Active Office: Designing for Physical Activity in Digital Workplaces

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Abstract
Over the past centuries, our lives have become increasingly sedentary. Having an office job today, all too often involves sitting at a computer, performing the same small repetitive movements with our fingers, hands, and eyes over and over again. The shape, size and form of computing technology have influenced and placed limits on the physical movements that we perform throughout the day. Our research thus focuses on the question how human-computer interaction can fluently embed interactive technology into our workplaces to allow for more physically active working styles, and re-introduce diverse bodily movements in to our work routine. The present work describes how we are approaching this topic from a dual design perspective: macro-level support of smooth transition between different work postures, and micro-level design of bodily interaction technologies that increasingly acknowledge the richness of human motor skills.

Author Keywords
Workplace Design; Physical Activity Promotion; Embodied Interaction;

ACM Classification Keywords
H5.2 [Information Interfaces & Presentation]: User Interfaces - Ergonomics.

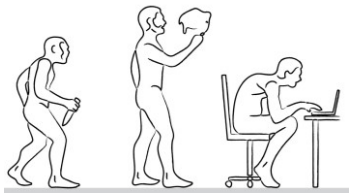

Figure 1. As our lives have become increasingly inactive, modern society has to deal with classic diseases of civilization. Work-related musculoskeletal disorders are one of the most common chronic diseases – often resulting from years of sedentariness and poor posture at the workplace (e.g., office jobs) [8].

Figure 2. Our research focuses on the design of active workspaces that support the integration of bodily actions into the predominantly sedentary office workflow.

Introduction

Over the past centuries, there has been a major shift in the types of activities that we perform every day, and our lives have become inactive for the most part. From an evolutionary perspective, we have traded the variety of skilled movements that we once used to perform in crafting and agricultural domains against the monotony of large movements in industrial production, and later against the monotony of small movements in computer-mediated work. As a consequence, our complex musculoskeletal system remains unchallenged and many of our highly specialized body functions remain unused. In contrast, physically active work routines have been identified to hold high potential for the avoidance of prolonged sedentary behavior and related degenerative phenomena [7]. Given the fact that an average adult person spends the majority of his waking hours at work, the World Health Organization (WHO) has identified the workplace as important area for the setting of health-promoting and preventive measures [16].

From an interaction perspective, we have traded the direct mapping between form and function that we once found in artisan tools against reduced numbers of mechanical controls on machines and early computers, and later against the basic operations of point-and-click interaction in desktop interfaces. As a consequence, most modern computer interfaces no longer provide a perceptually meaningful link between actions, form, and feedback – thereby increasingly challenging users' cognitive skills to learn and remember various digital functions and input sequences [2]. In contrast, embodied interaction styles have demonstrated high potential to more effectively match computer interfaces to the richness of human perceptual and motor skills [3].

Addressing this tradeoff, our research focuses on the design of digital workspaces that support the integration of bodily actions into the predominately sedentary office workflow at multiple levels to facilitate large-scale and small-scale body movements:

- **Macro Level:** How can we design workplace environments that allow for seamless alternation between different work postures?
- **Micro Level:** How can we design input technologies beyond point-and-click interaction, to increasingly leverage the richness of human motor skills?

Related Work

To counter the critical trend towards increasingly sedentary lifestyles, many companies have initiated workplace health promotion (WHP) programs to improve health and overall well-being of their employees by raising awareness for health-related topics and promoting increased physical activity [16]. Unfortunately, many of these interventions have been of limited success as they pose high demands on workforce commitment, or require employees to leave their desks for exercising (e.g., gym classes). Moreover, it is suggested that structured physical exercise is unlikely sufficient to prevent chronic diseases within the context of otherwise sedentary lifestyles [8].

To overcome these limitations, recent research has increasingly focused on implicit methods of WHP that are integrated into the daily work routine, e.g., taking the stairs rather than the elevator, standing during meetings rather than sitting at conference tables [4]. Office environments have been equipped with furniture elements such as active chairs, standing desks, stepping devices, or treadmill and cycling workstations.

Figure 3. A sit-and-stand workspace design that facilitates work in sitting and standing posture.

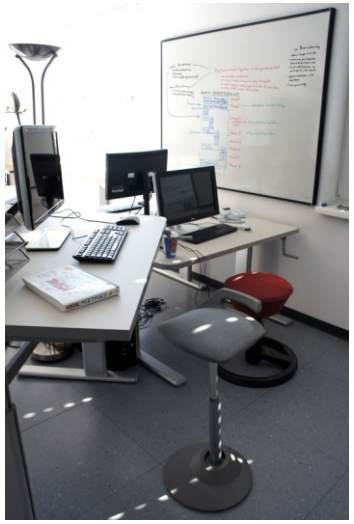

Figure 4. Example of one participant's personalized sit-and-stand workspace arrangement.

However, since computer technologies have become an integral part of today's office work, the integration of physical activity into the work routine brings along a number of challenges that have been rarely addressed by the HCI community so far [9]. The facilitation of a physically active work process poses demands on user interface technology (e.g., interface design, interaction metaphors, ergonomics) that may be rather different from those of today's stationary work environments. Addressing these demands therefore needs to be considered for the design of future systems within increasingly flexible and mobile work environments.

Our Work to Date

Approaching the design space from a macro-level perspective, our initial research included a field study of a novel sit-and-stand workspace concept (see Figure 3). In contrast to commercially available solutions, this design includes two work surfaces at sitting and standing height – which allows users to seamlessly switch between these work environments at any time. Over the course of three weeks, five office workers were equipped with such a setup, and interviewed about their usage experience. The results allowed us to get a better understanding of the interplay between physically active workflows and computing activities, and how this may imply requirements for HCI design [13]:

- We identified a variety of channel factors [14] related to participants' *personal condition*, *work task*, and *workspace configuration* that were perceived to influence their work dynamics in a positive (encouraging) or negative (limiting) way. We learned that even seemingly small time and effort requirements may be perceived as enough of a burden to limit participants' freedom of movement.
- We identified two basic concepts for the incorporation of posture changes into the daily work routine, i.e., *task-driven* approaches that are based on direct coupling of specific work tasks and work surfaces (e.g., reading e-mail when standing), *self-determined* approaches that are based on arbitrary alternation between work postures.

In a following long-term in-situ deployment, twelve participants were equipped within a similar sit-and-stand workplace design over the course of six months. While the results largely confirmed the findings of the field study, they allowed us to gain an even deeper understanding on a long-term perspective [15]:

- Over the course of time, we observed participants converge towards a *hybrid* approach, which was based on opportunistic alternation between work postures based on characteristic work styles that were commonly associated with sitting or standing work (e.g., concentration vs. communication, individual vs. collaborative, focus vs. overview).

Based on the insights from these studies, we developed prototype systems that address the main identified design challenges. *PECAN (Personal Extraction of Context from Analog Notes)* is a pen-and-paper system for ad-hoc digitization of handwritten notes, which allows users to move freely within the workspace by decoupling of physical representation and information. *Sitzgscheit* is a shape-changing peripheral display, which allows users to be reminded of posture changes in an unobtrusive way. *50:50 (Fifty-Fifty)* is a sensor system for tracking of human presence within a work environment, which allows users to gain insights on their personal movement dynamics and behavior patterns.

Figure 5. A user controlling a PC through the movements of his body while sitting on a flexible office chair, e.g., tilting, rotating, bouncing.

Figure 6. A user controlling a PC through foot gestures, e.g., kicking, rolling, tapping, swiping.

Looking at the design space from a micro-level perspective, our research then moved towards exploring the opportunity of designing input technologies that increasingly acknowledge the richness of human motor skills for our interactions with computers. In our initial work, we explored the possibility of using an interactive office chair as alternative input device (see Figure 5). By equipping a flexible chair with a motion sensor, the movements of seated person can be tracked and transformed into input events that trigger actions on a computer [10]. In an iterative design process, we conducted a guessability-style [17] user study to investigate possible chair gestures, conducted Wizard of Oz experiment to collect initial user feedback, and performed a controlled experiment that compared chair-based input to state-of-the-art keyboard and touch input. The results allowed us to explore the design space for bodily interaction as novel input modality [11,12]:

- The embodied nature of motor body movements was identified as particularly suitable for interaction with *peripheral interaction scenarios* [1], as significantly reduced resumption lags allowed users to rapidly refocus on an ongoing primary activity.
- They were identified most suitable for *imprecise interactions* that take into account the nature of the bodily movements in comparison to high-accuracy input from traditional pointing devices.
- Integrating interaction areas directly into the physical environment was found to provide an *always-available interface* [5] that can potentially be detected anytime to provide always-available access to application functions. Besides that, it is important to provide sufficient solutions that prevent accidental activation through natural movements.

Extending this concept towards other types of *smart furniture interfaces*, we performed another lab experiment and guessability-style [17] user study where we investigated the suitability of various regions in a physical desk environment as potential input areas – for sitting/standing desk configurations, and hand/foot interactions. From the results we gained further generalizable insights for the integration of bodily interactions in digital workspaces [to be published]:

- We identified common properties that make different desk areas more or less suitable as interaction area based on their physical and visual accessibility, i.e., *reachability, approachability, aimability, movement distance, movement complexity, visibility*.
- We identified various gesture creation strategies that provided insights into users' mental models to create meaningful associations between bodily movements and digital actions [6], e.g., *ordered arrangements, spatial mappings, real-world & digital analogies*.

Conclusion

Addressing the timely issue of increasingly sedentary lifestyles, we have presented the insights from our research on designing for physical activity in digital workspaces. We have explored the design space for supporting physically active work processes both on a macro-movement (i.e., posture variation), and micro-movement level (i.e., hand, foot, body gestures). By addressing the design opportunities and challenges on these multiple levels, we believe that computing technology holds the potential to transition our work environments from sedentariness and point-and-click monotony towards physical action and movement diversity.

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