Tangible Interaction in Collaborative Environments

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Abstract

Tangible user interfaces (TUI) promise to enable natural and intuitive interaction with digital information through the physical environment. They are not limited to the interactions of a single person, but also support collaboration among – even dislocated – groups. Technological advances make it possible to integrate sensors and actuators as well as wireless communication and processing technologies into everyday objects, and the vision of "everywhere interfaces" is coming within reach. In this report we briefly discuss the contents of the papers presented at the second international workshop on Tangible Interaction in Collaborative Environments (TICE), and summarize the main issues of the discussions. The aim of the workshop was to explore the potentials and perspectives of tangible interaction for supporting collaborative work, and it was held in conjunction with WETICE'07 in Paris, France, on June 18th 2007.

1 Introduction

TICE 2007 is a continuation of the first workshop on Tangible Interaction in Collaborative Environments at WETICE 2006 in Manchester, U.K. Due to its interdisciplinary focus, TICE aims at bringing together researchers of various fields, including Human Computer Interaction, Tangible User Interfaces, Computer Supported Collaborative Work and Ubiquitous Computing, to present their research results and discuss key issues, approaches, open problems, innovative applications, and trends of tangible interaction in the context of collaborative environments. As for the first workshop, the call for papers focused on three topics:

- Interaction design of collaborative tangible environments
- Technological aspects of tangible user interfaces
- Case studies and application scenarios

Original research papers, experience reports and position papers outlining novel research domains as well as approaches of participants from all research fields related to these topics were welcome.

In the next section, the papers presented at TICE 2007 are summarized. Afterwards, the main issues of the discussions – including statements of the paper authors about their ongoing and future research – are subsumed.

2 Summary of the Papers

Three papers were selected for publication at TICE 2007, where the selection was based on a blind review by three reviewers at a time. The presentation session took place on Monday, June 18th 2007, together with the 12th international workshop on Security Technologies (ST). A time slot of about 25 minutes for presentation and 5 minutes for discussion were scheduled for each paper.

The first paper entitled *Tabletop Collaboration Through Tangible Interactions* [1] was presented by Sriram Subramanian. It is motivated by recent advances in tracking technology, which have led to the design of digital tables that support interaction using multi-finger input and physical objects. However, the tradeoffs between these input modalities are not clear, making it difficult for developers to make informed decisions when choosing input strategies for digital table systems. In this work, the authors consider the role that multi-finger input and physical objects play in the design of collaborative tabletop systems. The results of an observational study of group work on regular tables, and an experimental study of interaction techniques for supporting group handoff are presented.

The results show that people often perform several explicit communication and coordination activities that involve epistemic and pragmatic movements of physical tools. Furthermore, experimental results suggest that using physical objects for controlling digital information improves performance compared to using finger gestures.

The second paper entitled *A Tuple-Space based Middleware for Collaborative Tangible User Interfaces* [2] was presented by the workshop co-organizer Clemens Holzmann, as the authors were not able to attend the conference. The starting point of this work is the observation that several approaches for establishing a generic middleware for tangible user interfaces can be found in literature, which target towards the independence of application domains as well as flexibility in terms of the deployed sensor technology. However, supporting collaboration in all its aspects requires considering co-located and spatially distributed settings as well as synchronous and asynchronous collaboration, where participants may also change over time. TUIs thus have to allow the spatial distribution, asynchronous activities, and the dynamic modification of the TUI infrastructure, to name the most prominent ones. In order to meet these requirements, the authors developed a framework approach based on the LINDA tuple space concept. The implemented framework deploys arbitrary sensor technology for any type of application and actuators in distributed environments. A use case is presented as a proof of concept in real work settings, and to demonstrate the flexibility of the approach.

The title of the third and last paper is *A Dual-Driver System of Networked Fire Truck Simulator with Rotating Motion Platform and Force Display* [3], and it was presented by Tatsuya Nagai. It is about a collaborative multi-modal virtual reality environment for simulating a long ladder-style fire-truck with a tiller (rear steering) that is operated by two drivers, one in the front and another in the rear. Such a dual-driver system is useful to turn narrow corners rapidly and smoothly in case of emergencies. The authors describe the integration of two pairs of force displays - a force-feedback wheel and a rotary motion platform - in a dual-driver networked driving simulator which navigates through virtual space using a collaborative virtual environment groupware. Its force-feedback steering wheels display simple collision forces separately to each driver when the vehicle collides with walls or other vehicles. The visual, auditory and haptic modalities are described in detail, and a demonstration video is provided for download.

3 Discussions and Future Work

As the workshops TICE and ST were scheduled together in the same room, the workshop participation was quite high and many interesting discussions arose from the mixed audience.

The first paper [1], which was awarded the best workshop paper, showed that people often perform several explicit communication and coordination activities that involve epistemic and pragmatic movements of physical tools. Furthermore, experimental results suggest that using physical objects to control digital information improves handoff performance in comparison to using finger gestures. The results from the authors' studies show that digital tables can enhance tabletop collaboration through effective use of tangible interaction. In this regard, there was a discussion about the shape of the physical tools with respect to the digital information controlled therewith, where two approaches were distinguished: using one physical object either for each digital shape or for each function it is used for (e.g. moving and receiving digital objects).

A further discussion was about reasons why tabletop interaction with physical objects seems to be faster compared with multi-finger input. As the paper presents preliminary results from real-world observations, and from a study of one type of coordinated tabletop activity only (i.e. handoff), the authors plan to investigate tangible interaction techniques using several other collaborative tabletop activities, including large map navigation and multi-user sketching, in order to determine whether their results generalize to other shared tabletop activities. A further discussion point was about the market for digital tables, which recently received considerable attention due to commercially available products.

The simulation framework presented in the second paper [2] offers robust and flexible means to collect information about tangible artifacts using arbitrary sensor technologies, as it provides tailored information to one or more applications and is able to manage distribution of sensors, infrastructure components and applications. The framework has been designed to support collaboration of actors in work settings. It encourages a tuned mix of multiple – even spatially distributed – interactive systems including both sensors and software. The authors showed that all identified requirements could be met both from a conceptual perspective and at the implementation level. The presented approach is based on pre-compiled classes representing the tangible modelling elements. While these classes can be loaded and deployed dynamically, each alteration or (re)definition of an element's structural repre-

sentation has to be made directly in the source code.

In order to improve the framework's usability and allow rapid prototyping of tangible interfaces, the authors are currently working on enabling the specification of tangible modelling elements using an XML-based definition language. In future research, they plan to implement a meta-model-management layer based on ISO topic maps, which allow for flexible and dynamic specification and deployment of elements used in the tangible interface. For conceptual modelling using tangible interfaces, they furthermore plan an extension of their approach to support full representation of the domain models the tangible interfaces are used in. This should allow to check completeness and soundness of the represented models in the framework, enabling direct user feedback on validity of the physical representation's state.

The third paper [3] is about a groupware driving simulator for two drivers piloting a single virtual vehicle, with a multi-modal display and independent control of the front and rear wheels. Users can feel stimulation such as sight, hearing, and touch. A simplified kinematic model is used as a proof of concept for the multi-modal interface; although it does not aim at realistically simulating physical effects, it is sufficient for demonstrating the potential of the presented simulator for more complicated interaction scenarios. The current state of the simulator was shown with a demonstration video at the TICE workshop. For future work, the authors consider to improve the simulator – not only by modelling collisions, but also by improving the kinematic model for a more realistic driving experience with tangible effects displayed through the force feedback steering wheels. At the moment, the main focus is on experimenting with multi-modal interfaces – integrating haptic, visual, and auditory displays – on real vehicles, starting with a two-wheeled Segway scooter; however, such deployments are no longer within the scope of tangible user interfaces for collaborative environments.

4 Conclusions

The second TICE workshop at WETICE 2007 was a success, as there were interesting paper presentations and discussions as well. Although the number of accepted papers was less than expected, we observe an increasing interest in the topics of the TICE workshop, which shows that the application of tangible user interfaces to collaborative environments is a growing area of research. This is not only reflected in recently emerging conference series and workshops, but also in the vital discussions we had at TICE 2007.

Finally, we would like to thank all authors and participants for making the workshop a success, as well as the reviewers for helping us to evaluate the papers. Last but not least, we would like to thank Sumitra and Ramanda Reddy, finance chair and WETICE organizer, for making the event possible.

References

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