# Reconfigurable Interactive Environments for the Future of Work

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Inevitable technological progress changes the very nature of work. On the one hand, more and more processes are subject to automation, and cooperating with a robotic workforce becomes an increasing challenge. On the other hand, society is increasingly embracing diversity, and there is an emerging social need to build diverse and inclusive spaces for work. My research attempts to answer these challenges by designing, implementing, and evaluating a novel type of work environment: an Interactive Reconfigurable Environment (IRE) IREs will leverage artificial intelligence techniques to dynamically adapt the physical surfaces around a user to provide an efficient, usable and inclusive interface. An adaptive work environment will support concentration and productivity while ensuring work safety in mixed environments - industrial, semi-automatic, automatic, and, above all, in situations of cooperation between people and autonomous agents.

CCS Concepts: • **Human-centered computing** → **Interaction devices**.

Additional Key Words and Phrases: Smart Environments, Connected Home, Workplaces

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## 1 FOREWORD AND PROGRAM DETAILS

I am currently a PhD student at the Lodz University of Technology in the Department of Computer and Control Engineering, Institute of Applied Computer Science, in the discipline of Information and Communication Technology. My scientific supervisors are Andrzej Romanowski and Paweł W. Woźniak. I have started my last, fourth year of doctoral studies, and the expected completion date of my doctorate is September 2024.

## 2 MOTIVATION, PROBLEM, AND QUESTIONS

The rapid advance of technology is reshaping work dynamics with increasing automation and a growing need for diverse and inclusive workspaces. This dissertation aims to address these challenges by designing Interactive Reconfigurable Environments (IREs) that dynamically adapt physical workspaces using artificial intelligence.

IREs will empower diverse users in tasks like sensemaking, data analysis, and collaboration with robots. The dissertation's objectives are: (1) Establish foundational principles in Human-Computer Interaction (HCI) and Applied Artificial Intelligence (AI) for IREs; (2) Create a proof-of-concept prototype system to evaluate these principles; (3) Derive design guidelines for future IRE development.

The key questions this project explores are:

(1) How can AI and user modeling adapt physical workspaces to accommodate diverse user needs?
(2) How can we evaluate and classify types of IREs and translate findings into design guidelines?


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(3) What is the impact of IREs on workplace accessibility, especially for individuals with disabilities?
(4) How can challenges like complex actuation mechanisms be addressed in IRE design?

## 3 RESEARCH APPROACH AND METHODS

My dissertation research and prototyping structure are built upon the User-Centered Design (UCD) process, which places a strong emphasis on gaining a conceptual understanding of the design space. The research will encompass various methodologies, including interviews, controlled experiments, in-situ studies, and mixed-method evaluations. The initial phase will involve a comprehensive technical literature review focusing on adaptive workstations. The second stage, informed by the literature review, will analyze existing principles in interaction theory and ethical considerations within the context of research on accessibility and personalization.

The next phase of my dissertation involves conducting two rounds of interviews and developing an appropriate research methodology. In the initial stage, I plan to conduct interviews that combine verbal and visual elements, with a focus on creating sketches. These interviews will be conducted with a diverse group of users, considering variations in physical characteristics, individual needs, and the type of desk work they perform. Following this, I will proceed to create 3D models at an appropriate scale based on the sketches prepared earlier. These models will enable the evaluation of the functionality of solutions and provide users with the opportunity to make modifications. This will yield valuable insights and feedback from participants, allowing me to tailor our ideas to better meet their needs.

The final stage involves constructing, implementing, and evaluating a prototype in laboratory conditions in alignment with the insights gained from the interviews. Subsequently, a study will be conducted in a customized semi-industrial setting involving volunteers. Based on the results, I will make any necessary adjustments and improvements. A second experiment will then be conducted to further validate our findings.

## 4 RELATED WORK

During my work, I identified three essential and related research papers on adaptable workstations [1], reconfiguration of multi-segment touch screens [3], and systems that allow the design of workstations with feedback on pose and ergonomics in virtual reality (VR) [4].

The first of these papers, by Bailly et al. [1], describes a movable desktop with a mouse, keyboard, and monitor. One of the main advantages of this solution is the ability to personalize the starting position of the workstation, as well as convenient screen rotation and remote control of peripherals. Unfortunately, "LivingDesktop" is limited to the peripherals on the desk surface, which makes it difficult to adapt to the individual needs of users on the scale of the whole station.

Another approach is the "AdapTable" system [3], which is based on moving platforms around the room and provides a large touch surface, similar to tabletops, with a greater range of accessibility and flexibility. However, platform content adaptations only occur in the digital sphere.

The third solution is a VR application that allows the design and adjustment of the station settings (desk and storage facilities) in virtual reality and then creates them in real life but is limited by a single user and a static design [4].

My dissertation will be an attempt to combine the advantages of these solutions, creating mobile elements of the workstation, such as a table, storage system, and environment, which will allow the movement of elements not only in the scale of the room but also on the work surface while maintaining the flexibility and universality of the workstation tailored to the specific needs of the user.

## 5 FINDINGS AND DISCUSSION

I have conducted extensive research involving a systematic literature review of over 7,000 articles in the technical field. From this review, I identified 16 systems for inclusion in my study, analyzing them in terms of their properties, implementation methods, and evaluation approaches. This analysis led to the establishment of a design space for Reconfigurable Interactive Environments (RIEs) with four categories: Reconfiguration Geometry, Reconfiguration Interface, Reconfiguration Principle, and Scale of Actuation. Notably, prior research on RIEs lacked empirical studies and employed a variety of implementation tools.

However, several critical issues in the current state of RIEs emerged:

(1) Many RIE studies lack user evaluations, focusing primarily on system improvements rather than user experiences. To enhance usability and user satisfaction, more empirical studies are needed. Moreover, safety measures are lacking in many systems.
(2) RIEs are often designed without considering diverse user groups, limiting their inclusivity and adaptability to various user needs, such as height adjustments.
(3) The design space for RIEs remains underexplored. Combining different reconfiguration geometries and scales could create more adaptable and versatile RIEs to cater to a broader range of user needs and contexts.
(4) The study itself has limitations, including a selective focus on space adaptation in HCI research, missing other relevant areas like ergonomics and robotics, and not comparing with shape-changing displays or large high-resolution displays. A broader review could yield different insights.

In the next phase, I conducted mixed interviews with users, incorporating verbal and visual interviews through sketching. The key findings included workplace customization, influence of job type and personal experience, recommendations for future work, generational differences.

Current workplaces often overlook the importance of ergonomics and employee well-being, resulting in uniform workstations that lack personalization. This has a detrimental effect on productivity and motivation, particularly among younger individuals. While remote work provides greater opportunities for personalization, it comes with its own set of costs. Workplace preferences vary among different age groups and job types. Younger, less experienced employees value spaces for relaxation and are more receptive to changes. Decorative elements are integrated across age groups and job categories, and the preferred number of screens varies according to job type.

Back pain is a common issue, with younger individuals being more receptive to active solutions. To improve future workplaces, we should consider incorporating height-adjustable desks, automated chair adjustments, shape-shifting screens, projectors, and holograms for flexible displays. Workstations should strike a balance between minimalism and customizable vertical surfaces, as well as mobile boards. Mobile cabinets equipped with automated content relocation and adjustable divisions are also recommended. Versatile workspaces featuring mobile elements and non-screen relaxation areas can cater to a wide range of needs. Additionally, mobile elements, discreet lighting, and displays should ensure privacy and adaptability in decorating.

Ergonomic needs in the workplace vary depending on age, experience, and job type. Younger generations prioritize change and relaxation at work, while more experienced employees tend to make smaller, incremental improvements. It is crucial to take into account generational differences and individual preferences when analyzing workplace ergonomics.

My technical research has also included the development of a prototype that recognizes Lego elements in three dimensions and their color. This was achieved using interactive surfaces with sensors in the base, allowing the detection of objects by measuring capacity. The prototype was also used in two studies that were published as articles [2, 5].

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