Collective Interaction – Let's join forces

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Abstract. In this paper we introduce the concept of Collective Interaction. Collective Interaction involves designing for co-experiences among co-located people sharing collective resources for controlling interfaces. The particular approach we explore in this paper is to instrumentalize collaboration, such that the interaction itself is a matter of collective action. To illustrate this we provide an interaction model and a definition of Collective Interaction, and present two design cases based on this model, one in the context of a public library and one in a home-context. We outline design rationales, and discuss experiences from trial use of the prototypes.

Keywords: Collective interaction, interaction design, interaction model, social computing, co-located users, co-experience

1 Motivation

Collective interaction happens often in everyday life, e.g. when two people coordinate their actions to carry a heavy object together, or when, for safety reasons, it is required that at there are two people working together, when dealing with nuclear explosives.

However, few interactive systems are designed to support collective interaction, in the sense we propose it here. Collective Interaction is a matter of instrumentalizing collaboration such that the actual, physical interaction with one application involves co-located cooperation. Apart from the obvious seriousness in safety systems Collective Interaction potentially exhibits playful aspects that facilitate communication among co-located people beyond what can be experienced in game-like environments. Collective Interaction takes departure in users negotiating a shared goal for the interaction and sharing the interaction mechanisms for achieving the goal. Collective Interaction does not imply an ideal of efficiency, but rather an ideal of extended sociality beyond the actual interactive system, sociality by the system rather than through the system.

In line with the work presented here Hindmarsh [5] also identifies the potential in designing to encourage interaction between people as a largely overlooked issue in current interactive systems. To further explore the qualities of this type of interaction,

we have developed the interaction model of Collective Interaction and designed a set of prototypes based on this model in the domains of libraries and homes. Based on our experiences with the prototypes we suggest that the interaction model can be a vehicle and a path into designing for playful activities in domains beyond gaming. We start out by presenting the model of Collective Interaction, building upon an earlier interaction model for shared group displays [**16**], but depicting a closer collaboration model than this model depicts. Our focus on instrumentalizing collaboration is well in line with an emerging interest in shared and co-created user experience, and in the following section we position our work in this landscape as well as a sparse set of emerging Collective Interaction design concepts, and we discuss related concepts Next we describe two cases of designing for the proposed interaction model. We outline their design rationales, discuss and reflect upon use experiences from their applications in real life contexts. Based on this we identify a set of design sensibilities to consider when designing Collective Interaction environments. Finally, we discuss future work.

2 Collective Interaction

We define Collective Interaction in the following way:

Collective interaction is when users actively coordinate their actions towards a shared goal; Collective interaction instrumentalizes collaboration such that the interaction itself is a matter of collective action. Collective Interaction requires more than one user for controlling and taking full advantage of the system.

In terms of input and output devices, Collective Interaction is when multiple and colocated users share both one logical input channel and one logical output channel. The input channel may consist of a number of interaction instruments, which are logically coupled in the interaction.

The purpose of a collective interaction system is to compel people to negotiate a shared goal. The actual use of the system can either be to achieve the goal or tease one another by working against and prohibiting the achievement of the goal.

Single display groupware (SDG) [16], has been proposed as an interaction model for shared displays, focusing on designing to support collaborative work among co-located people. In the SDG model, each user has a separate input channel, and all users share an output channel, as illustrated in figure 1. Stewart et al. [ibid], define input and output channels as channels that provide logically independent input to the computer and output to the users. They focus on keyboard and mouse in combination as one logical input device and output in the form of a display. In SDGs, users may independently provide input to a system, whereas in our model of Collective Interaction, we propose a closer collaboration model than the SDG depicts. SDG's and Collective Interaction can be seen as two strands within the overarching concept of Sharable Interfaces [15]. Collective Interaction, as defined here is when users share not only the output channel but also the input channel.

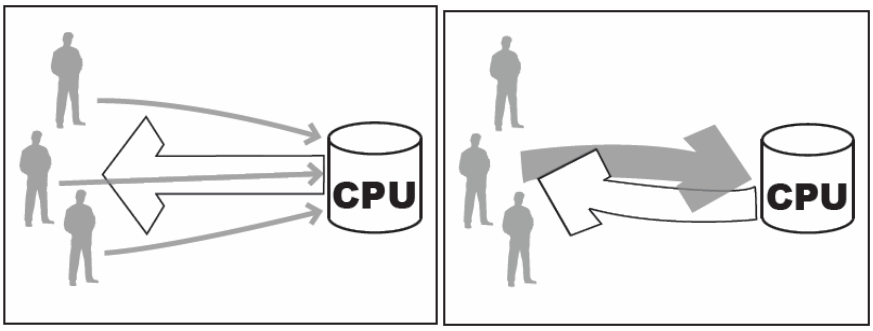

Fig. 1:
Single Display Groupware interaction model [16] Co-located people have each their independent input channel and share one logical output channel.

Collective User Interface model: Co-located people share one logical input channel and one logical output channel

We can further draw upon Bardram's use of activity theory [1] to illustrate the difference between the SDG interaction model and the Collective Interaction model. Based on activity theory Bardram [ibid] identifies a three level hierarchical structure of a collaborative activity and uses these levels to distinguish between different forms of distributed collaboration in work situations. The three levels are co-ordinated, co-operative, and co-constructive levels of activity.

Co-ordinated activity is when "Individuals are gathered together to act upon a common object, but their individual actions are only externally related to each other. They still act as if separate individuals, each according to his individual task." [Engeström, 1987; p. 333 according to Bardram [ibid, p. 29]])

Co-operation is a mode of interaction in which the actors focus on a common object and thus share the objective of the collective activity, instead of each focusing on performing their assigned actions and roles. "The important difference between coordinated and cooperative work is the common objective, which enables the participants in the distributed activity to relate to each other and make corrective adjustment to own and other's actions according to the overall objective of the collective activity" [ibid, p. 30].

The third level is co-constructive activity. This kind of collaborate activity is more radical, and rare in the daily flow of work-activities. It implies re-conceptualizing both organization and interaction in relation to people's shared objects.

For our purpose here, we apply Bardram's level of cooperation to denote the collective action around the shared objective. We are not suggesting, that there is a one-to-one correspondence between level of collaboration and interaction model. Level of collaboration can only be studied in concrete situations, and in the case where people for the first time selects and experimentally adopts a system based on the Collective Interaction model, they may be collaborating on a co-constructive level. However, we do suggest that inherently, the SDG interaction model lends itself towards coordinated activity, where people have different foci and different goals, where as the Collective Interaction model necessarily implies the negotiation of a shared goal, as the interaction itself involves negotiating the physical actions of

different people. This is exemplified in recent research on SDG's, which has investigated means for avoiding interference between users of SDG's [19]. In contrast, the intention behind the Collective Interaction model proposed here is to establish means for bringing people together and to let them establish common goals and engage in playful activities, which necessarily involve interfering with one another.

To sum up the key characteristics of Collective Interaction:

1. The interaction itself invites for human-human interaction beyond what is in the interface – potentially deviating discussions from what is displayed
2. The spatial organisation of people induces expectations of use
3. A shared goal is established on the basis of sharing responsibility and negotiating control of interaction
4. Establishing shared goal through negotiation is essential both in order to achieve the goal and in order to challenge it through e.g. teasing other participants.
5. The interaction may be asymmetrical, in the sense that people take on different roles, but the efforts of all participants are accounted for and valued in the use of the system.

Obviously the application of Collective Interaction has its limitations, and as we discuss later, there are both advantages and disadvantages to such a model.

3 Related work

In the following, we outline how our work is a design oriented approach to shaping experience in co-located social contexts, and how this is well in line with a demand for looking into social experiences, which has been raised in the experience design area.

Forlizzi and Battarbee have proposed co-experience partly as a criticism of the highly individualistic approach to experience design [5]. They offer a framework for understanding different types of experiences in relation to the design of interactive systems. In their framework, co-experience is one type of experience, namely user experience in social contexts [ibid]. Forlizzi and Battarbee [5] argue that interactive technology can play an important role in supporting co-experience. We sympathize with the criticism raised by Forlizzi and Battarbee [ibid], and where they focus mainly on how technologies per se can support co-experiences, our interest is to investigate how we can design technologies that invite co-experience by their design. Our thesis is that Collective Interaction is one means among others in this direction.

Ludvigsen [10] also introduces a framework of interaction in social situations. He suggests this framework as providing a scale of engagement ranging from at the lowest level 'distributed attention' where the only thing shared is the presence in the space, virtual or physical. 'Shared focus' is where the situation develops a single focus shared among its participants. 'Dialogue' in turn is where people invest themselves and their opinions in a dialogue visible to all participants. Finally, 'collective action' is the socially most engaging interaction. This is where participants

are working collaboratively towards a shared goal. Ludvigsen [ibid] argues that such collective experiences are often remarkable experiences, which stand out and are remembered. In line with Forlizzi and Battarbee [5], Ludvigsen [10] makes no distinction between collocated social experiences and social experiences that are mediated by digital or virtual spaces. In our research we focus on co-located users and we find the frameworks operational in qualifying the type of experiences we aim to design for, namely co-experiences [5] or in Ludvigsen's terms collective actions [10]. But notably we do this through focusing on designing for such experiences in co-located situations.

Efforts around Computer Supported Cooperative Play (CSCP) [2] [8] [20] share with our work the interest in supporting cooperative, and playful activities. However, much of this research focuses on collaboration in virtual environments [2] [20] and not on supporting play among physically co-located users. However, the PingPongPlus game [8] is an interesting example of cooperative interaction. Ishii et al. [ibid] made a table for table tennis reactive using microphones, making it possible to display graphic patterns on the table in response to the balls trajectory and contact points. Here the logical input channel consists of the collection of microphones added to the table and the output channel consists of a video projector displaying the patterns onto the table. In our research, we complement this work through focusing on how more playful activities and co-experiences can be made part of other areas than classic sport activities.

There are potentially further examples of cooperative interaction in the area of Smart toys. E.g. Zowie Playsets consist of a physical toy with movable pieces which are connected to a PC [6]. Again this example is in classic play activities and the mission of this paper is to complement this research through broadening the domain in which co-experiences can be supported by technology design.

An example close to one of our examples is Strömberg et al [18] who designed Nautilus which is an interactive group game where groups of 3-6 players act as the crew of a diving bell who are send on a mission to rescue a dolphin. The players stand together in front of a wall display depicting the underwater world. The players control the diving bell with their combined body movements on the floor. E.g. when the crowd moves to the sides, the diving bell turns to the sides. Moving back and forth results in slowing or speeding up. The floor is augmented with pressure sensors to track their movements. The players can, by means of camera detection, raise the bell through rapid up and down arm movements. The more they all wave their arms, the faster the bell rise.

In the physical world, we have a number of examples of Cooperative Interaction. In its simplest, physical form Cooperative Interaction can be found in e.g. the seesaw at children's' playgrounds. Participants establish level of agreement in terms of how rough the game is to be played, but knowing the impact of and from the system on ones own body also gives the opportunity to tease the other e.g. by leaning backwards and while down causing the other to "sit and dry" up in the air; teasing in this case is challenging the idea of a shared goal. Interaction is negotiated and encouraged by the participants. In this way, working with or against one another, the seesaw becomes a tool to understand and practice collaboration; collaboration is instrumentalized.

In an architectural perspective, the above examples resembles with some of the work in [12], where streets and plazas are used to identify to types of use and orientation in terms of designing interactive floors, where streets provide the basis of uniform direction of attention, plazas creates a cross-field for meeting and greeting. Tabletops as interactive surfaces, which has been explored in e.g. [16][13] do much the same as plazas, in that they create a place where we people can group around and thereby it facilitates human-human communication without loosing sight of the interface.

4 Design cases

In the following, we present two selected concepts from our research projects to illustrate and investigate the model of Collective Interaction more in depth. Both concepts include concrete examples of how collaboration is instrumentalized.

4.1 iFloor

iFloor is an interactive floor designed for a public library setting in order to pursue a richer social environment that facilitates visitors in contacting other visitors in the library. Interviews with library visitors and librarians suggest that recently, the social space in the physical library has taken a turn towards a supermarket-like atmosphere largely as a result of serving the individual user rather than providing a space for social gatherings, activities and public awareness [7]. Encouraged by these findings we chose to design an installation that can counteract this trend and promote a change in conception of the library in the pursuit of a richer social environment that facilitates users in contacting one another and raise awareness that apart from librarians other library visitors can be knowledge resources too.

According to this we use the floor as display surface in order to make it as generally accessible and sharable as possible and pursued an interaction model that is inadequate for single use and encourages contact with other co-located visitors and the involvement of several people in interacting with the installation.

The design response is an interactive Q/A floor (figure 2), the iFloor [7]. intending to bring visitors in the library together and spurring conversation and fruitful happenstance encounters. The Q/A's are pushed to the floor using individual mobile phones or email clients, and are displayed in the floor interface in an extending circular pattern pivoting on the center of the display to avoid creating a privileged view-point and rather making any viewing direction possible (see figure 2). For interacting with the floor and navigating between the various messages send to the floor visitors collectively move *one cursor*. In order to hit an area of interest on the floor, people need to coordinate their body movements around the floor.

When the prototype is attempted to be operated by a single user, the cursor is attracted to the rim of the display and thereby give no chance for exploring the whole

interface, whereas if two or more persons are collaborating on moving the shared cursor the different direction and strength in attracting forces is calculated into a middle-value allowing the whole interface to be explored. Tiny graphic strings in the interface connect the people's position at the rim of the display and the cursor providing a clue of connection and control. As the cursor roll over Q/A's in the interface, the messages enlarge and comments to questions are revealed along with a tool-tip box informing people how to ask and respond to questions. On the basis of this people negotiate where to move in order to move the cursor to a shared goal.

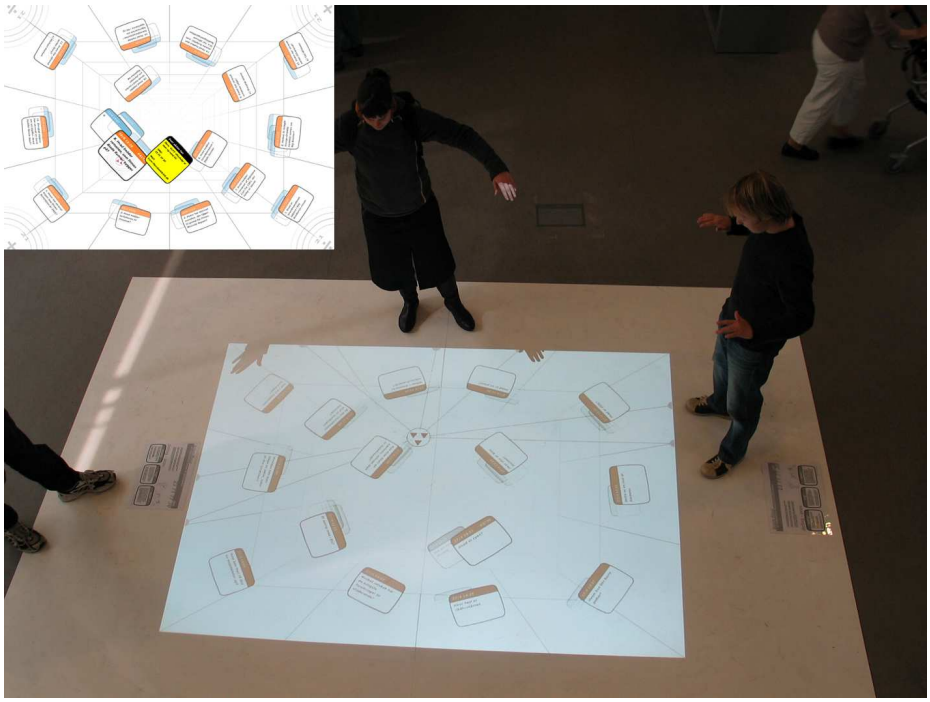

Fig. 2: iFloor in use in a library context

The floor was installed over a three-week period in a public library setting. In the qualitative evaluation of the prototype [7], we found that the iFloor promoted a sort of "step stone wonder and learn process" as follows: the interface of the floor would react as soon as someone entered the tracking area surrounding the floor, the movement of the cursor would attract peoples attention causing one to stop and start exploring what it might be. With one person using the floor, others were attracted and soon discussions started to evolve around what the installation might be for and how it could be controlled. Furthermore the floor display and the organization of people around the display supported quick and easy shifts between human-computer-interaction and human-human interaction as one could gaze to acknowledge and chat with participants without loosing contact and view of the interface in the periphery.

The prototype combines the interaction model of SDG in terms of how the content is send to the floor, namely by using individual input channels in relation (mobile

phones and email clients) to a shared output channel whereas the instrumentalization of collaboration is apparent in the interaction with the content displayed on the floor and how it is navigated by the use of one shared cursor.

4.2 Squeeze

The motivation behind Squeeze is to create playful means of constructing and experiencing the history of a home. Squeeze consists of a house-camera and an oversized and interactive sack chair (figure 3), which is a site for collective and playful exploration of the history of the home as captured through the pictures taken with the house camera. An image captured by the house camera is automatically put on display on a wall close to the 'chair'. When people sit/hang out/mock about in the furniture, the pictures can be explored in different ways. As explained in the following, the Collective Interaction model has guided the interaction design.

First the whole furniture reacts on deformation through displaying more pictures at a time, as e.g. in figure 3 where 4 pictures are displayed at a time. The more activity on different places of the furniture, the more pictures are displayed. This is enabled by Piezo electric cable, which is wrapped around the furniture. The means of moving back and forth in time consists of two active zones positioned in each their end of the 6-meter long, and malleable furniture. Thus to navigate the pictures, the participating people need to negotiate the navigation between them, potentially verbally but also to manifest it in their collective interaction with the furniture. Moreover, also in each end of the furniture, another active zone allows users to stretch and rotate the pictures through squeezing the furniture. Through distributing the controls over the larger-than-one-person surface of the furniture, users need to cooperate in the detailed physical interaction with the pictures.

Squeeze has been put on trial use in two families. The focus of the evaluation was to observe how the key characteristics of Collective Interaction might play out in the immediate use. Making the whole furniture sensitive to activity and thus to showing more pictures at a time invited, in particular the children (between 2 and 9), to act actively and cooperatively towards this shared goal. The families shifted a lot between interacting to get new and more pictures put on display and storytelling and pointing engaging with the contents of the pictures and notably each other. Due to the flexible nature of the furniture it was easy to shift positions and to face both the contents on the wall and other family members.

In general the families were intrigued by the active and embodied interaction with the pictures provided by the prototype, and they certainly engaged in playing around with it. At times, the means for navigating back and forth, stretching and rotating did not work very successful. This happened in particular when users were uncertain about who contributed to the effect seen. Some times this was ok, but at other times it was frustrating. At this stage we hypothesize that it would have been easier to establish the kind of playful aspect, if the effect of the individual's interaction would be clear to all participants and thus easier to cooperate and negotiate on.

Fig. 3. The ‘chair’ and displays of pictures on the wall.

The Squeeze prototype combines the interaction model of SDG in terms of how pictures are taken in the home, namely by using an individual input channel (the in-house camera) in relation to a shared output channel whereas the instrumentalization of collaboration is apparent in the interaction with the sack-chair manipulating the images displayed on the wall.

5 Discussions and reflections

The possibilities to embed sensor and actuator technologies in the physical environment and in this way design interactive spaces and furniture, open up for new challenges and possibilities to design for shared experiences among collocated people. It supports collective exploration of the materials instead of having co-experiences through in turn watching others being active, as depicted in [7]. iFloor and Squeeze both exemplifies how these large-scale interactive surfaces hold a rich potential for designing for collective interaction and co-experiences.

As the interaction model of shared input and output as well as the exemplar concepts suggest, there are both advantages and disadvantages associated with Collective Interaction. The advantage of Collective Interaction consists primarily of the potential in shaping co-experiences, and in bringing people together in new ways,

opening up for embracing more ludic opportunities and embedding these in everyday life [1]. Instead of offering an efficient way of exploring materials, the interaction model provides means of negotiating interests and supporting serendipitous and playful navigation. The disadvantage of this model of interaction is of course that it is potentially inefficient and imprecise.

Both of the prototypes presented in the above combines the interaction model of SDG for providing input to the system and Collective Interaction for navigating the content. In the Squeeze case the combination works well whereas the use of mobile phones for providing input in the iFloor case is regarded cumbersome. At this point we hypothesize that though the concepts involves users to shift between interaction models it is not the shifting that is the primary cause of breakdown, but merely we see it as an issue of designing a coherent level of accessibility and anticipated use efforts across the involved models. Where the iFloor prototype is immediately and effortlessly accessible for navigation, the Squeeze prototype demands intense physical activity. New content in Squeeze is simply produced by picking up the house-camera and capturing an image, whereas sending input to the iFloor causes the user to step out of the interaction loop around the floor and concentrate on punching in and sending a text message. Normally sending text messages is considered easy, but in combination and comparison with the effortless access to the floor it was experienced too cumbersome. This indicates that when designing interactive systems involving two or more interaction models the level of anticipated user efforts and accessibility in interaction should be considered carefully in a holistic view of the total system.

The presented concepts are in physical terms large interactive systems providing physical room for several participants. IT systems consciously designed for Collective Interaction take in spatial considerations as they facilitate several co-located people to interact simultaneously. Architecture is not primarily concerned with the individual user, but with how spaces and places facilitate collective use. Collective Interaction shares characteristics and qualities with architecture and interior design as these disciplines too provide frames and settings for people's social life; promotes and invites for various ways of being, playing and working together, as McCullough [11] writes: *"Architecture serves the body not just the gaze. It is not just perceived it is inhabited"*. Collective Interaction may potentially be a shared design subject between the traditions of human-computer interaction and architecture as it draws extensively on the design knowledge from both traditions. However more work is needed to determine the applicability of the interface model in larger contexts such as city plazas; what design challenges, constraints and possibilities will emerge if a range of Collective Interaction interfaces were deployed as the primary model of interaction for e.g. an exhibition?

Collective Interaction encourages people in establishing a shared goal of interaction. As indicated in the cases, cooperating on a shared goal also provide room for individuals to break the rules, teasing and preventing others from reaching the goal. However, both for teasing and collaboration, shared awareness of controls and what they do are criteria of success. The prototypes of iFloor and Squeeze encourage sharing responsibility, both on the level that any participant is needed, affects the system and in the sense that all should be willing to react upon request of others in terms of doing specific actions to achieve a shared goal or the goal defined by one of the participants; thus the systems instrumentalize interaction.

6 Conclusion

Provoked by current trends in technology development and grounded in design cases, we have pointed to the prospects of designing for social experiences amongst co-located people. We have coined a model of Collective Interaction to complement previous work and we have suggested this as a concrete vehicle in designing for social experiences, and we put this model in perspective with respect to experience frameworks and architecture.

Through providing examples of Collective Interaction concepts for the home and a library context we suggest that this model can encourage interaction design for social experiences in domains and situations that benefit from playful approaches. In particular the instrumentalization of cooperation show promises in learning environments such as schools and museums where collaboration and human-human interaction is required if not mandatory for accessing and understanding complex concepts consisting of intertwined entities reacting upon one another e.g. natural processes, historic events, political negotiations etc. Finally, we suggest that the discipline of architecture has much to offer, when designing for collective interaction and atmospheres for collaboration, as architecture provides a long tradition for spatially arranging and encouraging social settings.

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