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Strategy, Ownership and Space: The Logistics of Collaborative Interaction

Robert Porzel[1], Adeel Naveed[1], Yuting Chen[1] and Marc Herrlich[1]

Digital Media Group, University of Bremen[1]

Abstract

Enabling collaborative work on multi-touch tables comes with many challenges for the design of tabletop systems. For example, multi-touch tables have been not standardized, tabletop groupware systems are built for various purposes and the diversity of task activities constitute some of the challenges for enabling natural collaborative human computer interaction on multi-touch tables. While many studies have been conducted on individual problems, aggregate guidelines for designing an appropriate tabletop groupware system that can adapt to variable conditions are still under construction. In this paper we contribute some insights toward more general guidelines via an empirical study that sought to untangle the interrelated effects of ownership, individual collaborative strategies and workspace usage.

1 Introduction

When users are collaborating on multi-touch tabletop systems they can adopt different strategies for approaching the task at hand. They also have to find ways of dealing with the ownership of visible objects to be manipulated as well as having to settle on usages of the space provided by the interactive surface. It seems unlikely that these decisions are absolute. Therefore, it is viable to postulate the hypothesis that these decisions are interdependent. In the experimental study described below we seek to find more concrete evidences concerning these interdependencies. For this we took ownership rules as our independent variable and observed the ensuing effects on the adopted strategies and the utilization of space.

In our experiment four users were given that task of solving four jigsaws – each representing a picture cut up into nine puzzles that were randomly mixed and evenly distributed. The assembly was performed under three different constraints:

a) “take-only” where users were only allowed to take pieces from others,

b) “give-only” where users were only allowed to give pieces to others,

c) “free-way” where users were allowed to give and take pieces.

We will present the outcome of this study and the corresponding results of these constraints following a short glimpse at the pertinent state of the art.

2 Related Work

Collaborative scenarios seem to be a natural match for large displays and interactive surfaces such as big multi-touch screens or tables because of the sheer amount of screen estate they offer. However, besides featuring a large interaction area, only a few hardware devices directly support collaborative work and applications. One notable example is the well-known DiamondTouch table that is able to map touches to actual users or seats (Dietz and Leigh 2001). Other approaches employ additional cameras (Ramakers et al. 2012) or special sensors (Walther-Franks et al. 2008) to enable user distinction on multi-touch devices based on optical tracking. For a comprehensive overview of multi-touch detection techniques and the practicalities of touch detection we refer the reader to the works of Schoening et al. (2008) and Teichert et al. (2010).

Researchers have investigated different evaluation methods for collaborative work and groupware systems (Herskovic et al. 2007). In our study we concentrated on two main aspects of collaborations mechanics as described by the Collaboration Usability Analysis method (Pinelle, Gutwin & Greenberg 2003): shared access and transfer of objects. While researchers already investigated different aspects of collaborative behavior, e.g., how users divide and utilize the available workspace (Kruger et al. 2003; Scott et al. 2004; Yamashita et al. 2008; Tang et al. 2010), what kinds of collaborative strategies they employ (Ryall et al. 2004; Preguiça et al. 2005; Mendoza et al. 2005; Herrlich et al. 2011) or how transfer of ownership of objects is carried out (Staahl et al. 2002; Scott et al. 2003), it is still not fully understood how these aspects influence each other. This work is a first step towards filling this gap.

3 Experimental Approach

In our experiment users were told to complete a jigsaw from the nine puzzles located in front of them. They were also told that once they join two pieces that they will not be able to separate them again and that they faced a collaborative work task and can only win when all pictures are successfully completed. Additionally, individual groups of collaborators had to work under given constraints – either give-only, take-only or free-way as described above.

In total 32 users have participated in our experiment creating eight groups with four randomly selected participants each. More than 77% of the users have used multi-touch applications before on different gadgets and smart phones. The users' interaction was recorded by a camera mounted above the multi-touch table.

4 Results

A tabletop workspace can be divided into nine partitions: four private spaces in front of the users, a middle space at the center and four corner spaces (Scott et al. 2004). We have, therefore, counted the number of puzzles placed at the corner-, middle- and front spaces of tabletop, which showed the familiar result that show that users on the shorter sides of the table frequently used also the corners of the tabletop as a private space whereas users on longer side of the table worked almost exclusively in their front spaces. In our task, however, spaces were not only used for private assembly of pieces, but also for collaborative work.

In Table 1, given below, we have manually counted the number of times a specific tabletop area is utilized for private or group work.

Zones	Group	Private	Private	Private	Private	Private
Areas	Middle	Front	Top-left	Top-right	Bottom-left	Bottom-right
Give-only	7	39	4	6	3	5
Take-only	3	44	4	5	2	2
Free-way	22	26	4	1	1	2
Total	32	109	12	12	6	9

Table 1: Constraint-dependent **space utilization for private and group work**

This shows that the ownership constraints imposed on the users affect the tabletop areas utilization. In constrained sessions, front and corner spaces are mostly utilized for private work. In the free-way condition, there is an increase in the utilization of the middle space as for group work. To double check these findings, we performed an optical flow analysis, which showed frequent usage of different tabletop areas. Five regions were defined in every video for data collection. These regions provided us with motion detection information across time. An unpaired t-test confirmed that the middle part of the table is utilized more than corners depending on the existence of constraints versus unconstrained ($p=0.0038$) and during unconstrained sessions, corners are more utilized when compared to constrained sessions ($p=0.0030$).

Lastly, we have observed three different problem solving strategies:

a) individual - all group members work independently on available puzzles;

b) group - all group members work together to solve the puzzles;

c) hybrid - including both individual and group strategy i.e. in the beginning all users work individually; a user with a finished tasks starts helping the other group members.

We correlated a corresponding annotation of strategies with the three ownership constraints and with overall task accomplishment rates. The task completion rate decreases from almost 100% to 41% when groups opt for an individual strategy. Our results also show that the give-only and take-only constraints have a clear impact on strategy selection as shown in Figure 1.

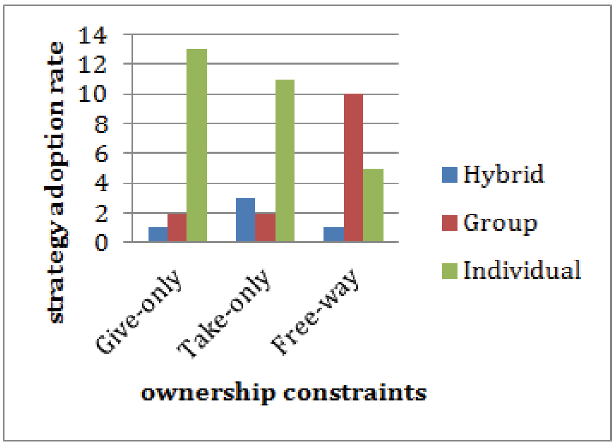

Figure 1: Strategy adoption within three constraints

5 Conclusion

The work described herein shows that ownership rules – as imposed in our study – have a profound effect on the collaborative strategies employed by the individual groups. This, in turn, affects not only efficiency but also has ramifications for the employment of the interactive surface for different kinds of utilization. In general, we see that designers of surface computing applications could either foster or inhibit collaborate work by imposing different types of ownership constraints. As a consequence they may adopt their applications to anticipate the ensuing differences in area utilization.

In terms of future work several further questions arise from the findings presented above. Firstly, our study employed a specific task where each participant faced the same challenge as all the others. Nevertheless, there are collaborative tasks which are more heterogeneous and even ones that are hierarchically dependent. Therefore, it is necessary to test if the same interdependencies between ownership, space and strategies can be observed in such cases. Lastly, our findings give rise to the hypothesis that user-experience and usability of collaborative multi-user applications should improve when the design of the application follows the general principles outlined above. This, however, needs to be vindicated by contrasting applications where spatial configurations are aligned with ownership constrains and ones where they are not.

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