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A pattern-based approach for developing creativity applications supported by surface computing

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ABSTRACT

Whereas creativity tasks have traditionally been supported by conventional media and tools (such as paper, pens, scissors and glue); mobile phones, tablets and other devices based on interactive surfaces are increasingly been used as additional support. Large-sized multi-touch interactive surfaces appear as an interesting alternative for supporting creativity processes and for supporting synchronous collocated collaboration. However, they have mostly been used for visualization and navigation purposes. Their use as authoring means, which would be essential in creativity tasks, has only begun to be explored. Applications and platforms that have been developed in this area rely on low-level primitives for implementing representation of ideas and discussions. We have identified a significant gap between the level of development tools and the abstractions required by end-user applications that aim to support creativity processes using interactive surfaces. This gap makes it difficult for developers to build applications that provide richer, more flexible support for innovators working collaboratively around interactive surfaces. Based upon a thorough analysis of existing applications and user practices in the field, we have identified the key actions and interaction patterns that take place during collaborative creativity sessions. Thus, we propose ISCALI (Innovation Solutions Centered on Activities for Large-sized Interfaces), a model that can be used both for describing and for prescribing the role of multi-touch surfaces in collaborative creativity tasks. In accordance to Activity Centered Design, ISCALI comprises three major components: activities, actions and operations. The central activities within the processes of creativity comprise generation, organization and evaluation of ideas. Each of these activities encompasses sets of actions. Finally, several operation sets achieve the goal of each of the actions. Based upon our model, we designed a general architecture for collaborative creativity applications. This architecture addresses the development gap through a proposed set of building blocks. These building blocks implement the main interaction patterns needed for stimulating creativity tasks that rely on interactive surfaces. We have implemented prototypical versions of these building blocks, referred to as TOKAs (Touch Operations for Creative Activities), and have made them available to developers. Independent developers have implemented applications that facilitate the use of various methodologies that foster creativity and synchronous collocated collaboration. These developers have taken advantage of the availability of TOKAs. The implementation and use of TOKAs demonstrate ISCALI's expressivity for describing and guiding the development of applications that support collaborative creativity on top of interactive surfaces.

1. Introduction

The work of creativity has to do with the generation of new ideas or new associations between ideas. Many techniques have been devised to facilitate the participation of individuals and groups in the work of creativity (de Bono, 1999; Osborn, 1957; Rohrbach, 1969; Whiting, 1958). We focus on the group dynamics that occur when participants share their ideas and select the one that is most appropriate to solve a problem, as in the case of the brainstorming method. Most of these techniques are carried out with the support of different tools and artifacts (such as pens, markers, paper, dice, or timers). More recently, some creativity techniques for idea generation have been supported by multi-touch surfaces (MTS).

MTS are interfaces between humans and computers that provide many technological advantages. They are capable of identifying two or more points of contact between the user and the screen in different positions, offer direct-touch input and bimanual interaction in a natural way, enable simultaneous interaction between multiple users and have a higher level of input flexibility than a mouse. Thus, given

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their characteristics, MTS show great potential to support the work of creativity (Ardito et al., 2015).

Generally speaking, applications that are based on MTS are appealing for a wide range of users, mainly because of the ease and intuitiveness of the interaction style they promote. Users have found it natural to select or move objects, or to zoom in or out in order to obtain more detail or a better perspective, by just tapping, pressing or sliding their fingers on the display. But so far, MTS have been used mostly for navigation and visualization purposes. Authoring on MTS still is generally limited to entering text using virtual keyboards, or sketching through relatively simple palettes.

The success of software applications for MTS depends on how well they support human activities. Collaborative work of creativity involves generating a large number of idea representations in the form of verbal utterances, handwritten text, sketches, idea associations, diagrams and more elaborated narratives. If MTS are intended to effectively support groups involved in the work of creativity, they must enable the diverse set of interactions and behaviors that take place in collaborative settings. Platforms for supporting a wide range of methodologies for fostering creativity are needed. Unfortunately, developing new MTS-based applications still requires significant effort in using low-level primitives that facilitate interaction with tactile surfaces and building complex components on top of them in order to implement natural user interfaces needed by creative workers.

The aim of this paper is not only to motivate the use of MTS, but also to offer a new model for supporting the development of MTS-based creativity applications. To this end, it is necessary to thoroughly analyze and understand how mechanisms that foster creativity are performed. Among the existing approaches for supporting work analysis and design, we can mention Requirements Engineering (RE) (Nuseibeh and Easterbrook, 2000) in software engineering, as well as User-Centered Design (UCD) and Activity-Centered Design (ACD) (Williams, 2009) in human-computer interaction.

While RE and UCD focus on the user (the process of designing the system that users want and considering goals and tasks in so doing), ACD focuses on the activity (activities, actions and operations performed by users to achieve a specific goal). RE asks for the purpose, by identifying stakeholders and their needs (Nuseibeh and Easterbrook, 2000). UCD considers who the users are and their level of knowledge, their context of use, their reasons for use, their performance patterns and their preferences. ACD "emphasizes the design of computer-mediated environments to support and structure the interactions and interdependencies of an activity system" (Gifford and Enyedy, 1999).

Since our goal is to support the activities that promote creativity, with special emphasis on the process of idea generation, we decided to rely on ACD. We used ACD to find patterns in interactions between people who generate new ideas with MTS. We perform direct observation and video analysis of creative sessions using MTS applications. We paid special attention to the main activities and sub activities carried out during these creative sessions. Then we focused on specific interactions of participants with the applications. In this way we obtained the main activities, actions and operations of users during creativity sessions using these interfaces.

The basic reason for focusing on activities is to determine which tasks or activities must be enabled by a multi-touch application built for creativity and to determine how a multi-touch device would be operated. We need to help application developers in their goal to develop software applications designed for creativity using multi-touch interfaces. To achieve this goal, we need to learn about the activities, actions and operations that end users perform in the processes involved in creativity.

Activity-Centered Design is an approach that divides activities into various levels of sub-activities. The objective of ACD is to understand users as participants in activities. ACD is a human-centered approach for large and heterogeneous populations (Norman, 2013). ACD has its theoretical basis in Activity Theory (AT), which defines activities and actions taken by users to achieve a specific goal. AT is a broad framework that provides a cultural, social, developmental, and tool-centric perspective on people engaged in activities (Leontiev, 1978).

We posit that if ACD is applied properly in surface computing, through an analysis of the structure of activities and requirements, a helpful classification of user interactions can be obtained for the support of the development of interfaces for innovation and synchronous collocated collaboration. Such interactions should exhibit *patterns*, which in our context refer to actions or operations that are performed in a regular and repeated way when interacting with MTS to achieve the specific goal of a given task. Patterns can thus be regarded as components of a model that describes interactions in detail – close to reality – including the essential elements of the process of creativity that are the basis for the optimization of the mechanism that support creativity at its most elementary level – where creativity is carried out – at the user level.

This paper presents an analysis (based on ACD) of how software developers apply various techniques to create applications for creativity. This paper also presents a model for the process of creativity that relies on MTS, derived from this analysis. The paper is structured as follows: Section 2 offers a brief overview of models that support the process of creativity, followed by a more detailed review of works related to the support of creativity by MTS. We analyze salient activity models and widget toolkits for developing applications that support creativity using MTS in Section 3. Then, Section 4 presents the ISCALI model. Section 5 presents the architecture that we are proposing for applications that use MTS. Section 6 shows our toolkit for applications development. The paper closes by presenting conclusions and future work.

2. Related work

The work of creativity is the manifestation of creative effort as in the formation of concepts, artwork, literature, music, painting and design (Osborn, 1957; Sawyer, 2006). One of the basic strategies used by the mind to solve problems is the formation of concepts. The work of creativity can be supported by multiple methods, ranging from highly structured methods such as TRIZ (Altshuller, 1999) to less structured methods such as "analysis", "association", "synthesis", "lateral thinking", and "brainwriting", among others (de Bono, 1977) that focus solely on idea generation. This work focuses on methodologies to support creativity that fall within the category of less structured methods. Thus, the next sub-section shows an overview of the processes that are performed in some exemplary techniques that foster creativity.

2.1. Methodologies to support creativity

Many techniques, methods and tools have been proposed to promote creativity. In this section we present an overview of basic methods that support creativity. Further on, we classify these methods based on similar characteristics.

"SCAMPER" is a general-purpose checklist with idea-spurring questions. It was proposed in Osborn (1957). SCAMPER is an acronym that stands for: Substitute, Combine, Adapt, Modify, Put to another use, Eliminate and Reverse. To use this tool, it is necessary to ask questions about existing products or topics related to problem solving, using each of the seven prompts above as a guiding checklist.

"Six Thinking Hats" (de Bono, 1999) is a creative method for group discussion and individual thinking, which involves six colored hats. Each hat represents a different way of thinking. The white hat stands for available facts and information. The red hat represents emotional reactions. The black hat is used for discernment to identify reasons for being cautious and conservative. The yellow hat is used for an optimistic response and to identify benefits. The green hat covers creativity, statements of provocation and investigation. Finally, the blue hat is appropriate for discussing how the meeting will be conducted and to develop the goals and objectives. The main idea behind this technique is parallel thinking, which ensures that all people in a meeting are focused on