Chapter 1
An Introduction to Collaboration Meets Interactive Spaces

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Abstract Interactive Surfaces and Spaces have become ever more pervasive in the past decade. Indeed, the current explosion of media that pervades our everyday lives invades our senses through (increasingly) interactive displays surfaces in all sizes, shapes and formats. Indeed, interactive walls, tables, mobiles (tablets and phones), as well as wearables change the way human beings interact with information and collaborate with one another. At the same time, these surfaces and devices are redesigned and reinvented through new social protocols and collaborative work styles that arise from the experimentation and long-term usage of novel people/device ecologies. The book reflects a high interest among researchers and practitioners about this particular approach and the challenges it entails. It offers an up to date and comprehensive scientific overview of the new generation of devices and their myriad combinations. While pervasive display technologies are changing the way we relate to media, people and society are also shaping and adapting new techniques, methods and idioms. Our purpose is to update both researchers and practitioners with exciting new work around the emergence of social protocols that arise from the experimentation and long time usage of interactive surfaces and also includes numerous case studies, based on recent work.

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1.1 Part I: Devices and Techniques for Collaboration Through Interactive Spaces

This book offers an updated comprehensive scientific overview of the interplay between technological advances in collaborative technologies and the social interactions that occur when using interactive surfaces and devices. Existing books on interactive surfaces are either too focused on technological advances and their benefits, or just based on the social interactions that occur when using interactive surfaces and devices. With this new book, we propose to offer an updated comprehensive scientific overview of the interplay between these two factors. One possible way to best describe the book's idea is as follows: interactive walls, tables, mobiles (tablets and phones), and wearables change the way human beings interact with information and collaborate with one another in a co-located or distributed space. At the same time, these surfaces and devices are redesigned and reinvented through the emergence of new social protocols and collaborative work styles that arise from the experimentation and long-term usage of these surfaces. As far as our knowledge goes, no other book offers perspectives on this interplay. Moreover, there is a high interest among researchers and practitioners about this particular approach and the results it entails. Attesting there is a large participation and interest we have been receiving over recent years regarding the workshop series on Collaboration Meets Interactive Surfaces (CMIS): Walls, Tabletops, Mobiles, and Wearables that forms a foundation for this book.

This books starts out by outlining the degrees of freedom we currently find when starting to design interactive surfaces with the specific goal of improving human collaboration and cooperation. Naturally, this restricts the design space and consequently determines how much collaboration can happen in a specific domain, independently of what domain or problem we are addressing. This section of the book sets the stage for a second section about case studies and applications. Devices and techniques were clustered following an analysis of the accepted submissions we received, in the following manner: (i) interaction techniques, (ii) large displays, and (iii) wearables.

1.1.1 Interaction Techniques

Advances have been consistent in interaction techniques for improving collaborative activities mediated by interactive surfaces of all kinds. The first chapter in this book is authored by Plimmer et al. and covers tabletop 3D object manipulation through touch and tangibles. They demonstrate the advantage of combining touch and tangible regarding 3D object manipulation. The research was constructed on top of a 3D turn-based game and investigates how the users adapt to the bi-manual interaction using touch as well as the tangible.

In the next chapter, Rekik et al. describe and analyze the variety of movement patterns that participants use when performing multi-touch gestures. This chapter also gives understandings about the different strategies participants use to generate this variety of patterns, when they are asked to, as well as their mental models regarding preference. There were two experiments setup, from which the authors collected nearly 6,700 multi-touch gestures from nearly 50 participants. These experiments provide a qualitative analysis of user gesture variability and also derive a taxonomy for users' gestures that complements existing taxonomies.

Finally, and still inline with interaction techniques for collaborative spaces, Sousa et al. describe work around remote proxemics. As virtual meetings become increasingly common with modern technologies, they still add unproductive layers of protocol to the flow of communication between participants, rendering the interactions far from seamless. Therefore, Remote Proxemics is proposed as a technique to mitigate these negative aspects, as it is an extension of proxemics aimed at bringing the syntax of co-located proximal interactions to virtual meetings.

1.1.2 Large Displays

The interplay between mobile phones and large displays has become a trendy subject, since content sharing between large displays and personal mobile devices is central to many collaborative usage scenarios. This is the topic of the first chapter in this section. Langner et al. describe NiftyTransfer, a suite of 5 bidirectional transfer interaction techniques to move digital content between mobile devices and a large vertical display. The chapter provides a detailed overview of design goals and interaction techniques, and reports on a study exploring the usefulness of the techniques. Five techniques are presented that explore three main aspects: multi-item transfer and layout, the dichotomy of casual versus precise interaction, and support for physical navigation.

Isenberg presents a survey of the different approaches currently in use regarding the interaction with large surfaces. The analysis is performed in the context of scientific visualizations, which has traditionally been a domain where large scale and/or high resolutions displays are particularly useful. This chapter demonstrates that the reported systems are valuable giving a complete overview of 3D scientific visualization on interactive surfaces.

Finally, a very well-known interactive large display is presented: CubeIT, a multi-user presentation and collaboration system at Queensland University of Technology (QUT) in Australia. The output medium of CubeIT is composed of 48 multi-touch screens and projected displays above these. As functionalities, CubeIT allows students and academic staff to share their own multimedia content, allowing collocated and simultaneous screen interaction to explore its content, which is an interesting concept and an insightful evaluation. This system uses three interface mechanisms: the multitouch wall itself, a mobile app, and a website.

1.1.3 Wearables

Wearable systems are becoming more common ways to interact and collaborate through interactive surfaces. This book presents two different contributions in this field: using head-worn displays and using eye gaze.

Shared Façades, by Ens et al. is a new approach for distributing virtual information displays across multiple users. Their method is extremely sophisticated: it applies a random walk algorithm to balance multiple constraints, such as spatial constancy of displayed information, visual saliency of the background, surface-fit, occlusion and relative position of multiple windows, to produce layouts that remain consistent across multiple environments while respecting the local geometric features of the surroundings. Results show that the balanced constraint weighting schema produces better results than schemas that consider spatial constancy or visual saliency alone, when applied to models of two real-world test environments.

Head mounted displays (HMDs) and head worn cameras (HWCs) can be useful for promoting remote collaboration. In the chapter by Billinghurst et al. they describe explorations in using gaze cues for this type of activity. Overall, they conclude that showing gaze cues on a shared video is better than just providing the video on its own, and also that combining gaze and pointing cues is the most effective interface for remote collaboration.

1.2 Part II: Case Studies and Applications

1.2.1 Collaboration Aspects

Chang et al. present advances in collaborative aspects regarding the usage of interactive timelines in collaborative digital tabletops with automation. The techniques in this case study are particularly useful when dealing with highly complex scenarios, since the maintenance of situational awareness in the context of automated dynamic changes is paramount to keeping users making optimal decisions. They designed an interactive event timeline to enable exploration of historical system events. On average, the participant groups exhibited high scores of situation awareness for a cooperative tabletop game task.

Activity-based collaboration for interactive spaces is a new conceptual and technological framework for designing interactive systems with a better mapping between activities people conduct and the digital entities they use. Bardram et al. present this framework together with some applications in supporting collaboration across many interactive surfaces. This chapter provides a focus on the framework's support for collaboration ("activity sharing") and multiple devices ("activity roaming"), after which two case studies are presented in order to illustrate its application.

1.2.2 Software Development

This book presents several application domains where collaboration is improved through the use of interactive surfaces of different shapes, sizes and capabilities. One of those domains is business process modelling. The chapter by Nolte et al. deals with the challenges of collaborative process modeling and makes the case for interactive spaces where different interactive technologies are combined in order to allow for orchestrating collaboration, since it is possible to form breakout groups on demand or work on a process model in solitude before coming back together.

A related topic is described in the chapter by Kropp et al., where the authors look specifically at cardwalls for agile software development. They present two studies, one on the general use of cardwalls and the second on a concrete tool called aWall (using a large interactive wall display) that supports agile team meetings. As with other case studies presented in this book, this chapter shows encouraging results in the way that team collaboration can be improved through properly designed large interactive surfaces.

1.2.3 Emergency Management

Emergency management is one of the most attractive application domains for collaborative surfaces, especially large ones, since users—under this scenario - make extensive use of large maps to take decisions about any crisis, and to establish a common understanding of a critical situation, in order to plan and coordinate appropriate countermeasures.

Döweling et al. present a comparative study, in which 30 participants performed tasks reflecting actual crisis management work on a tabletop system, classical paper maps and an off-the-shelf desktop geographical information system. They report encouraging results, in which users were most efficient using the tabletop and perceived its user experience as superior. In addition, the tabletop offered a team-work quality comparable to classical paper maps.

Chan et al. propose what they coin as the emergency operations center of the future, an exploration into "the integration of various novel technologies in EOC design, in an effort to make emergency response more efficient." They implemented a multi-surface system that includes display walls, tabletops, tablet devices, and mobile/wearable computing devices as a testbed for examining how proxemics, augmented reality and social media can be used to improve decision-making during emergencies.

1.2.4 Security

Collaboration within interactive spaces cannot happen without a proper technical infrastructure enabling fast communication between the different parts of the user interface, which needs coordination. However, this coordination poses privacy and security problems. Frosini and Paternò describe a solution for achieving secure user interfaces when these are distributed through dynamic sets of users and devices. Their solution has been designed to guarantee authentication, authorization, authenticity and data privacy in collaborative distributed user interfaces. It consists of a software architecture for this purpose and a related implementation. They also demonstrate the importance of authentication mechanisms in the security aspects faced by collaborative user interfaces.

Brown et al. investigate surface application design and development. Their research on security analysis has focused on work to understand information related to security, including both computer security and security in a more general sense. One of the original aspects that stems from their approach is the premise that sensemaking is a key activity. This raises significant challenges, as the intervening actors may be concealing information, and providing misleading or irrelevant information. In addition to the technical contributions, the chapter by Brown et al. is also interesting because it presents a review of several projects about surface computing for security analysis. Several issues were identified from this analysis, including the fact that analysts need to take away results, work alone, and bring back new ideas, and this influences the way surface computing should be implemented, in particular that it can support collaborative epistemic interaction, and they can be improved by support for guidance, interaction history, and annotation.

1.2.5 Medical, Accessibility, and Community

Interactive surfaces have been widely known to the medical domain for quite some time and this book provides two very interesting applications. One application by Augstein et al. about collaboration around an interactive tabletop in rehabilitation settings. The other application by Bornschein and Prescher, about a collaborative workstation for sighted and visually impaired users.

Therapy for patients who acquired brain injury (e.g. a stroke or accident) is quite tedious and difficult due to the repetitive nature of the tasks. Collaboration can be easily facilitated with tabletop computers because they can be interacted with by multiple people in parallel. The chapter by Augstein et al. propose an approach towards rehabilitation using an interactive tabletop in collaborative settings, covering the therapeutic motivation behind as well as aspects related to interaction design and modalities.

The chapter by Bornschein and Prescher about visually impaired users is also very interesting from a technical perspective, since blind users get both auditory and tactile feedback from a workstation through a dynamic planar tactile pin-matrix device.

Both this section and the book finish off with a very relevant chapter by Dix et al., which describes their experience in the design and installation of a low-cost multi-touch table in a rural island community. Among many interesting conclusions, this chapter notes that when installing collaborative surfaces in local communities it is particularly important to be sensitive to local needs and not simply impose a solution because it is the latest, trendy technology. Of course this creates equal challenges in interpreting the research data as each setting is unique with specific stakeholders and issues. We feel this chapter is a perfect closing to this book, as "collaboration meets interactive spaces" also implies that the context of this "meeting" should always take the best interests of the user community that is served by these interactive surfaces.

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