from ubiquitous computing into a functional posture correcting device. We are looking into how we can use variations in audio being fed into each ear affect the way people position their head.

Limitations Future Work

While our prototype of the system has promising results, there are still limitations that need to be addressed in future work.

Since we implemented the prototype with time-of-flight sensors, users with long hair had to tie their hair back in order to get a precise calibration of the distance between the headphones and their shoulders. This could be overcome by using other sensors such as gyroscopes.

Due to the placement of our sensors and the simple heuristic we used to determine bad posture, we found that our system was very effective at detecting poor side-to-side head posture but was less so at detecting subtle forms of forward head posture. We believe can be ameliorated in future work by using a combination of different kinds of sensors, different placements of sensors, and different detection heuristics.

For future work and improvements to our project, we would also like to have long term user studies which assess how PAUSE-ture affects a user's head posture. Ideally, this would be implemented with monthly check-ins. We acknowledge that this was not possible within the time constraints given for this class project. Additionally we would also want to optimize the size of our overall wearable design to enable more ease of use.

Our prototype system is too large to deploy in portable environments; however, the hardware components can be easily integrated into a smaller form-factor to optimize the portability of the system. Other design alternative to build on this project includes wearable PAUSE-ture devices that can be easily clipped on to other over ear headphone brands and potentially even on smaller earphones, which would widen the demographic of our target audience. One thought is to integrate this system into Apple Airpods, which already have built-in sensors.

Lastly, we would also work on how we could implement the music playback and feedback system which accommodate other forms of audio players and streaming platforms besides the Spotify API.

6 ACKNOWLEDGEMENTS

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7 RESOURCES

A public repository of our code can be found at
github.com/charlesyu108/PAUSE-ture-Head-Posture-Correction

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