Tabletop Interaction: Research Alert

Wolfgang Mähr, Richard Carlsson, Jonas Fredriksson, Olivier Maul, Morten Fjeld
TableTop Interaction Laboratory, www.t2i.se
CSE, Chalmers TH, SE-412 96 Göteborg, Sweden
{wolfgang, richard, jonas, olivier, morten}@t2i.se

ABSTRACT
At the t2i Lab we focus on tangible user interfaces (TUIs) to advance and improve the user experience in computer supported learning and problem solving. By directly interacting with physical controls, complex concepts such as the chemistry of a molecule, dynamics of physics, or the rules of a market may be more easily understood. Through their capacity to closely track user actions TUIs may offer more direct interaction. Several disciplines are involved in tabletop interaction, such as gesture-based interaction, social protocols, haptic rendering, tracking-, and display-hardware. This demo paper presents the two projects Augmented Chemistry (AC) and eMotion. AC is a combination of TUIs and computer graphics for organic chemistry education with a focus on concepts like the octet rule and tetrahedrons. eMotion focuses on bridging the gap between computers and human emotions by enabling computers to estimate their users' emotions by evaluating their mouse motions.

Author Keywords
Human-Computer Interaction, User interface design, tabletop interaction, tangible interaction, emotion

INTRODUCTION
This demo paper presents two projects from the t2i Lab in the field of tabletop and tangible interaction [1]. These are Augmented Chemistry (AC) [2] and eMotion [3]. The demo paper aims to reach potential research and industry partners.

AUGMENTED CHEMISTRY
Augmented Chemistry (AC) is an application using a tangible user interface (TUI) to assist organic chemistry education [2]. The novelty of the system is to support users to construct molecules with the help of physical controls such as a gripper, a construction platform, and a cube (Fig. 1, left). These handles make it easier to grasp such concepts as the octet rule, tetrahedrons, and electro-negativity.

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Figure 1. AC system with back-projection screen (left). TUI and GUI working at the same time: the rotation cube is operated with the right hand while the constructed molecule sits on the centre platform (right).

AC was developed at HyperWerk FHBB. It was extended with additional functionality and evaluated in a joint project which involved ETH, HyperWerk FHBB, and the aprentas school of chemistry. The comparative evaluation was carried out to determine whether AC can be successfully used in chemistry lessons at a secondary school level. This empirical evaluation compared learning effectiveness and user acceptance (the dependent variables) of AC versus the Ball-and-Stick Model (BSM). It was carried out at a secondary school with twenty-six biology and laboratory students, all in the first year of their secondary education (15-17 years of age). The effect of the learning method (AC or BSM) on the dependent variables was measured repeatedly in an experiment of the AB-BA design. The students were divided into two groups of equal size and worked individually with AC and BSM at two different times. One group used AC in a first session and then the BSM in a second session. The other group used the systems in reverse order. The users' mood, mental task load, physical task load, satisfaction, perceived usability, and system preferences were measured using questionnaires and then converted into an assessment of user acceptance. The results showed that subjects using the BSM solved the problems more effectively than those using AC. However, retention of the lesson, as measured in a subsequent test, did not reveal any significant difference. There were also only slight differences in subjective usability between the two methods. System preference was measured by nine subjective criteria. In terms of ease of learning the system, ease of use, helpfulness in problem-solving, and comfort of use, the BSM outperformed AC. In terms of enjoyability, visualization, content availability, future use, and effectiveness of learning, AC outperformed the BSM. In conclusion, this study shows that the tested version of AC does not provide a learning environment superior to that of the BSM. In order to replace the BSM with AC, a higher user acceptance of AC is required. If its usability is improved and its functionality enhanced, AC may potentially provide a superior learning experience to that of the BSM.

Addressing the outcome of this evaluation AC was further extended at the t2i Lab. Firstly, a graphical user interface (GUI) has been incorporated into the TUI for enhanced interaction, keyboard-free system configuration, and internal/external database (DB) access (Fig. 1, right). Along with these changes, the three-dimensional (3D) rendering has been improved using shadows and related effects to enhance depth perception. Secondly, AC has been ported to different operating systems and is now compatible with Linux-, Windows-, and Mac OS X based platforms. Also, it now supports USB and Firewire (IEEE1394) cameras. Finally, system capacity to import and visualize molecules from an extensive XML-based DB has been realized. This gives users the ability to download and interact with any molecule up to a certain complexity. Currently, our development is focused on exploring different camera positions. We are also exploring spatial tracking of a physical ball-stick model to minimize the cognitive distance between construction and visualization of molecules.

EMOTION

eMotion is a project aiming to bridge the gap between user emotions and the computer operated [3]. Emotions play an important role in human behaviour and cognition. Creativity, problem solving, and well-being are also heavily related to our emotional state. Current computer systems, however, do not interact with the user on emotional level—doing so could improve the user experience significantly. Not only would such an improved experience make the user more productive, but also more satisfied with the system and therefore increase user confidence in computers. Furthermore, such a system could help computer workers—such as operators, secretaries, and programmers—to work with more focus, thereby producing fewer errors.

There are many well-known methods for subjective and objective emotion measurement. While established methods require user cooperation, impeding workflow, more recent methods are only loosely coupled to the user and therefore produce questionable results. This means that current methods cannot be used to provide continuous, reliable, and environment-independent results without impeding the user.

eMotion shows a new way for emotion measurement via user mouse motions. It combines the advantages of established methods by being directly connected to user actions without being intrusive. To prove the value of this new concept, a set of software tools for measurement was written and validated in an experiment [3]. Results show that it is possible to use the computer mouse as a sensor for user emotional states. Mouse movement speed and precision values were tracked, analyzed, and found to be statistically significantly different under high and low levels of arousal. No significant differences were found for high and low levels of valence.

The system estimates user emotions using a mouse tracker (http://sourceforge.net/projects/mousetrax) written for Mac OS X in Objective-C. The system tracks user mouse motions with an interval of a few milliseconds enabling the calculation of factors like speed, acceleration, targeting, uniformity, and efficiency of the movement (Fig. 2).

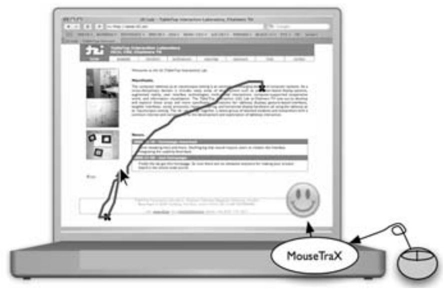

Figure 2. Schematized future eMotion system. The mouse tracking system records the mouse movements, enabling the application to react on user actions. Here, the system visualizes tracked data and user emotional state (smiley).

In the next steps of this project, measurements shall be profiled by a self-learning algorithm so that users can compare current and historical values of their individual motion characteristics. At the same time, we want to continue researching the relation between user valence and mouse movements. While our research so far has been based on using a standard mouse as input device, we would like to examine the effect of alternative input devices such as graphic pens, keyboards, or even eye tracking devices.

SUMMARY

Tabletop interaction is a rapidly expanding area of research, as the newly established IEEE conference (http://www.tinmith.net/tabletop2006/) shows. At the t2i Lab we work on challenging issues related to the use, development, and evaluation of tabletop systems. We are now looking for industrial/research partners to continue and broaden these and other research projects.

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