Better Posture Awareness through Flower-Shaped Ambient Avatar

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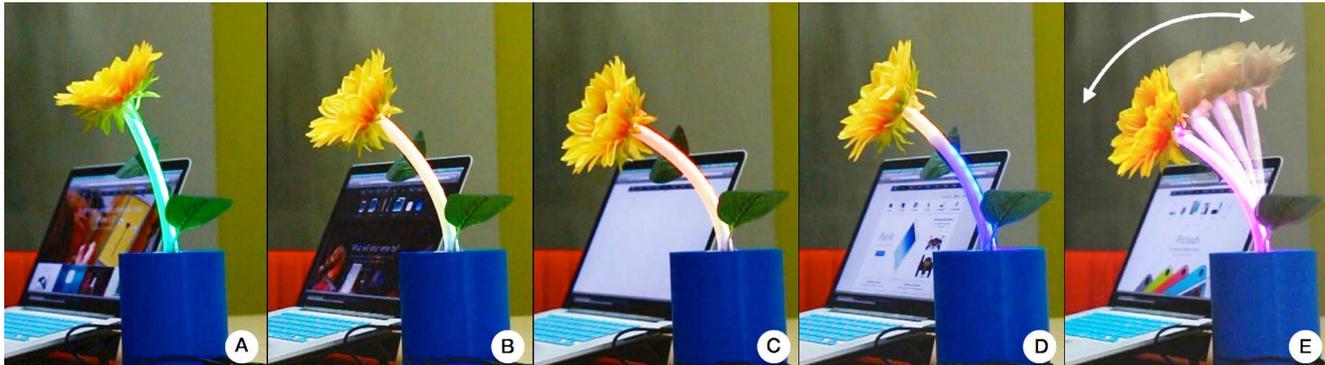{ burnness1, boss.ssong, jdcho07, andrea.whites }@gmail.com

Figure 1. The flower avatar can emulate the users' postures with great level of details by bending the stem up to 50° (A, B, C). Colors and flashing lights are also used to indicate both incorrect postures (A, B, C) and long sitting sessions (D). Finally, the stem animation suggests users that they should perform a stretching exercise (E).

ABSTRACT

Incorrect postures and long sitting sessions are among the main causes of back pain and discomfort, a problem affecting a growing portion of office workers. In the past, researchers have suggested possible ways to notify with alerts those users who sit improperly, but often such notifications are perceived as intrusive and tend to be ignored. In this paper, we present a flower-shaped physical avatar that subtly and pleasantly (through motion, colors and sounds) provides an ambient feedback to users about their postures. Compared with similar previous work, the flower-avatar described in this paper presents, through better sensing and fine-grain output capabilities, a more expressive ambient media platform that showcases the potential of media ambient avatars in health-care scenarios.

Author Keywords

Ambient media; physical interface; flower; back posture.

ACM Classification Keywords

H.5.2. Information interfaces and presentation: User interfaces.

INTRODUCTION

Poor sitting postures for prolonged period of time are responsible for the development and perpetuation of stiffed neck and back-pain related conditions [13]. As the average office worker spends approximatively 50,000 hours seated at the desk in front of a computer throughout his/her career, it is not surprising that 40% of all office workers are considered at risk of back-related discomfort or injuries [5] - a figure that in the next decades might just worsen.

The proliferation in recent years of mobile phones, small computers, sensors and wearable devices have helped researchers to find possible solutions for this problem, by sensing users incorrect sitting postures and providing notification alerts to warn them [e.g., 5, 14]. Although these approaches are promising, in practice most users who deal everyday with an increasing amount of notifications on multiple devices, each requiring a share of their attention, tend to ignore such alerts or to consider them invasive [5]. Depending on the nature of the interrupted task, even notifications meant to safeguard users' health could be perceived as disruptive, adding stress to the users and ultimately causing frustration rather than pain relief [1, 3].

For such reasons, many researchers have envisioned alternative strategies to notify users in more subtle ways, for example using peripheral displays [11], wearable devices [2], or ambient media - static or actuated physical objects [12], avatars [8], or places [7] which display information without requiring immediate users' attention. This last class of interfaces is also known as calm technology [6], as it allows users to smoothly shift the focus

of their attention from background to foreground tasks. For example, with Jeremijenko's Live Wire (Xerox Park, 1995), users could keep focusing on their primary task, while remaining aware of the network traffic condition represented by the motion of a spinning wire in the office [6]. The major benefit of using ambient physical media like a spinning wire is that, when compared to graphical alerts or haptic feedback, physical objects are considered the most informative but less invasive form of notification [5].

In this paper we present a novel ambient system, which, through an array of sensor modules, recognizes users' posture and activities when seated in front of a computer, and then uses a physical avatar shaped as a flower to subtly inform whether users are sitting properly or they are jeopardizing their back-health. Though previous work [5] had a similar objective and used a flower-shaped display as a binary notifier (good/bad posture), our work is different because proposes a much richer sensing system capable to discern among four different problematic sitting behaviors, and a much more expressive mechanical output display, capable of rendering uniquely and with multiple degrees of freedom each of the particular conditions affecting the user. We believe that the increased expressiveness of our multi-sensory system for both the input and output channels could enable researchers to envision new possible usage scenarios for physically actuated ambient media, such as for example, applications for healthcare.

RELATED WORK

Ambient media are those interfaces that allow users to smoothly transfer the focus of their attention from peripheral background information represented in the environment to a foreground task [6]. A prominent early example of ambient media space is the ambientROOM [7]. It is a physical room in which visual displays (e.g., lights and water ripples, shadows on the ceiling), sound through speakers, room temperature, airflow, and physical objects (e.g., clock and bottle) are all together used to represent background information (e.g., activities of a distant loved one, or physical presence of others) and to respond to users' actions (e.g., uncorking the bottle releases information in the room). The main advantage of ambient media, compared for example with explicit notification systems [5], is that they subtly provide information for background processing rather than enforcing them to users (calm technology). Other examples of ambient media include animated information (e.g., collages with news stories) on peripheral monitors [11], personal and wearable displays for near-eye notifications [2], physical and customizable avatars to represent instant messaging contacts' activities [10], and a physical commercially available Internet device such as the Nabaztag [8] that allows, among other features, to handle remote phone calls.

Another approach to ambient media is advocated by Poupyrev et al. [12], suggesting that a combination of tangibility and motion can further enhance the design of physical ambient media. The authors introduce several examples, starting from the Vaucanson duck (18th century), which is the oldest documented mechanically actuated ambient media [12]. Since then, a myriad of physical actuated devices were developed, including shape displays, pneumatic interfaces, tactile arrays [12], and even flower-robots capable of multiple degrees of freedom [9]. Highly related work from Haller et al. [5] features a simple flower-like notification system based on shape memory alloys that mimics the user's posture. However, due to the hardware limitations, this actuated flower is only capable to render two states (correct vs incorrect posture), resembling more a notification system than not an ambient display.

PROTOTYPE

Typical sitting posture problems appears in the neck and lumbar region of the back and are often related with the degree in which the trunk is bended forward [13], and the amount of time the user remains statically seated [5]. Moreover, great changes of posture are also a good indicator of discomfort and potential problems [13]. Our prototype uses two different sensor modules to track the back curvature and the user proximity to the computer monitor (e.g., some users tend to lean toward the monitor to better see screen text). Moreover, it tracks the rate of changes of posture and the amount of time the user remains seated. It uses this information to determine the overall sitting behavior, and, through a flower-shaped actuated physical ambient avatar, it constantly provides a feedback to the user. In the following sessions, we describe the hardware for the input modules, the flower avatar, and the software to determine the user's posture.

Sensors input

A module (5 x 5.5 x 2 cm width/depth/height) with a six-axis gyro+accelerometer sensor-board (MPU-6150) and a micro-controller (Arduino Pro Mini) is pinned to a user's back (e.g., shirt's collar) to track the degree in which the user's trunk lean forward (Figure 2). The micro-controller reads the data from the sensor (such data is filtered and processed by the on-board Digital Motion Processor library), and custom code determines the user's back posture through a state machine with five states (from correct posture to fully bended back). The user's current state is then sent by bluetooth communication (HC-06 module) to a remote PC running the application controlling the flower avatar. All the module parts are powered with a

Figure 2. System overview with sensors and avatar.

3.7V lithium battery and are connected with jumper wires on a mini breadboard.

The second module (8 x 5.5 x 2 cm width/depth/height) is used to track both the user's proximity to the computer monitor and the time the user remains seated. A Sharp GP2Y0A02YK0F infrared proximity sensor is attached to the computer case, pointing toward the user and tracking his distance. Similarly, a 4x4 cm Force Sensitive Resistor (FSR) is positioned on the chair's seat and acts as a switch to detect the user's presence. Both sensors are connected to an Arduino Uno, which, through a USB cable, sends data to a PC hosting the main application.

Flower avatar
We built a custom-made mechanical avatar shaped like a flower to represent the user's posture and provide a feedback about potential sitting problems. The flower avatar is composed by an actuated stem and a pot where the controller and communication units are located (Figure 3).
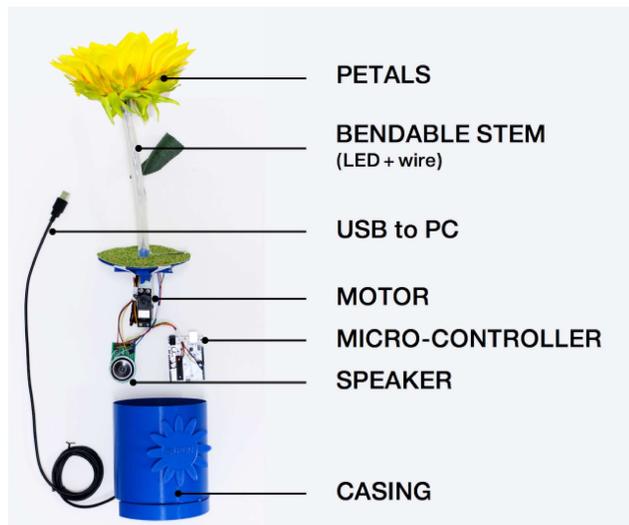

PETALS

BENDABLE STEM
(LED + wire)

USB to PC

MOTOR

MICRO-CONTROLLER

SPEAKER

CASING

Figure 3. Exploded view of the mechanical flower avatar.

The stem is made by a bendable silicon tube (20 cm long, outer/inner diameter 18mm/10mm) containing a strip of 13 small RGB color LEDs, and a nylon wire that causes the stem to bend when pulled. The tip of the stem is decorated with fake petals, to resemble a blossoming sunflower.

The pot is a cylinder case (15 cm height by 14 cm diameter) designed in Rhino3d and 3D printed on a Cube X 3D printer. It encloses a small servomotor (capable of 4.3 kg-force-cm torque at 6V) responsible of pulling the wire, an Arduino Uno serially connected through USB interface to a PC, and a small audio speaker.

Software
The flower avatar and the sensor modules are all connected to a PC running a custom software written in Java. Using the sensor data, a state-machine determines the user's posture, and according to the result, it instructs the avatar how to operate. There are several output modalities, including LED color changes, stem bending, sounds and stem animations. We describe how sensory input and avatar operations are blended together in the next session.

APPLICATIONS
Using the input/output platform described above, we envisioned four different types of application to help users maintaining a correct posture when seated at a work-desk in front of a computer. Such applications are aimed to track typical sitting problems and provide an immediate but subtle feedback to the users through the actuated flower-shaped avatar. The system is also capable to determine whether the user is constantly ignoring the ambient feedback, and in case of critical but unaddressed posture problems, it can generates explicit notifications to correct the user behaviors. Finally, because these applications are multi-modal and might result in high cognitive load, users can decide, according to their preferences, to run them all simultaneously or selectively in any combination.

1) Tracking back posture
When a user sits incorrectly at the desk, the gyroscope module pinned on the user's back determines the degree of curvature of the cervical region, then computes the corresponding user's posture (state) and wirelessly transmits it to the PC controlling the flower avatar. When the flower receives a request to change state, within a second the motor inside the pot pulls the wire so that the stem bends of an amount proportional to the user's back curvature. Moreover, also the color of the stem changes depending on the curvature: when the flower is vertical, the stem color is green, an analogy of the flower's good health. A bended stem is represented with shades of yellow, signifying that the flower is becoming unhealthy. When the flower is completely bended, it shows a red stem, to indicate that it is dry (Figure 1.A-C).

Differently from previous work that presented a bending flower avatar capable of displaying either the user's correct or incorrect position (2 states) [5], our prototype can describe the user's position with much richer details, hence better helping users to identify not only if they are sitting in the incorrect posture, but also the degree of their mistakes. Specifically, the flower stem can bend up to 50° according to five different states (from vertical to completely bended), each state accounting for 10°.

2) Tracking sitting time
Long sitting sessions without exercise or pauses are among the most common causes of back pain [5]. To encourage a healthier behavior our software tracks the amount of time in which the user remains seated, using the FSR sensor located on the chair seat. When the user is seated, every 5 minutes one of the 13 LED in the stem turns blue, from bottom to top, similarly to a progress bar (Figure 1.D). The color blue was chosen to resemble the color of the flower pot (also blue), an analogy that subtly indicates that the flower is "turning into a static object" because of the user's lack of motion. When the stem is completely blue (after 65 minutes), the system plays a short melody and the blue

lights blink, signaling that the user should take a walk for few minutes. If the user returns to his seat after 5 or more minutes (a customizable threshold), the flower resets to the neutral state.

3) Tracking proximity to the screen

Users tend to bend toward the monitor whenever reading small fonts on the screen. We used a proximity sensor mounted on the computer case to track the distance of the user from the monitor. For our purpose, we only distinguish among three different states (normal, near, very near). If the user is near to the screen, the LED lights encased in the stem start blinking to signal that the user is getting too close, but if the user gets even closer to the screen also a sound melody is played through the speaker inside the case.

4) Tracking posture changes

Continuous posture changes are a symptom of discomfort and potential problems, but this situation can be improved by practicing simple back exercises [13]. Using our state machine the system can track the rate of change of postures per minute. If such rate is higher than a configurable threshold, the flower animates with motions of the stem and its color changes to purple (an analogy of bruises), signifying that the user should practice a short physical exercise (Figure 1.E). After a 10 seconds stretching exercise (sensed by the gyro-module), the flower avatar goes back to the neutral state.

CONCLUSION AND FUTURE WORK

Physical ambient media is becoming a well establish model for discretely presenting background information to users [6]. Examples usages include peripheral displays [2, 11], objects in a room [7], and physical avatars [5, 9, 10]. More recently, physical ambient media that can also be mechanically actuated are becoming prominent [12]. In this paper we contribute to the corpus of literature that describes new types of physical and actuated ambient media. Specifically, in this paper we presented an actuated flower-shaped avatar that through colors, sounds, motion and animations of a bendable stem provides a continuous feedback about the posture of users seated in front of a computer. The final goal of this work is to subtly inform users about wrong postures, encouraging physical exercises and adjustments that could help avoiding possible back pain and injuries. Future work includes testing this system with real users in a longitudinal study, and building additional input sensors and output modalities. Finally, we plan to extend this work by seeking other applications for this avatar to promote healthy behaviors in working places, and by exploring different physical form factors.

ACKNOWLEDGMENTS

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