Rotating, Tilting, Bouncing: Using an Interactive Chair to Promote Activity in Office Environments

Kathrin Probst
Media Interaction Lab,
FH OÖ - University of Applied Sciences Upper Austria
mi-lab@fh-hagenberg.at

David Lindlbauer
Media Interaction Lab,
FH OÖ - University of Applied Sciences Upper Austria
mi-lab@fh-hagenberg.at

Patrick Greindl
Media Interaction Lab,
FH OÖ - University of Applied Sciences Upper Austria
mi-lab@fh-hagenberg.at

Markus Trapp
Mechatronics Engineering,
University of Waterloo
maftrapp@uwaterloo.ca

Michael Haller
Media Interaction Lab,
FH OÖ - University of Applied Sciences Upper Austria
mi-lab@fh-hagenberg.at

Bernhard Schwartz
Medical Technology Department,
FH OÖ - University of Applied Sciences Upper Austria
bernhard.schwartz@fh-linz.at

Andreas Schrempf
Medical Technology Department,
FH OÖ - University of Applied Sciences Upper Austria
andreas.schrempf@fh-linz.at

Abstract

A typical office worker nowadays spends the majority of his time sedentary in the course of his working life. In this paper, we address the problem of sedentariness in the context of office work through smooth integration of light physical activity into the daily work routine. Equipping a flexible office chair with motion sensing functionality, the chair becomes a ubiquitous input device that provides an office worker with the possibility to use the movements of his body for tilting, rotating, or bouncing to control his workplace computer. Based on this idea, we apply an existing gesture taxonomy to body movements on an active office chair, and explore different application scenarios for ubiquitous gestural chair interaction.

Author Keywords

Physical Activity Promotion; Interactive Chair Interface; Embodied Interaction; Gestural Interaction

ACM Classification Keywords

H.5.2 [Information Interfaces & Presentation]: User Interfaces - Ergonomics;

General Terms

Human Factors, Design

Introduction

Today, a typical office worker spends a major amount of his work time sedentary throughout his daily routine: sitting in the car on the way to work, sitting while working in front of the computer, sitting during meetings, sitting while having lunch – consequently, prolonged sitting has become a predominant element of our lives. Prolonged sedentary behavior has been identified as one major health risk though, leading to a variety of chronic diseases [8,15]. Various possibilities have been proposed to keep people moving during the workday (e.g., taking the stairs instead of the elevator). However, for most office workers it is difficult to achieve a considerable reduction of the time spent seated within the office environment.

To promote physical activity even in such sedentary situations, this work explores the possibilities of using an interactive office chair to smoothly integrate physical activity into the daily working routine. By equipping a flexible chair[1] with a motion sensor, the movements of a person sitting on the chair can be tracked and transformed into input events that trigger various actions on a computer. This way, the chair becomes an input device that is ubiquitously embedded into the work environment, and provides an office worker with the possibility to use the movements of his body for rotating, tilting, or bouncing a chair to intuitively control his workplace PC. In this work, we explain the implementation of our sensor-based chair interface, we explore three different gesture styles for chair interaction (i.e., *deictic*, *manipulating*, *semaphoric*), and describe possible application scenarios of using recognized input gestures for the control of a desktop computer.

[1] http://www.swopper.de/en/3dee

Related Work

Existing sensor-based chair interfaces proposed different technologies to get information about a person's sitting posture that range from mechanical [2,5,7,10,14,21] to optical [4] and motion-based [6] solutions. Chairs have been used for unobtrusive measurement of body movements [7,10] and the development of posture recognition systems for the classification of a person's sitting behavior [5,19,20] or emotions [2,21]. Chair-based tracking data has furthermore been explored for supporting people in learning [10,14] and ambient assisted living [7] environments. Finally, the usage of interactive chairs has also been explored as input devices for the navigation of virtual 2D and 3D environments in computer games [4], or for direct control of the mouse cursor in a desktop environment [6]. Our work differs from past research in this field in two major points. First, we explore the usage of an interactive chair within an office environment, with the goal to promote the *implicit and occasional* integration of light physical activity into the daily work routine. Second, we explore chair interaction in the context of *gestural* interactions for the control of application-specific functions on a desktop computer.

Therefore, different previous works of gestural interaction and classification have been taken into account. The usage of hand, finger and full-body gestures has been explored extensively (e.g., [18]), as well as their usage for primary and secondary tasks like controlling a music application while typing [12] or controlling an interface while driving [1]. Based on findings in this context, we apply an existing gesture taxonomy [11] to body movements on an active office chair for the identification of different interactions.

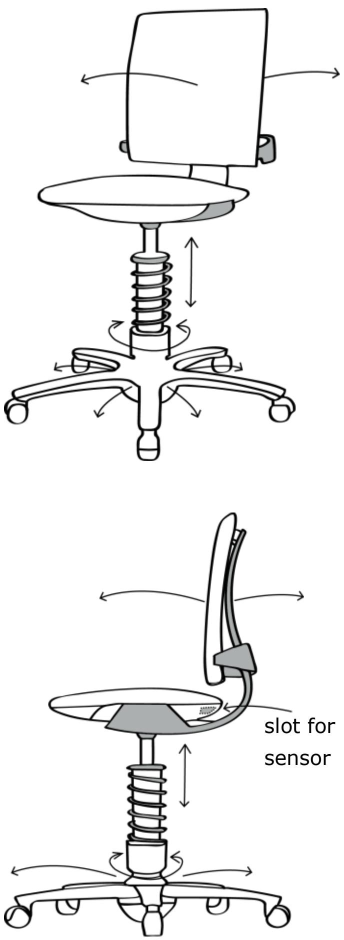

Figure 1. The 3Dee active office chair.

Sensor Implementation

Our interactive chair is a 3Dee active chair[1] (see Figure 1), a flexible office chair supporting various movement directions (rotate, tilt, bounce). We use a Nordic Semiconductor µBlue™ Smart Remote supporting low-energy Bluetooth® 4.0 technology, equipped with a gyroscope and an accelerometer. For motion tracking, we chose this chip because of its low energy consumption, size, and cost. The accelerometer and gyroscope measure the acceleration resp. velocity along x-, y-, and z-axis. We combine both values to a joint measure (sampling at 100Hz), to calculate the angular position of the sensor in the 3D space. The device transmits the data in real-time via a custom protocol containing information about tilt, rotation and motion to a desktop computer running Microsoft Windows 8 operating system. Based on the received data, we apply gesture recognition mechanisms to distinguish between different chair interactions.

Chair Interactions Techniques

We use the gesture taxonomy developed by Karam and schraefel [11] as a foundation for the proposed interactions to provide users with additional control, and to promote movement in a predominantly sedentary workday. The classification of gestures has been explored extensively, mostly in the context of hand gestures. The taxonomy distinguishes between five different gesture styles: *deictic*, *gesticulation*, manipulating, *semaphoric* and *sign language*. Since gesticulation and sign language are closely related to human speech, we think they are not appropriate in the context of chair gestures. Therefore, we apply the other gesture styles (deictic, manipulating, semaphoric) to categorize the proposed chair interactions.

Deictic Gestures

Deictic gestures are described to "involve pointing to establish the identity or spatial location of an object within the context of the application domain" [11]. An example of a deictic chair gesture is *interrupt reaction* (see Figure 2). Pointing at (leaning or rotating towards) another display or workstation to interact with a notification can be categorized as deictic gesture. This type of interaction is especially interesting for distributed display setups (e.g., [16]), which have the need to handle notifications or interrupts on distant monitors. Our interactive chair offers the opportunity to react without using or releasing the keyboard or mouse. Leaning or rotating towards the distant screen containing the alert window triggers the notification handling and moves the window to the current screen. If multiple notifications are present, all of them are moved on the primary screen and the user can select which one to handle first. This way, users can react to notifications anytime they want without the need to respond immediately and in a more comfortable way than moving the mouse to another (distant) monitor.

Figure 2. Example for a deictic pointing (rotating/tilting) gesture to handle notifications on a distant display.

Manipulating Gestures
Karam and schraefel [11] use a definition by Quek et al. [17], stating that a manipulating gesture's "intended purpose is to control an entity by applying a tight relationship between the actual movement of the gesturing hand/arm with the entity being manipulated". Although applied to hand gestures, this definition also holds in the context of chair interaction. Constantly operating the mouse [6] with the chair can be exhausting and can lead to the well-known Midas Touch problem [9]. *Scrolling* in contrast may be performed from time to time in different situations (e.g., web or document browsing) and thus is more suitable to be integrated into the daily office work. Using the forward and backward tilt can be used to control the scrolling within an application. Similar to the *Touch-n-Go* technique, used to control e.g. maps [13], the direction and speed of the user's movement can be used to control the scrolling behavior (see Figure 3). Through the continuous navigation, we are encouraging users to move while seating, without demanding exhausting movement when scrolling large content.

Figure 3. Example for a manipulating (tilting) gesture to control scrolling of web content in a browser.

Semaphoric Gestures
Semaphoric gestures are based on a stylized dictionary, containing gestures that require prior knowledge or learning [11]. These gestures can be static (static poses), dynamic (movement) or stroke (e.g. mouse stroke to control back functionality) gestures. We apply dynamic and stroke gestures to add an additional gesture interaction dimension (besides mouse and keyboard) to the desktop PC. We use the gestures to *control a browser's back and forward functionality* or *to switch between tabs* by tilting the chair left and right. Additionally, we are mapping dynamic gestures like moving the chair up and down to *reload the browser* (see Figure 4) or *confirming or rejecting pop-up dialogs* by tilting the chair from the front to the back (confirm) or left to right (reject). Also, using the chair to switch between applications (like the *Alt+Tab* functionality) by leaning to the left or right side offers ways for interaction in motion and breaking static sedentary behavior. Additionally, we are exploring the usage in mail programs, file organization, to unlock screens, to open menus, and for window overview and management.

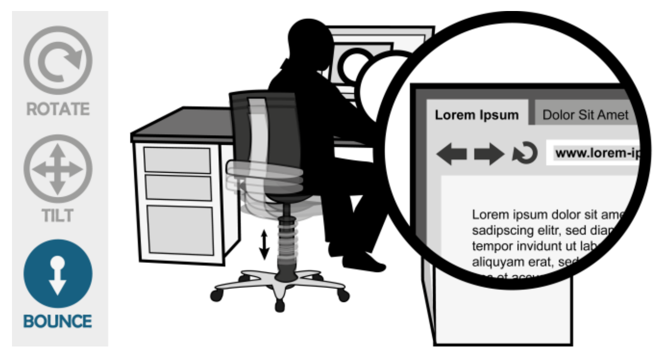

Figure 4. Example for semaphoric gestures to invoke a web browser's back/forward (tilting), or refresh (bounce) functions.

Other Interactions

One additional interaction that we explore is to use the interaction chair as a *presence sensor*. By looking at the sensor data, we can easily measure if the user is currently sitting on the chair. This is especially interesting in a context like [16], where users tend to move between workplaces and the system needs information about the user's presence. Although this could also be achieved by analyzing mouse or keyboard events, the chair sensor also has information about the presence if the user is sitting at the workplace but not interacting with the computer (e.g., reading or writing on paper). This way, the presence of the user can be detected without installation of e.g. a visual tracking system.

Challenges and Opportunities

As with other gestural interfaces, distinguishing between the user's natural movement on a flexible office chair and dedicated gestures or interactions is challenging. Baudel and Beaudouin identified several challenges when working with gestures: *fatigue, non-self-revealing, lack of comfort, immersion syndrome*, and *segmentation of (hand) gesture* [3]. While fatigue (hand and arm-fatigue due to constant hand elevation) and lack of comfort (due to data gloves) don't apply to our proposed chair interactions, the other three challenges also emerge when working with chair gestures. Like hand gestures, gesture-based interactions with an interactive chair are not immediately clear to users ("non-self-revealing"), bringing along the need for an introduction to possible interactions. Since users are constantly moving when sitting on a flexible office chair, gestures and actions can be hard to distinguish from regular movement ("immersion syndrome"). Also, the continuous nature of movement and gestures brings up challenges when distinguishing between gestures ("segmentation of gestures"). These are, as for many gestural interfaces, the main challenges that evolve when using the system. We will examine these problems more closely to get a deeper understanding on when these challenges occur and how to meet them. Interactions with interactive chairs like the sensor-equipped 3Dee chair offer the opportunity to change the static sedentary lifestyle of office workers. Using the interactions as an optionally usable addition to a regular interface can motivate users to having a more active and dynamic daily routine without distracting them or forcing them to use such interactions. Additionally, using the chair as an input device offers great opportunities when interacting with e.g. notifications, secondary tasks or multiple workstations – especially for distant display interactions and interactions that do not require mouse or keyboard input.

Conclusion & Future Work

In this paper we presented our chair sensor implementation using an accelerometer and gyroscope. This sensor combination gives us the opportunity for fine-grained, real-time data, which we use for implementing several different interactions. We use the data for real-time gestural interaction based on a gesture taxonomy to explorer interactions in a structured way by using insights from research of finger-, hand-, and full-body gestures. We presented our proposed applications as well as challenges and opportunities that arise with this type of interaction. We think using the chair as an additional input device has high potential to be a beneficial addition to traditional input devices and motivation of a more active daily work routine. For future work, we plan to evaluate the proposed interactions and compare them to regular interactions with mouse, keyboard and other input methods.

References

[1] Alpern, M. and Minardo, K. Developing a Car Gesture Interface For Use as a Secondary Task. In *Proc. CHI EA '03*, ACM Press (2003), 932–933.

[2] Anttonen, J. and Surakka, V. Emotions and Heart Rate while Sitting on a Chair. In *Proc. CHI '05*, ACM Press (2005), 491–499.

[3] Baudel, T. and Beaudouin-Lafon, M. Charade: Remote Control of Objects Using Free-hand Gestures. In *Communications of the ACM 36*, *7* (1993), 28–35.

[4] Beckhaus, S., Blom, K.J., and Haringer, M. ChairIO – The Chair-Based Interface. In *Concepts and Technologies for Pervasive Games* (2007), 232–264.

[5] Daian, I., Van Ruiten, A.M., Visser, A., and Zubić, S. Sensitive Chair: A Force Sensing Chair with Multimodal Real-Time Feedback via Agent. In *Proc. ECCE '07*, ACM Press (2007), 163–166.

[6] Endert, A., Fiaux, P., Chung, H., Stewart, M., Andrews, C., and North, C. ChairMouse: Leveraging Natural Chair Rotation for Cursor Navigation on Large, High-Resolution Displays. In *Proc. CHI EA '11,* ACM Press (2011), 571–580.

[7] Forlizzi, J., DiSalvo, C., Zimmerman, J., Mutlu, B., and Hurst, A. The SenseChair: The lounge chair as an intelligent assistive device for elders. In *Proc. DUX '05*, AIGA (2005), 31.

[8] Healy, G., Lawler, S., Thorp, A., Neuhaus, M., Robson, E., Owen, N., and Dunstan, D. *Reducing prolonged sitting in the workplace*, Victorian Health Promotion Foundation (2012).

[9] Jacob, R.J.K. Eye Movement-Based Human-Computer Interaction Techniques: Toward Non-Command Interfaces. In *Advances in Human-Computer Interaction* (1993), 151–190.

[10] Kapoor, A., Mota, S., and Picard, R.W. Towards a Learning Companion that Recognizes Affect. In *Proc. Emotional and Intelligent II,* AAAI Press (2001).

[11] Karam, M. and schraefel, m.c. *A taxonomy of Gestures in Human Computer Interactions*, 2005.

[12] Karam, M. and schraefel, m.c. A Study on the Use of Semaphoric Gestures to Support Secondary Task Interactions. In *Proc. CHI EA '05*, ACM Press (2005), 1961–1964.

[13] MacKay, B., Dearman, D., Inkpen, K., and Watters, C. Walk'n Scroll: A Comparison of Software-based Navigation Techniques for Different Levels of Mobility. In *Proc. MobileHCI '05*, ACM Press (2005), 183–190.

[14] Nanayakkara, S., Wyse, L., and Taylor, E.A. Effectiveness of the haptic chair in speech training. In *Proc. ASSETS '12*, ACM Press (2012), 235–236.

[15] Owen, N., Bauman, A., and Brown, W. Too much sitting: a novel and important predictor of chronic disease risk? In *British Journal of Sports Medicine 43*, 2 (2009), 81–83.

[16] Probst, K., Leitner, J., Perteneder, F., Haller, M., Schrempf, A., and Glöckl, J. Active Office: Towards an Activity-Promoting Office Workplace Design. In *Proc. CHI EA '12*, ACM Press (2012), 2165–2170.

[17] Quek, F., McNeill, D., Bryll, R., Duncan, S., Ma, X.-F., Kirbas, C., McCullough, K.E., and Ansari, R. Multimodal Human Discourse: Gesture and Speech. In *ACM Transactions on Computer-Human Interaction 9*, 3 (2002), 171–193.

[18] Saffer, D. *Designing Gestural Interfaces*. O'Reilly Media, 2008.

[19] Schrempf, A., Schossleitner, G., Minarik, T., Haller, M., Gross, S., and Kurschl, W. PostureCare - Towards a Novel System for Posture Monitoring and Guidance. In *Proc. IFAC '11*, Elsevier (2011), 593–598.

[20] Tan, H., Slivovsky, L., and Pentland, A. A Sensing Chair Using Pressure Distribution Sensors. In *IEEE ASME Trans. on Mechatronics 6*, 3 (2001), 261–268.

[21] Vanhala, T., Surakka, V., and Anttonen, J. Measuring Bodily Responses to Virtual Faces with a Pressure Sensitive Chair. In *Proc. NordiCHI '08*, ACM Press (2008), 555–559.