Posture Monitoring and Improvement for Laptop Use

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Abstract
Both Repetitive Stress Injuries and laptop use have increased. The poor ergonomic design of laptops has the potential to create or exacerbate existing RSI. We propose a persuasive Attentive User Interface which provides feedback in order to improve user neck posture. This system measures the angle of the user's neck and determines the quality of his/her neck posture. We then provide exercises to strengthen the neck and improve the user's posture. We performed a study which showed an increase in neck comfort among our system's users. The study demonstrated the potential of our system, which should be further tested.

Keywords
Attentive User Interfaces, Captology, Posture Monitoring

ACM Classification Keywords
H5.2. Information interfaces and presentation: Ergonomics, GUI

Introduction and Motivation
Poor posture contributes to user strain and the occurrence of Repetitive Stress Injuries (RSI) [7]. Poor alignment of the head is bad among laptop users

because it is difficult to create an ergonomic workspace when using a laptop.

Laptop use is increasing as laptops become more affordable. Many schools and employers are supplying persons with a laptop [12]. They must then carry out a large portion of their daily tasks on laptops. The occurrence of RSI, such as Tension Neck Syndrome (TNS), has increased over the last fifteen years [7, 12]. This trend is likely to continue as laptop use increases. RSI make laptop use an unpleasant experience. They reduce a person's quality of life, productivity, and they can result in extra expenditures on health care [7].

The two primary strategies for reducing head-neck RSI among laptop users are to maintain a neck angle of 0° to 19° while viewing the laptop screen, and to use stretching and strengthening exercises after periods where the neck angle exceeds 19°. A laptop system that provides feedback to reduce RSI related behavior should persuasively incorporate both strategies.

We intend to improve user neck posture through a monitoring and feedback application. Our system uses Fogg's captology concepts of tailoring, suggestion, and self-monitoring to support the application's role as a persuasive technology [4]. We use an Attentive User Interface (AUI) to control feedback from the system so users can monitor their current postural quality while completing their primary tasks.

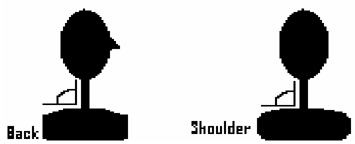

Figure 1: We measure the angle of the neck with respect to the back and the angle of the neck with respect to the shoulder.

We monitor the angle between the neck and body (figure 1). From that we identify the quality of the user's neck posture, and indicate this to him/her.

Our solution is designed to solve the problem of poor neck posture by making the user aware of his/her posture, by identifying posture weaknesses that contribute to RSI, and by recommending exercises and strategies that will prevent the potential RSI caused by an identified posture weakness [7].

Related Work

Many researchers have investigated how computers contribute to RSI. They have found that increases in neck angle result in load and torque increases on the cervical spine, height loss, increased discomfort, and RSI [2, 12]. They have also shown that laptop use increases user neck angles. Upright postures allow reductions in both the torque and the load on the cervical spine. This increases comfort and decreases the chances of developing RSI [13].

Posture monitoring systems have been proposed by Jaimes and Liu [5, 6]. Their systems use computer vision to determine the user's activities through his/her posture. By creating postural awareness Jaimes helps the user to improve his/her posture by continually indicating posture quality via an icon [5].

There are also commercially available software tools that aim to help reduce a user's chances of developing RSI. Many of these tools are designed to remind you to take breaks and perform exercises. RSIGuard Stretch and other tools incorporate features, like automatic clicking, that help reduce one's chances of developing arm and hand RSI [8]. While many of these tools track mouse and keyboard use, they cannot track postural changes. To account for this, RSI Warrior reminds the user to sit up straight but none of the tools recommend appropriate postural improvement exercises based on the user's posture weaknesses [9].

System Design

Prototype Design

We chose to use FLX-01 Flex Sensors from Images SI Inc instead of computer vision because the sensors are compact, easily transportable, and durable. We used a sensor to measure the angle between the neck and shoulder. This worked because the sensor starts in a bent position. Two sensors are used to measure forward and backward neck angles. This is because the sensor only registers bends made in one direction and lies flat when placed on the neck's back or front.

We secured the sensors with Velcro in a size adjustable dickey. Each sensor had its own position: one on the front, one on the left side, and one on the back of the neck. We then secured the wiring to the dickey using Velcro loops. These loops were added to prevent the sensor slippage we observed during initial testing. The sensor wires were directed, by the Velcro loops, over the left shoulder to allow the user freedom of movement and because right handed mouse use is predominant.

We recorded multiple sensor readings for each of the angles defined in the Posture Scale in order to determine the relationship between neck angle and sensor readings. At first there appeared to be no relationship between sensor readings and neck angles. However, each of the readings appeared to change in a fairly consistent manner. So we added a sensor calibration or 'zeroing' point, and took the readings again. This allowed us to take the difference between an angle's sensor reading and the zeroing point. This difference was consistent for each of the measured angles (0, 9, 14, 18, 29, 39, and >39) and it is used by our system to determine the user's neck angle.

Feedback Guidelines

The Posture Scale consists of six posture levels: Good, Acceptable, Neutral, Poor, Painful, and Extremely Painful. Each of these levels is represented by an emoticon and a color. The colors progress from green to red and the emoticons change from happy to crying as posture quality degrades. At the top of the scale Good Posture is shown using a smiley face and the color green. In the center of the scale Neutral Posture is shown using a neutral face and the color yellow, and at the bottom of the scale Extremely Painful Posture is shown using a crying face and the color red.

All changes in posture quality are communicated through an icon change in the window and taskbar. The icon shown matches the emoticon assigned to that level of the Posture Scale. The application is moved to the front of the monitor's z-order when a user's posture quality changes. It then quickly fades out. This keeps the user aware of his/her posture quality without stopping the progress of the current task.

We ran a pilot study with one subject for over 3 hours and found that the exercise recommendations were occurring more than once a minute. This frustrated the user and resulted in the system being ignored. As a result we added threshold values so that a more reasonable number of recommendations would be made. For the Extremely Painful posture the threshold value is 160 seconds, which is also the amount of time a posture must be maintained to be classified into a level on the Posture Scale. For the Poor posture exercise recommendation the threshold is 260 seconds, and for the Painful posture exercise recommendation the threshold is 210 seconds. Exercise recommendations are not made if the user is in a Neutral, Acceptable, or Good posture.

The exercise recommendations use a negotiated interruption strategy [1]. This strategy allows the user to ignore the interruption and continue as if nothing has happened, or respond to the recommendation at a more convenient time.

Experiment

We ran a study with seven subjects in order to evaluate the effectiveness of our system. Each of the subjects had prior laptop experience, and they all performed different tasks for a minimum of six hours. They were instructed to calibrate the system and use the laptop as they normally would. Subjects were further instructed to recalibrate the system should they take a small break, and they were told that they could ignore any messages our system provided.

Subjects completed a survey before and after each session; sessions consisted of a minimum of 1.5 hours of laptop use. The survey taken prior to each trial assessed the subject's initial level of pain and muscle tension. The survey completed after the trial gathered data on both the subject's level of pain and muscle tension, and the subject's opinion of the application. This allowed us to assess comfort level changes caused by laptop use with and without our system. The system software recorded the number of exercise recommendations made per session.

Results

To measure the effectiveness of the system we compared the number of exercise recommendations each subject received in their first half-hour of use to those received in their last half-hour. We also compared the change in comfort level experienced when using a laptop without our system to that experienced when using our system. Comfort levels were calculated from the user's ranking of the amount of pain and muscle tension in their shoulder, neck, and head region. To measure the effectiveness of the interruption management aspect of the system we used the survey completed at the end of each test session.

The system succeeded in increasing user awareness of their posture, and for some that resulted in improved posture. Four users showed postural improvement, two showed postural degradation, and one showed no change. However, most users showed increased comfort levels, and the group's comfort level improved after using our system (figure 2). The two users that demonstrated degraded posture experienced positive or no change in Average Comfort level. These two expressed no interest in improving their posture, nor did they care how bad their posture was.

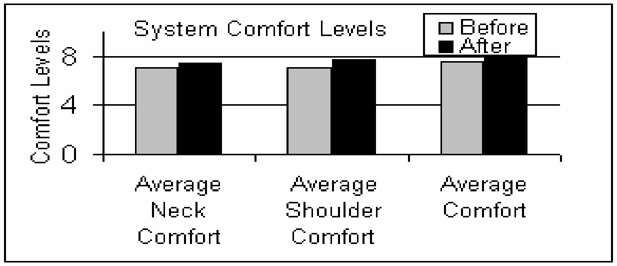

Figure 2: The comfort levels summarize the user's level of pain and muscle tension before and after using our system.

Average Comfort levels decreased when our system was not used (figure 3). This indicates the results in figure 2 are atypical of laptop use.

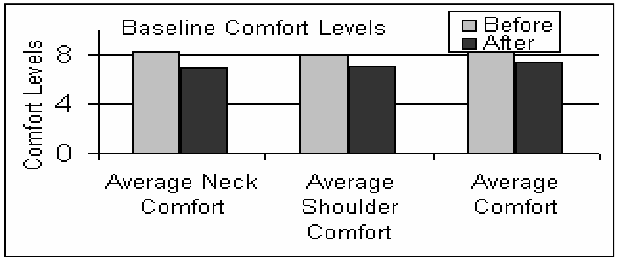

Figure 3: The comfort levels summarize the user's level of pain and muscle tension before and after using a laptop. 0 is lowest and 10 is highest.

The average comfort increase while using the system is smaller than the average comfort decrease from laptop use (figure 4). While the observed change in comfort levels is statistically insignificant, it may indicate a comfort improvement trend from our system's use.

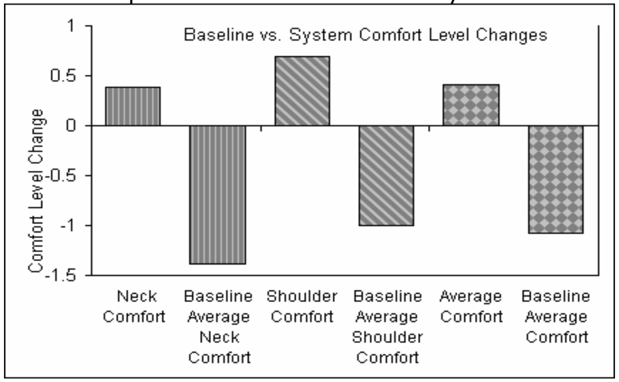

Figure 4: A comparison of the change in user comfort while using our system to the comfort change when using a laptop.

Most users found the system useful and usable. When a user considered the system useless it was because s/he ignored the system due to a lack of motivation. The average usability, usefulness, and attentiveness scores are high (figure 5).

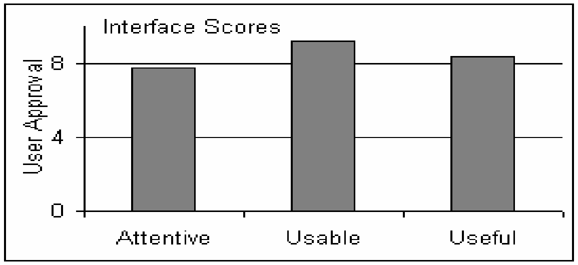

Figure 5: The user's scoring of our system's usefulness, usability, and attentiveness. 0 is lowest and 10 is highest.

Discussion

Our study has led us to believe that improvements could help the system realize its potential usability and effectiveness.

Development of a wireless dickie with the sensors sewn into it like they are in a data glove would allow the user more freedom to move around during a session and take breaks. It would also reduce how often the sensors need to be calibrated since the dickey could be worn on bathroom and coffee breaks.

To expand the system's persuasiveness, support for surveillance and operant conditioning could be added [4]. Surveillance could be introduced by providing the user's data to a healthcare professional for further analysis and feedback. Operant conditioning could be introduced using a rewards mechanism to reinforce positive posture and behaviors.

The users who demonstrated postural improvements were intrinsically motivated to improve their posture. This indicates that the system may help improve the posture of motivated users. However, the length of our study is insufficient for showing a change in behavior since approximately 90 days are required to form a new behavior [11], and improving one's posture is considered a new behavior.

Conclusion

The increase in comfort level while using our system indicates that the posture monitoring and improvement system we implemented holds promise. The feedback provided by our system is at the very least useful to motivated users, and helps to improve one's posture and reduce a person's risk of contracting RSI. This leads us to believe that our system is worthy of further evaluation.

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