A TABLETOP INTERFACE FOR GENERIC CREATIVITY TECHNIQUES

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ABSTRACT

Within this paper, a multi-touch based tabletop application supporting a generic model for creativity techniques will be introduced. Therefore, based on related work, requirements will be worked out and transferred into a concept and a prototypical implementation. After this application has been described in detail, an evaluation done with the system will be presented. The results of this evaluation will be discussed by referring to a survey and observations. Finally the conclusions and prospects for future research will be shown.

KEYWORDS

Creativity Support System, Tabletop, Creativity Technique, Collaborative Problem Solving, CSCW, HCI

1. INTRODUCTION

One preferred way to guide creative problem solving processes are creativity techniques which are applied in many companies (Fernald1993). Depending on the domain, the context, the problem type or the people involved in the (creative problem solving) process, specific creativity techniques can be more or less adequate for finding appropriate solutions. Brainstorming is probably the most popular and most often applied (group) creativity technique for idea generation processes.

Collaborative IT support systems for the creative process (so called creativity support systems (CSS)) have been proven to foster creative idea generation. They reduce several negative effects by providing parallel input, contribution awareness and the possibility of anonymity and distributed work (Isaksen1998, Carte2006). Those systems are typically built on the client-server architecture and are used with personal computers. While this IT-support obviously emphasizes on the distributed, parallel and possibly anonymous work of each individual, one could pose the question if there are also any disadvantages.

In this context, Hilliges points out that "*physical, social and interaction contexts* […] *play an important role in guiding cognitive processes*. [...] *Current computer systems already cover a variety of communication channels for distributed collaboration* [...] *and support for collaborative work (CSCW). However, important parts of our professional and personal life still depend on co-located collaboration and face-to-face communication, with all the nuances of facial expression and body language, and the immediacy of verbal communication*" (Hilliges2007). Especially in the field of co-located **collaborative** creative problem solving, the core requirements of communication, coordination and interpretation need to be fulfilled, but "*using single-user systems in a collaborative setting leads, in most cases, to a communication breakdown since the user's concentration has to shift away from the group and towards the computer in order to use it*" (Hilliges2007). Group work using this way of IT-support also leads to stereotypical impressions of the involved users based on language, typographic, and contextual cues (Walther1997).

Due to those disadvantages of classical IT-support for co-located settings, a paradigm shift from human-computer interaction to computer-mediated human-to-human interaction is taking place (Hilliges2007). To support this way of spatial interaction, new interactive workspaces are proposed, which are especially suited for creative applications (Rodden2003) by providing a physical layout, which supports the interactions and collaboration between the parties involved: so called single display groupware (SDG). By using those workspaces, people are able to collaborate directly face-to-face and in an intuitive and natural way while still maintaining most of the advantages of IT support (such as permanent recording and sustained manipulability of collaborative artifacts etc.). Especially, those devices emphasize the visibility of action, which can be seen as a fundamental aspect of group awareness (Dourish1992). Group activity is simplified by sharing the same part of the workspace, as others' actions and the interaction objects can be seen (Gutwin1998). While the older studies only targeted co-present multi-user collaboration around a single personal computer, more novel ones focus on SDG-devices with multi-touch tabletop user-interfaces. Those interfaces intensify the regarded effects of SDG and also address an important design-principle of creativity support systems (Resnick2005), as their natural and intuitive usage lowers the threshold to get started with an application.

Some studies have focused on the implementation of the Brainstorming technique on tabletop displays, which will be reviewed in chapter 2. Based on the fact that Brainstorming is only one out of many creativity techniques, a generic process model for instantiating different creativity techniques will then be briefly introduced in chapter 3. This model will form the basis of the tabletop-application presented within this work. From both directions, concrete application requirements will be worked out. Finally the specification and prototypical implementation of the application will be described and discussed. The discussion will base on the results of an experimental evaluation and survey. This work will conclude with prospects for future research.

2. RELATED WORK

Although the use of tabletop devices in regard to creativity support could provide some promising possibilities in collaborative co-located scenarios as shown before, only a few research projects have regarded the realization of such an application in the domain of creative problem solving so far.

Seth Hunter and Pattie Maes, introduced a tabletop interface for collaborative brainstorming and decision making (Hunter2008). The system includes support for two types of meetings: deciding between a set of alternatives and idea generation. In regard to decision making, the application allows for setting a dynamic background, which could for example be a matrix where ideas can be positioned in. An idea is represented just as single block of text, which can be modified, moved or deleted. Within this setting, the orientation of an idea corresponds to the user who created it and its size reflects the importance of the idea. Input of text is realized via speech recognition and, to compensate errors within the speech recognition, via a scalable multi-touch keyboard. In addition to just generating ideas, the system is connected to a database of semantically related terms which aid in finding additional associated ideas within the same context. Those associations get triggered by doing a “stroke” gesture over already existing ideas. A three month long-term evaluation, realized by lab demos, museum events and group internal usage showed that multi-touch computing seemed especially suited to augmenting collaborative discussions within social conversation spaces due to the fluid interaction with the application. Unfortunately, except of the implementation of simple brainstorming, no approach of supporting other creativity techniques was given.

Hilliges et al. (Hilliges2007) investigated the design guidelines for and implications of using a tabletop interface in combination with a large wall display for face-to-face group brainstorming. This application was primarily motivated by the advantages of tabletop displays for creative co-located work as already stated in the introduction. Ideas within the application are represented in the style of post-its, which are commonly used in traditional brainstorming. Text-input is realized via digital pens but without optical character recognition. The wall-display mainly acts supplementary as information space for grouping of ideas. The proposed design guidelines, which mainly aim at creating a socio-technical environment which positively affects collaborative creative problem solving, will now be briefly discussed.

DG1) Immediacy of Communication and Interaction: This mainly encompasses the avoidance of production blocking, a persistent storage and all time accessibility of ideas to each group member and the reduction of costs for interaction and communication.

DG2) Minimize Cognitive Load: As the human resources of keeping information in memory are limited, the application needs to create a context to minimize cognitive resources. This can be for example reached by creating an interface which is more compatible with the users` mental resources.

DG3) Mediate Mutual Association Activation: As external stimuli induce persons to have novel associations it is assumed that by creating a socio-technical environment which positively affects collaborative creativity, a context to explore the different ideas within the participants` knowledge network gets created.

DG4) Supporting Group Awareness and Overview: The visibility of action can be seen as the main design principle for embodied interaction (Dourish2001) while general group awareness provides a basis for informal communication. If group members are able to understand the actions of other members in a better and more intuitive way, isolation gets avoided and coordination and interpretation of others' actions get fostered. Therefore the users should get as much liberty of action as possible.

As those guidelines especially target tabletop-environments for creative idea generation, they will also lay the basis for the application described later in this work.

Both studies presented within this chapter only regarded systems which implemented the Brainstorming technique. As this is only one out of many creativity techniques with each incorporating its own functional patterns, it is understandable that the described applications seem to be inadequate to really evaluate the impact and characteristics of collaborative tabletop workspaces on creativity support in general. Therefore, the goal to be presented within this paper is how a tabletop-based system providing a generic support for collaborative creativity techniques can be realized.

3. A GENERIC MODEL FOR CREATIVITY TECHNIQUE-BASED PROBLEM-SOLVING PROCESSES

In order to provide a reasonable form of any computer support, it is always necessary to have a comprehensive understanding of the domain that is to be supported. Since our aim was to work towards a design for a tabletop interface that is capable of supporting various creativity techniques, we needed to have a precise model for these types of (creative problem solving) processes.

In previous works of our research group, we developed such a model, incorporating the key concepts of the descriptive and cognitive process models of creativity found in psychological literature as well as the key concepts of more than 50 different creativity techniques. The model is described in detail in Forster2008 and Forster2009. Since the model has important implications with respect to the design of the intended tabletop application, we briefly summarize its five most significant aspects:

CP1) General description: The main prerequisite for a creativity technique-based problem solving process to take place is a problem that needs to be solved. During the process, one or more process participants try to find ideas for solving the problem. When enough satisfying ideas are found, the process is finished.

CP2) Divergent and convergent phases: Any creativity technique-based problem solving process can be regarded as a sequence of two different types of process phases: In divergent phases, ideas for a given problem are sought, while in convergent phases, the ideas from divergent phases are evaluated. Keeping these two activities strictly separated is the main principle of the brainstorming technique and many other creativity techniques.

CP3) Additional information in each of the phases: In both type of phases, additional information can be provided in order to influence the potential outcome of the process phases. E.g. by providing a random word as mental stimulus within a divergent phase, the random stimulus creativity technique tries to make the participants invent more radical ideas. In convergent phases, additional information can be displayed to make the participants focus on a specific criterion (e.g. the feasibility of an idea).

CP4) Constraints for participant actions in each of the phases: The principle behind many of the investigated creativity techniques lies in constraining the actions a user may take in a phase of the creative process in order to stimulate and focus creative forces. Some techniques impose time limits, some techniques constrain the way users are able to express their ideas in divergent phases (e.g. only sketches are allowed) and others are limiting the way users may evaluate ideas in convergent phases (e.g. allowing free comments or not).

CP5) Idea model: The process model implies a flexible idea model that has to support various ways of representing an idea (text, images and sketches). In order be more expressive, it is advisable that the different representation forms can also be mixed, e.g. it should be possible to express an idea using a textual description and to add an explanatory sketch. Since new ideas often are just new combinations of old ideas, the idea model should support combining of ideas and parts of ideas.

4. THE PROTOTYPE

As a first prerequisite for our application, an already available multi-touch capable tabletop display was used (Echtler2008). This came along with a corresponding framework to identify gestures performed on it and allowed for the simultaneous collaboration within a group of 4 – 6 users. It already turned out in early phases of development that 4 users was the maximum for our approach as explained later. Unfortunately the used device did not provide any hardware-based user-tracking mechanism.

In order to apply the generic process model to the tabletop application, we had to design the main interaction elements in accordance to the requirements introduced above. In order to show the problem to be solved (**CP1**) and the additional information provided within each phase (**CP3**), an element displaying those information needed to be provided on the interface. This element could also display additional information required by **CP4**, for example the remaining time within a phase.

According to **CP2**, two types of process phases need to be supported. For *divergent* phases, the most important elements are the ideas that get created within the application. Based on **CP5**, the model for those ideas should be quite flexible. This led to the modeling of an idea as a set of so called "*aspects*" which could be *texts*, *images* or *drawings*. Users should be able to alter those aspects, move them to other ideas or to delete them. For *convergent* phases, a way to evaluate the ideas has to be considered.

As most promising way of text input we identified *virtual keyboards*, which allowed for an easy modification of textual-aspects (which is an explicit requirement of some creativity-techniques). An additional advantage of this way of text-input was its machine friendly representation, which especially seemed convenient for evaluating experiments. Last but not least it allowed for an easier interoperability with possible other interfaces (e.g. a web-interface). By providing a keyboard for each user, we addressed **DG1** (avoidance of production-blocking, all time accessibility). We decided to make the keyboard movable in order to support free positions around the table (**DG1, DG3, and DG4**).

For gaining more detailed research-options and to account each group members contributions, we also decided to track every action performed within the system. Based on the available hardware (and the missing tracking mechanism), this had to be integrated in the interface concept in the form of a personal *control-panel* which is needed to trigger all possible actions. This also allowed us to activate or deactivate specific actions according to the creativity technique or phase (**CP4**).

For the implementation of the described components we applied a widget-based approach especially suited for multi-touch input and breaking with traditional WIMP[1] design-principles. The design of / the interaction with those widgets was adapted to "real objects" to reduce cognitive load (**DG2**). Therefore, the interaction with the widgets is mainly based on multi-touch gestures like *moving*, *rotating* and *scaling*. The rotate-gesture especially enables the users to regard the scene from different angles of view what leads to the possibility of taking different positions around the table. For an even more "realistic" feeling of interaction, a physics engine (based on simple rigid body dynamics) was integrated. This way the users are for example able to slide widgets (especially ideas) to other users. (**DG1**, **DG4)**

The following section will shortly describe the implemented widgets:

[1] Window Icon Mouse Pointer

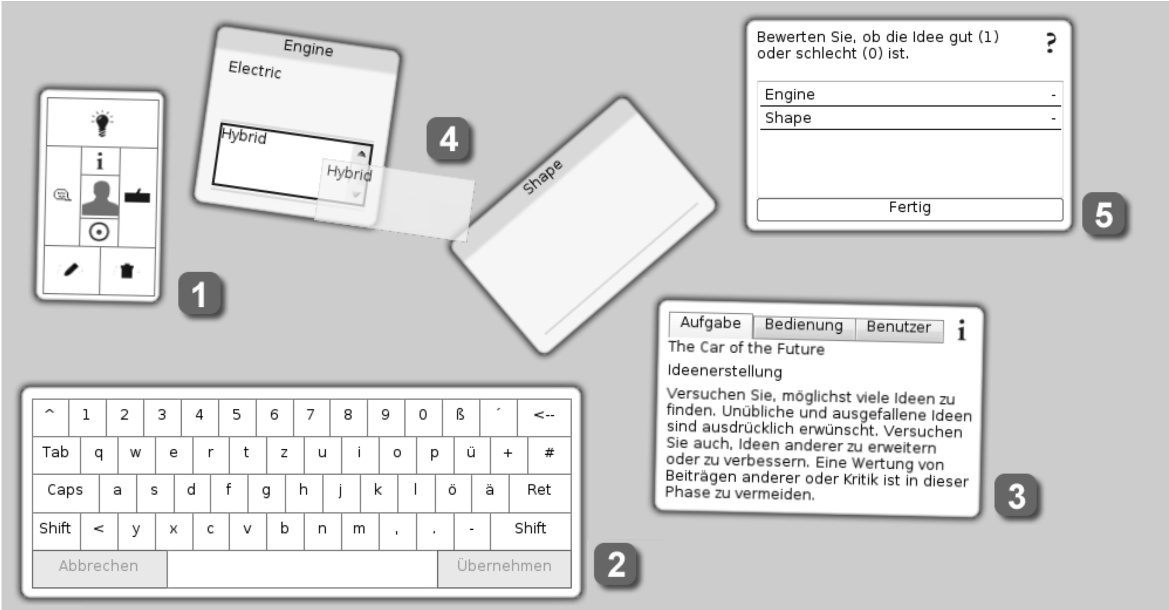

Figure 1. Implemented Widgets on the Tabletop Interface

The Control-Widget (1) mainly provides access to most actions which enable a user to alter contents of the system. In total it features 7 different buttons, some of which are disabled depending on the current process phase (divergent or convergent) or creativity technique. For divergent phases these are: creation, modification or deletion of representations of ideas. To allocate which user is executing which action, a drag and drop mechanism was implemented: a user has to press a button and slide his finger to an empty place on the table (create) or an existing idea/aspect (edit, delete). As soon the finger gets released, the action is performed on its last position. The remaining buttons on the control-widget provide the possibility to fold/unfold the virtual keyboard, the evaluation and the information-widget (description see below).

Virtual keyboard (2): Each user is able to unfold his/her own virtual keyboard. This keyboard makes use of the multi-touch input which allows simulating features of "real" keyboards like pressing the "shift"-key in order to write in capital letters.

Information-Widget (3): This widget displays the process-phase and problem specific information as described earlier.

The **idea-cards (4)** resemble real "post-its", a concept that has already been proposed in (Hilliges2007) and which is in line with the design principle "form follows function" (Sullivan1896). Aspects are separated by a small horizontal line, which can be dragged to increase the size of an aspect. In terms of functionality, the following features are available: Editing of title and aspects, reordering, moving (see the aspect "Hybrid" in figure 1) and resizing of aspects and merging of ideas.

The **evaluation-widget (5)** provides support for *convergent* phases and consists of two different views: The first one lists all generated ideas in order to select one of them for evaluation. The other (which gets triggered by selecting an idea) displays a detailed screen, showing the specific aspects and, according to the evaluation-technique, a list of available ratings and / or a comment box. It is also possible to cycle through all ideas within this view.

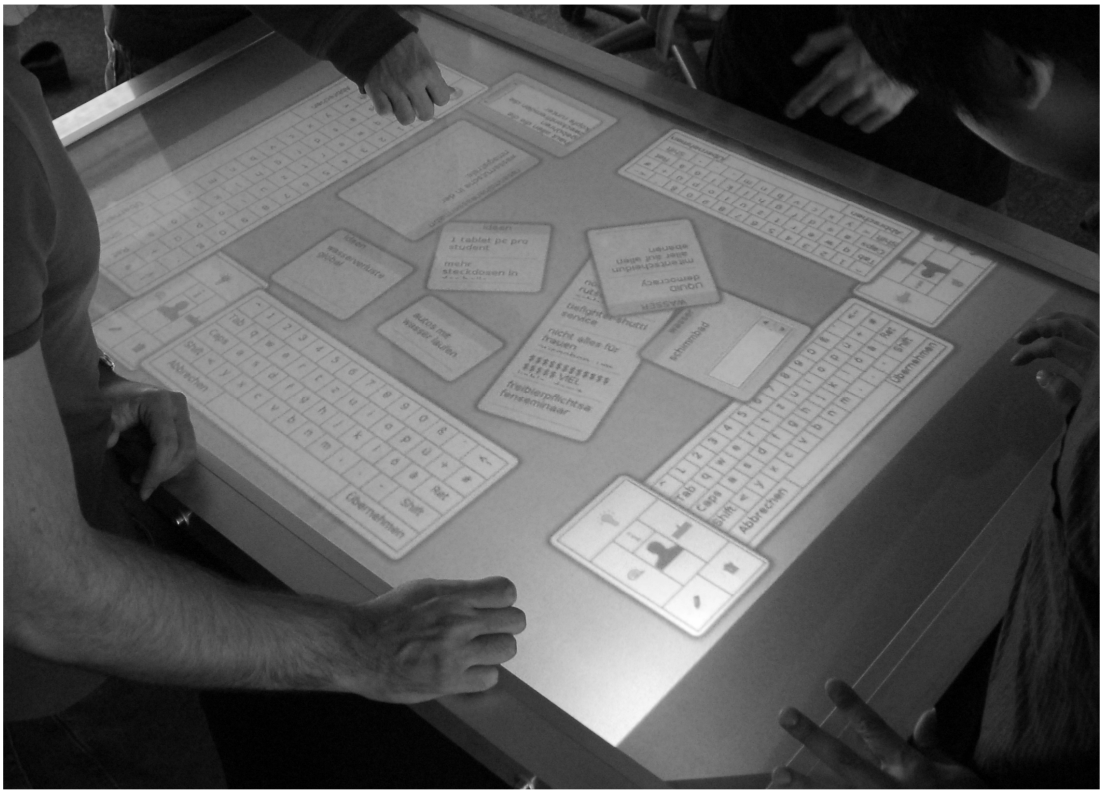

Figure 2. Collaboration at the Tabletop

An interactive demonstration of the application was introduced in a demo-video (Frieß2009). Based on this system, an evaluation was conducted with a total of 12 student participants. A photo that was taken during the evaluation session can be seen in figure 2. After an introductionary tutorial-session, each group (4 participants) worked through a three phase long creative process, each following a different creativity technique for idea generation (Brainwriting, Unrelated Stimuli and Forced Combination). Those were chosen as they represent different functional patterns of creativity techniques (see Vangundy1988 for detailed explanation). The duration of each phase was 10 minutes, so each group spent a total of 30 minutes. No chairs were provided around the table, to enforce the possibility to take different positions around it. Over the whole process, the interaction and communication patterns the people used were observed. In the end, a survey about general aspects of the application, as well as on tabletop-specific characteristics was conducted. Those observations, as well as some of the survey-results will be discussed in the next chapter.

5. EVALUATION RESULTS

In figure 3 a selected excerpt from the survey results is shown. Chart 1 unveils the most problematic element of our concept, the virtual keyboard. It`s not totally related to the keyboard itself but when conducting the study, the tabletop-display produced a problematic offset of about 1.5cm, which totally hindered an effective use of the keyboard. Another problem showed up with the large keyboard size, which interfered with liberty of action around the tabletop as it was not really possible to move the keyboard when switching to another side (where already another user was standing). For future studies a decoupled (virtual) keyboard, possibly running on handhelds would be a useful enhancement which specifically supports mobility around the table.

Figure 3. Selected Results from the Survey

Chart 2 shows that most users experienced their participation by using the application as more active, which possibly relates to the social group advantages of tabletop environments. Last but not least chart 3 shows that the use of “reality-like” physics, which obviously affects an intuitive and natural interaction with the virtual objects, is working. This is in a line with our observations that all participants acted quite naturally with the virtual objects. We also noted that in different demonstration applications that came along with the tabletop-framework and which didn`t implement a physics engine, people started missing the physically correct behavior of objects. Apart from the survey results, we made some other interesting observations:

The character of specific creativity-techniques seems to exert an influence on the importance of communication and coordination. For example in the 1st phase of the applied process (Brainstorming), most people worked for their own, without communicating very much. During the 3rd phase (Forced Combination), people had to deal with the ideas of others. This led to an increased communication, coordination and discussion activity. We also regarded a change in the way people work together, what manifested itself in changing positions around the tabletop. While each participant kept one fix side of the table within phase 1, some change took place during phase 3, as people started moving to another person`s side, in order to talk about one specific idea.

6. CONCLUSION

In conclusion it could be said, that creativity techniques seem to differ from each other and cannot be „summarized“ by regarding just one, as done in the related work with Brainstorming, which is only one out of many creativity-techniques. Within the scope of this paper it was shown, that a generic model of those techniques can be implemented on a collaborative tabletop interface and used in a productive environment. With the described prototype, a system which allows for a detailed examination of the collaborative aspects of different creativity techniques is available. Future research has to show, how the different functional patterns of creativity techniques influence the collaboration of a group.

If the observations made will still prove true with a statistical more representative mass of participants, will be shown in the scope of a detailed experiment, which will be target of our future work. Thereby especially the way of interaction (e.g. positions in the room/around the table, the posture of their shoulders and the intensity of verbal and gestural communication within each phase) shall be tracked and evaluated. By using the described 3-phase technique, conclusions about choosing appropriate collaborative creativity-techniques for tabletop environments shall be drawn.

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