PROJECT TATIN: CREATIVITY AND COLLABORATION DURING A PRELIMINARY PRODUCT DESIGN SESSION USING AN INTERACTIVE TABLETOP SURFACE

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Abstract: Project TATIN at the University of Technology of Compiègne was conceived with the goal of increasing the effectiveness of preliminary design sessions. This goal necessitated the construction of an extra-large interactive table, which would be multi-touch and multi-user. We develop BrainTouch, an application for the table to be used by design teams to help facilitate the process of brainstorming Post-it note session, which is a popular preliminary design among group team. We conducted a lengthy experiment to not only test the usability of the interactive tabletop but to understand collaborative behavior and creativity in preliminary design group session. This article presents the earliest results from the experiments.

Key words: collaborative design, multi-touch and multi-user surface, creativity, user testing, groupware.

Nomenclature:

x : Average of subjective assessments
t : Student's t-test
p : P-value
F : Fisher test (F-test)

1- Introduction

In light of the constant improvements in product and project design software (i.e. CAD, PLM) through advancements in computer science since the 1980's, the hypothesis can be made that these applications will continue to benefit from recent advancement in the field of tactile multi-touch displays [PC1]. This hypothesis is predicated upon a second observation: the existing tools dedicated to collaborative product design in co-presence [SB2] (i.e. interactive whiteboards) neither meet the user's needs on a technological level nor support a well-designed set of interactions techniques to address all the tasks in the use case of a group meeting [PM1]. For example, traditional software used to support meetings only allow for single-user interaction, where one user the acts as the "presenter" and other must wait for this role to be delegated to them by the software. This design unnecessarily obstructs the natural fluidity of meetings and restricts other members from playing a more dynamic role. These devices have typically recycled the same interaction techniques adopted from the WIMP (Window, Icon, Menu, Pointer) paradigm [CW1] instead of conceiving a new set that allow for multiple user interactions at the same time [R1]. Moreover, the interfaces suffer from latency between user's actions and the system's feedback, imprecise calibrations of the points of contact on the tactile surface, and poor screen resolution on the display.

Project TATIN (TAble Tactile INteractive) at the University of Technology of Compiègne explores a new frontier in preliminary product design supported by multi-touch and multi-user interactive surfaces and groupware. Among other objectives, it must allow the individual expert and the group to develop ideas equally and then share these ideas freely amongst themselves. Achieving this objective necessitates an investigation in the design of multi-touch technology inside an interactive conference table, which will not only be a space for cooperative design work, but also a platform of human-computer and human-human interaction that must inherently exist in, and possibly be engendered by, this environment. The goal is to construct a functional prototype (hardware and software) of an interactive table, so that we may test the appropriate scenarios and use cases for the optimization of the design process.

This paper is organized as follows: section 2 presents the state of the art on interactions mediated by shared interfaces and studies on collaboration where the group is present around the same device. Section 3 describes the TATIN platform, a multi-touch and multi-user conference table, while section 4 details the experiments used to observe a preliminary phase of design around the TATIN table. The results of these experiments will be disclosed in section 5. Finally, section 6 will present the conclusion we have reached, as well as a description of future works.

2- Collaborative Design and Multi-touch Technology

2.1 – Pre-design and Collaboration

Long before preliminary design procedures were formally studied and proven to be effective, their use was widespread among design teams to create innovative new products and services. Scaravetti explains that preliminary design encompasses both a phase of research or concepts and structural design, processes run in parallel [SP1].

Of all the methodological tools that are frequently used in the preliminary design phase, the most popular are causal analysis, functional analysis, and reliability solutions such as “FAST” or “FEMA”, or tools of innovation such as brainstorming or the method “TRIZ”. These tools are as plentiful as they are diverse, but all ensure that the participants of the design process converge toward common objectives. Primarily committed to the uncovering and classification of new ideas this phase is essential for the success of a project: if only 5% of a project's budget is invested into this phase, the effect is a 70% reduction in overall spending [SP1, U1]. This phase is critical in reveal hidden socio-technical aspects of group work and projects and this is why laboratories have been intensely researching this phase of the design cycle.

With regards to the TATIN project, conducting research on preliminary design methods gives us two advantages:

- traditional preliminary design techniques do not require the visualization or manipulation of physical prototype,
- the objects that will be manipulated represent merely concepts and are suitable for manipulation by participants of different skill levels, which ensures that all participants are able to collaborate.

Our approach is based on results from Shiba showing that collaborative design promotes a more efficient construction of a shared vision, for more effectiveness [SW1]. The innovative design of products and services is predicated upon the participation of actors from different professions who are present from the start of the preliminary phase of a project. The effectiveness of collaborative work therefore depends on the ability of participants to agree on a common language of ideas and solutions.

These phases are part of a process leading to the formation of a device, a solution to a previously unsolved problem, which ultimately will be formed by a fusion of ideas and concepts under digital or physical representations. If the resulting artefact from the preliminary design sessions is to bring the greatest efficiency to the remainder of the design lifecycle, the artefact must be one which shares its authorship amongst all stakeholders and participants of the meeting.

2.2 – Multi-Touch: Research and Commercial Applications

Despite high market prices (14k€-25k€), multi-touch interfaces are booming. Multi-touch technology has already established itself on phones and tablets and it is now entering the consumer market with large-scale interactive displays and tabletops, from the IBM PLATO IV to the Microsoft Surface, iLight, Epson xDesk, and DiamondTouch MERL, etc. We are witnessing a democratization of multi-touch technology, instigated in particular by Jeff Han's presentation at the TED conference in 2007 [H1].

What makes Project TATIN unique is that it was initiated with the desire to contribute more than just the hardware and development of a state-of-the-art interactive tabletop for conference rooms. The project acknowledges the potential of tactile surfaces in computer-supported cooperative work and will pioneer research to reveal the critical aspects of group dynamics around an interactive tabletop. In turn, the project will channel our findings to create new interaction techniques for groupware. This approach will be instrumental in creating much needed industry-wide focus for the design of innovative groupware applications for interactive tabletops

Moreover, we believe that the application of an interactive tabletop surface will have a significant impact in the field of design itself. These contributions can be particularly successful as it applies to preliminary design activities when multiple stakeholders who are engaged in collaborative design become involved and united, as illustrated by the project DigiTable [CL1].

Today, we observe that applications developed for interactive tables serve mostly public recreational uses (drawing, browsing images). The scientific literature generally addresses one of three areas of study: the manipulation of existing elements (e.g. databases of images, videos, casual gaming), the role of multi-touch tactile surfaces on group dynamics and working methods (human-human interactions, remote communication), or technical and technological possibilities of the tool itself (single-user/multi-user capabilities of interfaces, devices such as a keyboard augmented by the multi-touch surface).

In 2010, we note that applications on interactive tables are more numerous and diverse, but nonetheless, they are primarily designed for the general public and non-professionals. To our knowledge, no work has proposed applications for facilitating collaborative design sessions. The unique contribution of Project TATIN is therefore the proposal and evaluation of a new methodology of preliminary collaborative design, supported by an extra-large interactive multi-touch tabletop.

3- The TATIN Platform

As part of Project TATIN, constructing an interactive multi-touch tabletop enabled us to support the implementation of collaborative preliminary design sessions (Figure 1). The TATIN platform uses two HD video projectors positioned side by side to render the final double full-HD 83-inch image (1920 pixels × 2160 pixels and 1.60 m × 1.40 m).

Figure 1: Illustration of TATIN tabletop surface.

The input device of the platform TATIN is based on LLP (Laser Light Plane) technology [N1, SB1]. Infrared lasers augmented by linear filters are used to create a laser plane flush with the top surface of the table. All objects or users' fingers in contact with the surface of the table disrupt the laser plane. Two infrared-sensitive cameras beneath the table are responsible for tracking the fingers illuminated by lasers. Next, image-processing software (extraction of background, high-pass filter, etc.) is applied to the camera images to determine the position of different contact points on the surface of the table and transform them into software events (Figure 2).

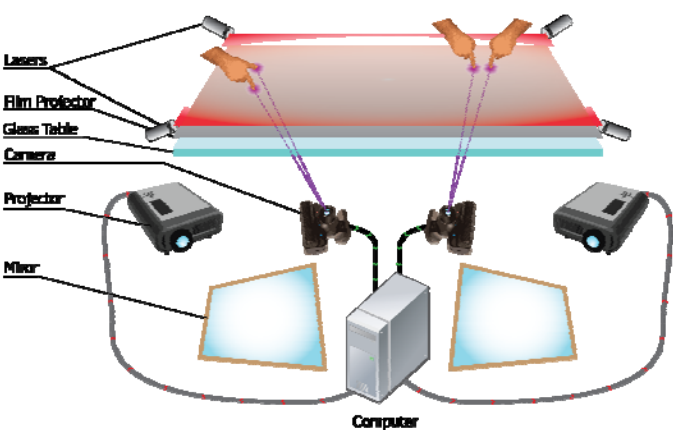

Figure 2: LLP technology principle.

4- Experiment and Procedure

The experiments conducted with the TATIN table were modeled after a similar set of experiments conducted by the project DigiTable [BB1]. Their experiments were centered on a simulation of a brainstorming session, a group creativity technique frequently used by design teams at the start of a project. These sessions allow the generation of ideas and functionality from a given theme or problem. Team members work individually by noting their ideas on Post-its and then work together to share, group, classify, and categorize their ideas. Our protocol was designed to compare the results of brainstorming sessions conducted in the control condition, on a conventional table with Post-its and pencils, to brainstorming sessions on the TATIN table, through a software, named BrainTouch©, that creates digital Post-it (Figure 4).

These experiments included a total of 48 testers divided into 8 groups of 6 people. The groups of users can be divided into two categories of users: 34 engineering students aged 20 to 25 years and 14 non-students aged 24 to 50 years. For each of the eight sessions we conducted, a group would brainstorm on two separate topics so they could experience the conventional Post-it session (control condition) and the TATIN table session (TATIN condition), one after the other. The topics were the design of "**a shared calendar for a family**" and the design of the "**Swiss Army knife of the twenty-first century**" and, in particular, a list of functions that these devices would have. To reduce bias in the observations, the sessions were counterbalanced with the choices of brainstorming topics and the choices of the brainstorming methods (Figure 3).

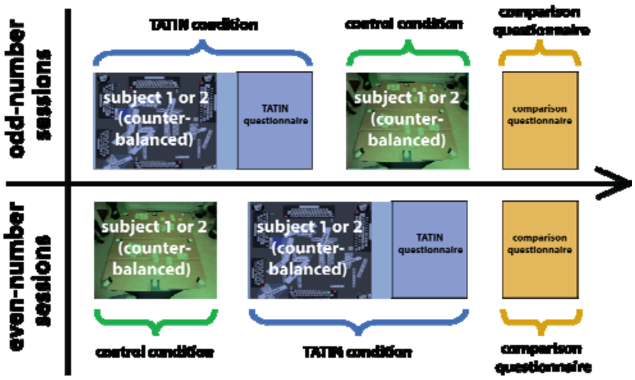

Figure 3: Protocol of evaluation with counterbalancing for the topics and conditions.

The experiments were constructed so we could observe data of three criteria: the quality of creativity, the quality of collaboration within the group, the subjective evaluation of the testers. The experiments lasted 3 hours and were conducted during the afternoons over a period of 2 weeks. Each afternoon was divided into two phases, one for each of the experimental conditions, with a short break in between the sessions. The brainstorming sessions were organized as follows:

- **8 minutes of individual idea generation:** users write

ideas one at a time, using only one Post-it per idea.
- **10 minutes of pooling of ideas:** each participant must present their ideas to the group.
- **12 minutes of categorization of ideas:** the group must conduct a semantic cleaning (deletion of doubles) and then semantic grouping, where the group must also make a name for each category.

The experiments were filmed and the videos will be analyzed to observe and evaluate the performance of creativity and collaborative behavior. The setup consisted of three cameras recording from three different perspectives and a microphone to record audio from the meeting.

The software BrainTouch was implemented using the toolbox MT4J [LR1]. The creation digital Post-its take place as follows: each user has a virtual keyboard in front of her, from which they may generate new Post-it. After typing the text on the keyboard, the user can either generate either a text Post-it by pressing the button “ENTER” or an image Post-it by pressing the button “FLICKR”. Upon pressing this button, the application will use the entered text to search the Flickr© database for images. After a moment, a series of fifteen images corresponding to the text appears in front of the user. By selecting one of these images, the user can generate the image Post-it (or, if the user finds no images suitable, the user can close the image selection window.) Possible actions by the user include: generating Post-its using the virtual keyboard, moving, resizing, and reorienting a Post-it, or removing a Post-it by dragging to one of the trash icons placed at the four corners of the table. Generated Post-its can also be slid under the users’ keyboard where it can be stored for safe-keeping. Finally, the user also has the possibility of grouping of Post-its to facilitate moving and categorizing them. To do this, the user must simply draw a circle with a finger around a group of Post-its. Groups of Post-it can be unbundled in the same way.

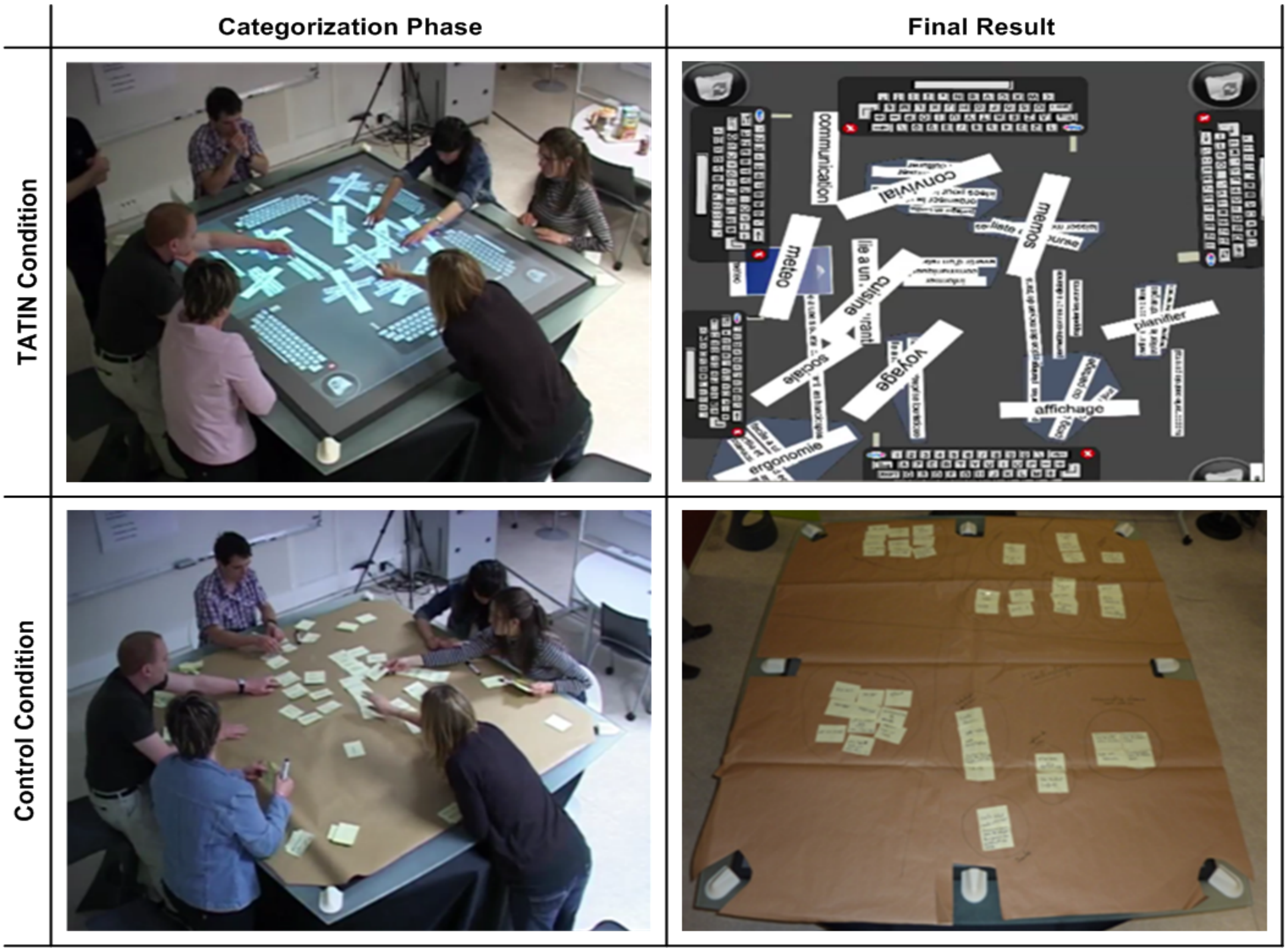

Figure 4: Illustration of two experimental conditions (Control & TATIN condition)

A questionnaire for the subjective assessment of the user experience on the table TATIN was given to each participant upon completion of the brainstorming session using the TATIN table. A questionnaire on the comparison between the pen-and-paper session and the TATIN table session was given to each participant upon completion of the two conditions. Due to counterbalancing, when the arrangement of the sessions within the experiments would the TATIN table as the second session, the users would fill the TATIN questionnaire first, and then the comparison questionnaire (Figure 3).

In each of the questionnaires, participants were asked to evaluate certain subjective criteria of their experience by the

Likert scale of 7 points. They could also add written comments on each of the criteria evaluated.

The results of the video observations and questionnaires will be compared with those obtained from the project DigiTable to allow us to gain insight on how the criteria are affected by the size of the table and the number of participants [BB1]. We suspect the social mechanisms at work in a brainstorming session may be contingent upon the distance between the table size and group size.

5- Result

This article presents only the first preliminary conclusions made from the experiments described above. It is here mainly to refer to the statistical results extracted from the questionnaires completed by the participants involved in the experiments. These questionnaires capture the user's subjective assessment of the paper and pencil brainstorming and the interactive table brainstorming. The variables measured by the questionnaire are, among others: ease of use, effectiveness, agreeableness, playfulness, etc. Figure 5 summarizes the observed variables and values (averages and standard errors).

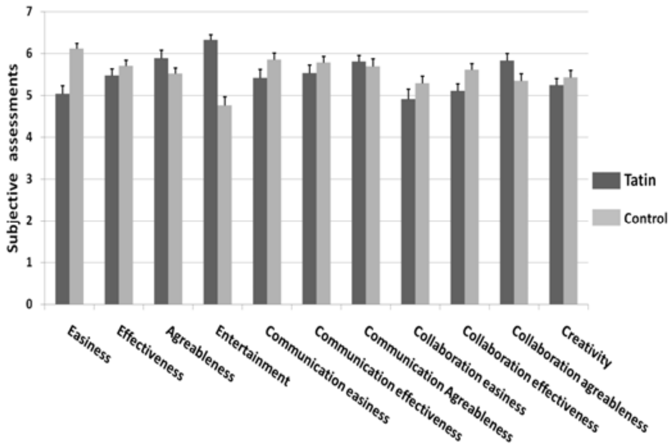

Figure 5: Averages and standard errors of subjective assessments

When the criteria are evaluated by averaging the results from the Likert scale of the questionnaire, the criterion with the greatest difference between the control and the TATIN condition is playfulness. This difference in playfulness strongly favors the tactile experience ($\bar{X}_{TATIN} = 6.33$ vs. $\bar{X}_{Control} = 4.77$; $t(47) = 6.67$, $p < 0.001$).

The feedback from the questionnaires highlight the attractiveness of the new technology, particularly the features that facilitate the process of brainstorming: the option of adding images, the simulated physics of the digital Post-its experienced when sliding them to others, circling Post-its with a finger to create groups of Post-its for categories.

We observe a slightly higher motivation for the TATIN condition then the control condition ($\bar{X}_{TATIN} = 5.80$ vs. $\bar{X}_{Control} = 5.38$; $(47) = 5.6$, $p < 0.001$) but when evaluated qualitatively, using the written comments of the users who attest for the motivational impact of the table, the difference becomes more apparent. Indeed, the interactions allowed by the table facilitate brainstorming sessions by reinforcing the desire to accomplish the task properly.

The willingness of users to employ the functionality of the TATIN table, coupled with the playful user experience offered, makes collaboration more enjoyable ($\bar{X}_{TATIN} = 5.83$ vs. $\bar{X}_{Control} = 5.35$; $(47) = 2.23$, $p = 0.03$) and creates a stronger rapport among team members by encouraging a higher number of verbal and digital exchanges.

The observed ease of use during the sessions with TATIN proved worse than the ease of use during the control condition (($\bar{X}_{TATIN} = 5.04$ vs. $\bar{X}_{Control} = 6.13$; $t(46) = 4.50$, $p < 0.001$). The efficiency of the collaboration was likewise judged to be worse in the TATIN condition (($\bar{X}_{TATIN} = 5.11$ vs. $\bar{X}_{Control} = 5.62$; $t(46) = 2.19$, $p = 0.034$). Certain elements may explain this condition:

- The amount of time we allowed the users to interact with the table before the beginning of the experiment was likely far too short to overcome the learning curve of the interactive tabletop. We believe that, with a longer initial training period, the users would feel more comfortable in interacting with the device.
- Entering text using the table's virtual keyboard is fundamentally slower and more labor intensive than a pen and Post-it note.
- During our sessions with the interactive table, users witnessed several bugs in the software. Some bugs were more trivial than others, but all degraded the usability of the table and the quality of the experience. Given the high number of comments made about these defects in the free response section of the questionnaires, the hypothesis can be made that the ease of use of the table would have been significantly increased had we developed more stable software for the experiments.

The final question of the questionnaire ("What could we do to improve the table and to increase its chances of being adopted in the future?") frequently solicited responses concerning the physical dimensions of the table and the development of other types of software (CAD, casual gaming, etc).

We can combine and compare our results with those of the experiments that were conducted on the DigiTable project [BB1]. Like the experiments presented in this paper, the DigiTable experiments also observed simulated creativity and brainstorming sessions on an interactive table compared against a control group. The two experiments also contrast; the DigiTable's experiments utilize an interactive capacitive surface (only one point of contact allowed per user) of 42 inches with groups of four compared to the TATIN's experiments that utilized an interactive LLP tabletop (several points of contact allowed per user) of 83 inches with groups of six. Moreover, the control group for project DigiTable was conducted with the user around a paperboard with one participant in the role of meeting organizer.

The first observation we make on the comparison between the two projects is that the results from the questionnaires are similar. For each of the criteria, it is often the same conditions which are ranked higher, whether they come from the TATIN questionnaire or the DigiTable questionnaire, and often at similar proportions. The results of our work thus confirm the subjective assessment of project DigiTable's creative sessions conducted both in the interactive table condition and control condition.

Next, we find that the overall satisfaction is higher on average for TATIN's efficiency ($F(1/76) = 6.39$, $p = 0.014$) and agreeableness ($F(1/76) = 4.61$, $p = 0.035$). We can hypothesize that TATIN's large workspace surface and the fact that it allows a greater number of participants to work together offers more comfort to users, a clearer view of team members and a more suitable distance for communication to improve working conditions when compared to DigiTable.

Our future work will focus on the analysis of videos which will allow us to understand the collaborative behavior and creativity of groups in TATIN, so that we may compare them to those of the DigiTable project.

6- Conclusion and Future works

As part of our research committed to improving the process of collaborative design, project TATIN considers the benefits of interactive devices such as extra large multi-touch tabletops. As there were no options available on the market, we were required to design and construct a table ourselves. This table enabled us to conduct experiments and compare the traditional method of preliminary design against interactive tabletop preliminary design.

Our first analyses of the data from the experiments show the interactive multi-touch tabletop has a positive impact on the motivation and satisfaction of the users. The users appreciate the features that the software BrainTouch brings to the brainstorming sessions. The extra-large size of the table also plays a role in the agreeableness of the brainstorming sessions.

Further analyses of the video and audio from the experiments will further confirm or repudiate the interest of an extra-large multi-touch interactive table for CSCW and preliminary design. Moreover, the data from the video will allow us to modify the current design and implementation of the table for the better. Indeed, we have already begun to formulate hypotheses from the results of the experiments to augment the collaboration around the table, for example lowering the height of the table, or adjusting the sensitivity of the surface. The data from the videos will also enable us to model collaboration of groups in preliminary design. With a working model of group interactions, we plan to incorporate additional input modalities (gesture / voice) and intelligent agents to facilitate the retrieval of data or to perform user identification.

Further work must ameliorate the gesture-based interaction and interoperability of the software. In the context of tools used by teams for design projects, we will investigate advanced interaction techniques for CAD applications that will overcome the design challenges of multiple users interacting with the same screen. Another area of interest is collaboration at a distance using two interactive tables.

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