A Networked Sketching Environment for Supporting Collective Creativity

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Abstract. In the early conceptual design, individual designers often make extensive use of sketches to explore design problems. Moreover, within the collaborative design sessions, designers communicate and discuss with each other by sharing their temporary sketches. These private design artifacts are used to externalize ideas and share them with other designers in order to facilitate the performance of design sessions. During such social interaction performance, some abstraction behaviors behind social activities like collective creativity are synchronized. However, the existent tele-communication tools proposed for separated design groups, slightly hold back the activities of collective creativity. It makes designers dedicated just in the table discussion, and negatively influenced on collective creativity sharing. Thus, some private design artifacts became isolated in tele-communicative environments. In order to respect this, we propose an approach that uses the notion of Digital Backchannel to realize the sub-channel communications. In this paper, we also present the implementation of a working prototype of groupware application. Finally, we discussed some points from our studies.

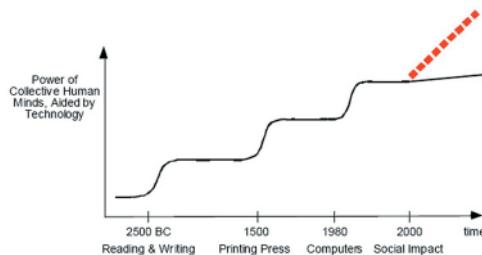**Keywords.** CSCD: CSCW; Natural User Interface; Digital-Backchannel; Collective Creativity

Introduction

Designers often rely on external information and resources in their creative design. Architects, for instance, often have sketchbooks holding a large number of design artifacts or externalizations (Oxman, 1997; Remko, 2002; Nakakoji, 1999) that they have accumulated over the years. In the early phase of the design process, designers browse their sketchbooks to find images that help them generate new ideas. Furthermore, creative activity is not only performed individually but

Figure1. The power of the collective, aided human mind. (Fischer G, 2005)

also placed in social context (Fischer, 1997). Some recent emergence of research has put the social aspects of creativity into consideration (Edmonds, 1999; Fischer, 2003). Figure 1 illustrates the major fundamental human inventions and creations that have increased the power of the unaided individual mind. (Fischer, 2005)

From the aspect of social creativity, Paulus & Yang (2000) argue that the idea exchange process in groups may be an important means for exchanging creativity and innovation. This is similar to what Osborn (1963) emphasizes in one of his four brainstorming rules: "improving and combining ideas". Individuals come from different backgrounds, and have to externalize their ideas and explain their assumptions and domain knowledge to each other for creative sparks to be increased (Warr, 2005) (Figure 2).

Therefore, our research concerns collective creativity among separated design groups, and our objective is to improve the user interface of tele-communication tools that impede the performances of collective creativity. In this paper, we first review the emergence of collective creativity in design groups and illustrate the problems and the requirements of how communication tools should respect. A server-client networked system has been implemented to realize the notion of sub-channel approaches. We then use our examples to test how designers interact with the interfaces. Finally, we conclude our initial results, and suggest that research in supporting creative design should focus on reinforcing the effects of these social influences on the creativity of separated design teams.

Collective Creativity

Let us review the definition of creativity and theoretical account of why social creativity should in principle be more productive than individual creativity. Then we will examine findings and identify characteristics of creativity and difference between
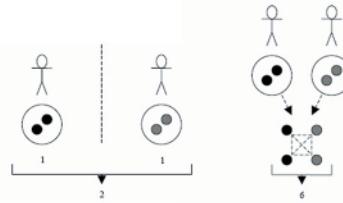

Figure2. Creative ideas created by (Left) nominal group and (Right) real group. (Warr & O.Neil, 2005)

individual and collective in social context.

Creativity

Warr (2005) compared existent models of creativity and proposed a unified definition of creativity as: "Creativity is the generation of ideas, which are a combination of two or more matrices of thought, which are considered unusual or new to the mind in which the ideas arose and are appropriate to the characteristics of a desired solution defined during the problem definition and preparation stage of the creative process". Creativity is the art of transforming one form of knowledge into another. Shneiderman (2003) proposed a four-stage framework for the creative process that he believes can and should be supported by appropriate computer tools: collect (information gathering), relate (furnishing useful insight), create (generating new solutions), and donate (disseminating in community). These four stages are cyclic and one can go from one to the others as needed. This framework is based on the following assumptions: (1) new knowledge is built on previous knowledge; (2) support creativity; (3) refinement is a social process; and (4) creative work is not complete until it is disseminated. The creative process depends on the designer's ability to discover the association between two as-yet-unrelated things, the developing design and specific visual design.

Creativity of Sketching

Within the domain of architecture, sketches and diagrams are common means by which ideas can be explored. In early conceptual design phase, the designer tends to make extensive use of sketch-

ing when generating design ideas. Oxman (1997) also defines creativity of sketching as using an iterative cycle of re-presentation and re-interpretion as a means for conceptual exploration. Reasoning through these initial, ambiguous sketches need not necessarily be logical but can be "ill-structured" or "analogical". Moreover, the same drawing can stimulate different perceptual models. The function of sketching here is that it stimulates a re-interpretation cycle in the individual designer's idea generation process. Re-interpretation provides new knowledge, and this new knowledge leads toward further re-interpretation (Remko, 2002), enabling the designer to extract new meaning from the sketches.

Emergence of Collective Creativity

Gennari and Reddy (2000) described the design process as "human activity, involving communication and creative thought among a group of participants". Osbon (1997) claimed that the average person could have up to twice as many ideas when working with a group than when working alone. In the group idea generating session, "Shared Visual Context" (Scrivener, 1994) fosters the group's creativity by providing an easily accessible resource of design information, which stimulates building on an earlier design idea. Much of our intelligence and creativity results from collective memory of communities of practice (Lave, 1991) and from interaction and collaboration with other individuals (Csikszentmihalyi & Sawyer, 1995).

Most research in the field of creativity reveals that designers who are engaged in a creative design task use external resources extensively. Such external resource include a variety of physical and logical information; for instance, browsing photographic images or talking to other people (Nakakoji, 1999). Sketches and other forms of external re-presentations produced in the course of design are also a type of external resource that designers depend on. Designers then incubate or foster such accumulated and fragmentary information, and

use it to discover a new or previously hidden association between certain pieces of data. Such external resources trigger individual designers' creativity by using design knowledge or representations created by other designers in the community. Then some abstraction behaviors like collective creativity occur.

Computational support for Collective Creativity

Some systems that have been built bring external knowledge to problem solving: one of such systems is presented by (Nakakoji, in 1999): as a designer works, the system searches the best image related to the current design topic, hoping to produce creative sparks. Other designers leveraging on the knowledge of the community, have previously catalogued these images. Another system, IdeaMagnager (Shibata, 2002) is a knowledge management system on a PDA that allows individuals to record their ideas whenever they have one. IdeaSpaceSystem (2001) was designed to support architects in the early phase of the design process by reducing fixation in the process and enhancing the 'fluency' of work. The IdeaSpaceSystem captures all design data and then uses the words to provide the architect with new associations and relations between words, in order to stimulate the generating of new idea (Segers, 2001). These systems present the idea of retrieving information to foster idea generation and exploration, but they work at the level of the individual (one designer working alone on a design problem).

The brainstorm system (Stenmark, 1999) permits the user to send mails to an idea server anonymously, these will then be posted and can be criticized by other users. The idea of anonymity is interesting, since it enables a person to contribute without having to worry about what others will think, alleviating "peer pressure". Nevertheless, too much (or harsh) criticism may discourage an individual from generating ideas or suggesting them. Fischer's EDC (2005) is an enhanced physical en-
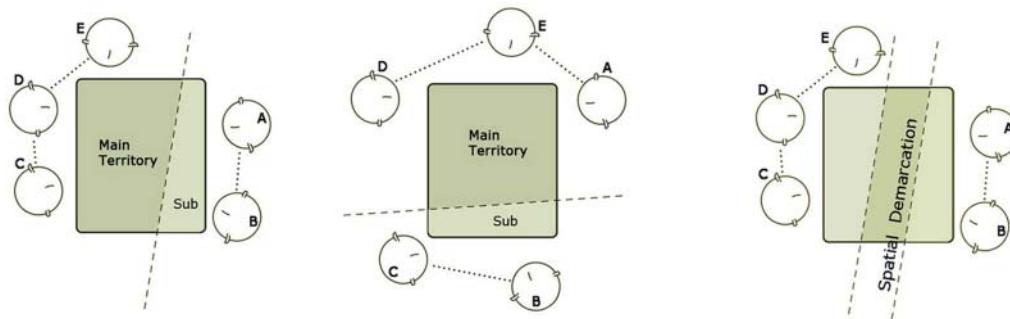
vironment that allows group members to discuss problem solutions with the aid of tabletop and wall displays, as well as physical objects to help design solutions and computers to record rationale.

Problem Statement and Approach

In the early conceptual design, individual designers often make extensive use of sketches to explore design problems. Moreover, within the collaborative design session, designers communicate and discuss with each other by sharing their temporary sketches. These private design artifacts were used to externalize ideas and share them with other designers in order to facilitate the performance of design sessions. During such social interaction performance, some abstraction behaviors behind social activities like collective creativity are synchronized. However, the existent telecommunication tools, proposed for separated design groups, slightly hold back the collective creativity activities. They also make designers just dedicated in the table discussion, and negatively influenced sharing in performance of collective creativity. Thus, private design artifacts are isolated in telecommunicative environment.

This research attempts to reduce the negative influences that impede the activities of collective creativity in the collaborative design session. Moreover, it attempts to re-link these fragmentary, ambiguous, even ill-structure design artifacts by increasing the fluency of user interface. In our preliminary studies, we already recognized several shortcomings of user interface. The key negative effect when a design community moves from co-located to separated collaboration is the interface that interferes with the realization of collective creativity. Figure 3 describes a traditional round-table discussion in the design practice. Discussing process often includes a main subject and few secondary whisperings.

Although some claim that whispering is intrusive, interfering and imprudent, some emergent reports indicate that such unofficial discussion is likely to augment the discussion of the main design subject on the main-channel and its negative effects are somewhat reduced. One of the causes is that there is a demarcation between main and sub territory (Figure 3).

When design communities move from co-located to separated collaboration session, the tele-communication or mediated-rich environment generally employ only one platform for sharing worked spaces in application of groupware. All of the users' attention is absorbed by the interface of the virtual main discussion space. It is downcast for whispering discussion in the context. For example, as Figure 4 illustrates, designer B needs first to pass through the main space for whispering, discussing, sharing with designer A. It frequently interruptes the discussion on the main interface. Designers are influenced by such negative effects and discuss passively and negatively.
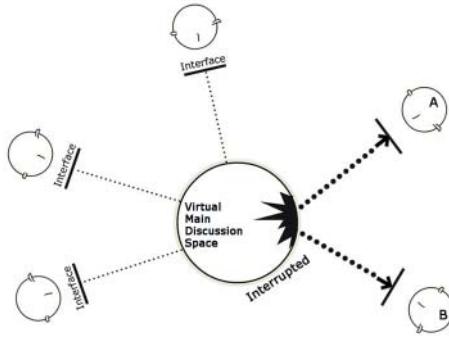
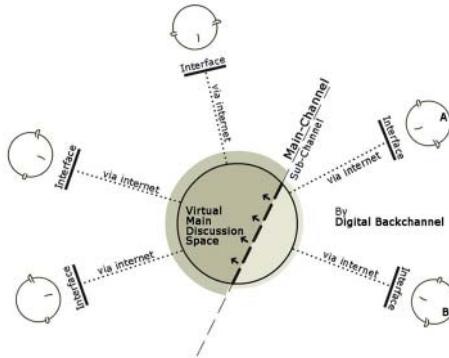*Figure4. With existent tele-communicative tools, whispering interrupted the discussion of main-channel.*

Figure5. A sub-communication channel for realizing whispering discussion on the communication tools.
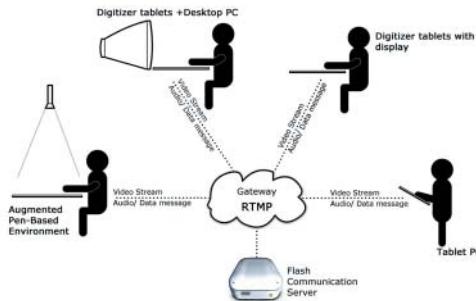

Figure6. System architecture and possible hardware for using.

Therefore, in order to overcome such flaws of telecommunication user interface, we propose a newl approach using Digital-Backchannel (Figure 5) in which a system has two or more virtual discussion spaces. The notion of setting a sub-channel by instant communication tools supports informal discussion in whispering ways, and occurs concurrently without interrupting the performance on the main-channel.

As mentioned above, we are mainly concerned with the early conceptual design session during which designers generally use sketches and modeling to express their ideas. We suggest some initial requirements that the interface should follow in our first prototype:

(a)   Allow designers to express ideas instinctively, effortlessly and merrily.

(b)   Simple functions for sketching are required, such as transparent editing, annotating and drawing.

(c)   Designers then can be inspired to extract ideas from discussing and sketching momentarily. This encourages them to think, associate, link and interact with ideas produced by other designers, because some abstraction behaviors behind interactivity like collective creativity are synchronized.

(d)   When some new crucial idea is generated, the system should proffer channel to interlink the sub-channel and main-channel smoothly without interrupting the discussion of the main-channel. Designers are encouraged to switch space between main and sub whenever they need.

(e)   A shared space of ideas as an open-stack bookshelf in which designers are encouraged to share their temporary ideas whenever their want.

In order to test the usability, a prototype of groupware was designed. The interface design was based on the requirements that we described above.

System Design

Our first prototype uses FlashCommunication-Server 1.5 components, and the concept of digital-backchannel (Joseph F.M. et al., 2004; Rekimoto J., 1998; Sharon Cogdill et al., 2001)-an instant communication technique- as our approaches for interface design. The system architecture is bases on the server-client networked platform of FCS (Figure 7). We employ Pick-Drag-Drop to combine the virtual paper (Aliakseyeu, 2003) and pen-based gestures. It is a familiar interface for designers to use. Natural gestures of pen drawing are used to change the edited function of interface. For example, we used "flip" as a metaphor to design the interface for switching channels; designers just need to press on the edge of paper and then drag out, and it will cause switching between channels. Additionally, any one of the designers on the back channel can still be aware of what happens to other colleagues on main-channel.

Our first working prototype presents the following performance scenario:

Transmission in back-channel: When a designer is not engrossed in the main discussion on the main-channel, he flips the interface naturally to get into the back-channel spaces. Then, he might generate some ideas that are irrelevant to the main discussion subject or might get inspiration from the idea in sketches produced by other designs. Additionally, he discusses ideas with some designer that is also unmindful on main discussion. Such activities of whispering on back-channel spaces are connived.

Inspired repeatedly: Conventional opinions indicate that whispering is interferes especially on a design session. However, some research argues that whispering sometimes is useful and original for collective creativity. Back-channel offers communal idea shared spaces, i.e. an opportunity for designers to interact with ideas from sketches produced by other designers. They expect fostering a new idea from these shared resources, or com-
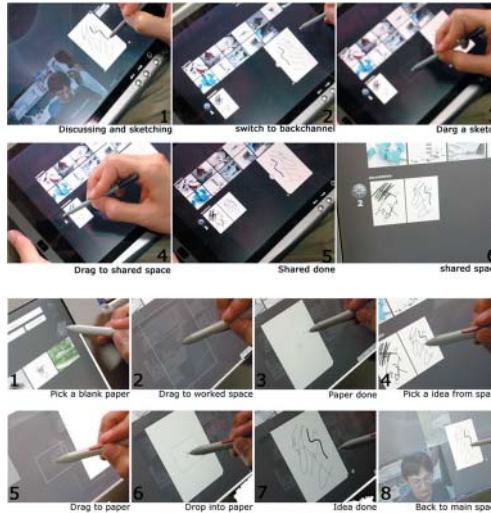

Figure7. A designer who uses tablet-PC is trying to pass an idea in sketches to shared spaces when he is on the back-channel spaces.
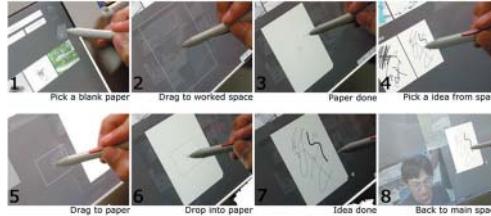

Figure8. Another designer who uses Digitizer tablets is dragging the idea in sketches from shared space by back-channel.

bine two ideas with a previous hidden relation as a new one, and push it back to the shared spaces. In this process, the system permits designers to re-think the sketch with overlap edition. Transparent sketching is commonly used in idea generating session.

Conclusion

The crucial contribution of the sub-channel approach and digital-backchannel technology is that it supports the main-channel's discussion and idea generation complementarily without interfering or being intrusive. It offers the main discussion a swimmingly channel and keeps rough ideas recorded and shared concurrently. The negative effects as production blocking and free riding on social creativity is mitigated slightly. A designer is sometimes not engrossed in brainstorming of the main-channel (as free riding), but thinking about some new idea irrelevant to the main channel's subject, which he later abandons. With this new interaction model, a designer can be inspired to keep and share his idea temporarily in the shared

space. Although these fragmentary ideas are seem unobtrusive, irrelevance and

indefinable, initial tests show us that new ideas combined and associated with different matrices of thought foster originality.

Bringing spatially distributed people together by supporting net-based communication allows the shift that shared concerns rather than shared location becomes the prominent defining feature of a group of people interacting with each other. Our research grounded in the basic belief that new media should not merely deliver predigested information to individuals, but rather provide the opportunity and resources for social debate and discussion. By bridging these fragmentary parts produced by individuals, the tools will enable designers to share private external resources in a real-time idea generating session. Consequently, more and more new, or previously hidden, inspiration possibilities emerge.

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