Spatial Sharing
Designing Computational Artifacts as Architecture

Maiken Hillerup Fogtmann
Aarhus School of Architecture
Nørreport 20
8000 Aarhus C
+45 89360000
maikenhillerup.fogtmann@aarch.dk

Peter Gall Krogh
Aarhus School of Architecture
Nørreport 20
8000 Aarhus C
+45 89360000
peter.krogh@aarch.dk

Thomas Markussen
Aarhus School of Architecture
Nørreport 20
8000 Aarhus C
+45 89360000
thomas.markussen@aarch.dk

ABSTRACT
The paper presents an architectural approach to designing computational artifacts and interfaces. It does so by identifying overlapping ideals and characteristics in the interaction design concepts of Collective Interaction and Kinesthetic Empathy Interaction with schools of thought in architecture. The implications and qualities of the approach are elaborated upon through concrete examples of design following the lines of the approach. On the basis of this the overlooked potential of designing computational artifacts as architecture is described. The approach both serves as a generative approach to designing spatial interfaces and forms the ground for articulating a critique of spatial interfaces in general as it is the claim of the paper that spatiality as understood in architecture not has been served and taken advantage of in its totality by spatial interaction design so far.

Categories and Subject Descriptors
A.0 [GENERAL]: Conference Proceedings
H.5.2: User interfaces, User-centered design.

General Terms
Design, Human Factors, Theory.

Keywords
Interaction design, Social Computing, Collective Interaction, Kinesthetic Empathy Interaction

1. Introduction - the shared computer
Just as Weiser proposed in his paper: The Computer of the 21st Century from 1991 [32] the computer has woven itself into the fabric of everyday life. Ubiquitous computing is widespread and in many ways an integrated part of our daily lives. In most cases it no longer makes sense to talk about the PC, because the time when it was one person, one computer is gone. During the day we are connected to many different computers e.g. at work, in the bank, at home etc. However, they all exhibit a notion of being personal. On the basis of this, one can’t help wondering if we are missing something?

So far the interaction design community has primarily focused on making computers and interfaces oriented towards personal use anywhere, anytime and of almost anything. It is our claim that by this approach we overlook the many qualities of actual and engaged co-presence of people sharing physical artifacts and architectural spaces. Imagine for example a group of people playing a game of soccer. What would happen if we gave them each a ball, instead of one to share? The development in interface design may have happened because of what computers are particularly good at namely working in distributed networks, whereas people thrive (or ought to) when being co-located together. However, the world isn’t divided in that manner, computers are used both in distributed networked set-ups and when people are co-located together, although computers are still primarily designed as if they were personal devices connecting people in a networked world. A caricature of computer development is that we have gone from 100 people sharing 1 computer (the age of terminals and mainframe computers) to 1 person 100 computers (pervasive computing). However, as computers become embedded in almost everything including physical spaces that people already share they too need to develop according to the context of co-present sharing. In line with this we propose a way of looking at the design of computer qualities to be collectively shared as a ball in a soccer game. This means that the participants have to negotiate, fight, communicate and relate to one another in order to reach a common understanding of the use of artifact, space or environment.

As such the presented approach shares many concerns with concepts as Co-experience [1], Single Display Groupware [30], Sharable Interfaces [27] and Collective Interaction [14], with a strong emphasis on what we share with [14]. Both Collective interaction[14][23] and Kinesthetic Empathy Interaction [5][6] deals with sharing architectural space and the coordination of action towards a mutual goal among co-located users where the sociality is extended beyond the actual interactive system. The term Co-experience as coined by Batterbee et al. [1] is claimed to encompass the social aspect of experience with and through products and interfaces. However, in our opinion it does not fully consider the role of the other participants, their bodily relations and the environments in which the experience emerges. When taking account for the presence of more than one body in space, our attention is drawn to architecture, because architecture is always experienced in the scale of the body, and the basic premise of architecture is that several co-present people share it. Furthermore it is not only the actual concrete bodily sharing of the space but also the individual awareness of sharing a space with other people.

In this paper we argue for the overlooked potential for use derived from a design approach, which can be denoted as “designing computational artifacts as architecture”. We do this...
by describing and making a caricature of how the prevailing focus on personal interfaces of single user interaction falls short of creating relevant engaging spatial interfaces for co-located users. This leads us to a section describing the computer experienced as architecture in the scale of the single body and multiple bodies and how this informs the design of spatial interfaces. We illustrate this through a range of selected examples followed and concluded by a description of the approach.

2. Related work
Our claim is that an architectural understanding of the bodily experience and awareness of other people’s co-presence in space has been missing so far in interaction design research. Admittedly, both the body and user’s sharing of digitally augmented environments have been promoted as new key foci of interest by recent paradigms in HCI, but none of these paradigms appropriately covers what we have in mind. In order to make our case, we will do two things. First we will critically examine dominant paradigms in interaction design. In doing so, we will be able to identify the shortcomings inherent in the current understanding regarding the body and its potential role in collective interaction. Secondly, we will look toward architectural theory for notions of space that more adequately accounts for our research scope. One of the central insights revealed by this paper is that architectural theory offers two valuable notions of space. By combining these two notions we are able better to understand how bodily awareness and experiences can serve as a resource for designing collective interaction.

2.1 Interface design paradigms
In line with [4] we claim that the designed artifact conveys the designer’s image of the user. Being inspired by the caricature of the GUI user [10] [33] and taking this approach further one could talk about how the computer, in various HCI paradigms sees its user; what is the user capable of and how he or she might interact with the computer as imagined by the designer. Taking this to the extreme the following caricatures (figure 1) of the computers vision of the user emerges. The caricatures serve the purpose of highlighting the focus of the designer and the neglected real world qualities overlooked by most designers of computational artifacts. The caricatures are not a rating of “best and worst”, but a perspective on the designer’s mental model of the user in the various approaches. However, the caricatures highlight a critique of the prevailing perspective of personal interfaces.

The development of bit-mapping display technologies revolutionized human-computer interaction, as it made the Graphical User Interface (GUI) possible which allowed not just expert, but also ordinary people to use PCs. Despite its massive success the designer’s image of the user behind GUI has rightly been criticized for restricting interaction with computers to “seeing and pointing” on graphical icons on a screen (Figure 1, a). With the advent of new computational techniques in the 1990s interaction designers have found an opportunity to design for more richly sensuous and engaging forms of interaction, often summarized in the commonly declared goal of making a move “beyond the GUI model and WIMP-interfaces”.

Mobile computing is considered to be such a move and has been heralded for miniaturizing the personal computer on people’s desktop into a portable device that they can bring along with them in daily life. In so doing, mobile computing no doubt extended the GUI image of the user (Figure 1, b). Nonetheless, basically mobile computing amounts to nothing more than the GUI model on two feet. The offspring of mobile computing such as the Palm Pilot, Treo, and other similar handheld devices were shaped in the “seeing and pointing” image. Furthermore, like the desktop computer, mobile computers are primary designed for single users, while its potential for Collective Interaction is at a minimum.

Arguably, a more decisive change occurred along with Tangible User Interfaces (TUI), a new paradigm in the late 1990s that were introduced by Ishii & Ulmer (1997). Criticizing the GUI model for its ‘painted bits’ that allow only the visual sense to steep into digital information, while “the body remains in the physical world”, Ishii and Ulmer aimed at giving “physical form to digital information, making bits directly manipulable and perceptible.” Hence, a transformation from painted to ‘tangible bits’.

TUI set up two closely related HCI design principles. First, tangible bits “allow users to ‘grasp and manipulate’ bits in the center of user’s attention by coupling the bits with everyday physical object.” As a paramount example of this principle, Ishii & Ullmer mention the metaDESK. Basically, the metaDESK is built up by physically instantiating fragmented GUI elements into physical objects. For instance, there is the arm-mounted activeLENS display, which functions as a physically embodied window, material models and object on the desk act as physical icons (phicons) that can be manipulated and relocated, and so on (Ishii & Ullmer, 1997, pp. 237-8). However, in the end metaDESK seems just to replace “seeing an pointing” with two-handed manipulation as the most privileged form of interaction (Figure 1, c). It looks upon the hands as control units for information processing rather than as part of a felt experience. Furthermore, the emphasis is on foreground interaction, the center of a single user’s attention.

Figure 1: Caricatures of the five dominant paradigms in HCI
and what (s)he is focusing on, not on how a felt awareness of a shared space may influence the interaction.

These aspects seem however to be covered by the second design principle that was introduced by the TUI model. Thus, according to Ishii and Ullmer (1997, p. 234), tangible bits also pointed towards designing interactive systems that “enable users to be aware of background bits at the periphery of human perception using ambient display media.” For Ishii and Ullmer this background interaction consists in users marginally perceiving information from ambient sources, for instance air, light, sound, water flow. In order to convey this information at the periphery of user perception designers are encouraged to use the computer as a medium as is demonstrated by the ambientROOM (Figure 1, d). The ambientROOM is a free-standing office room which is augmented with MIDI-controllable interfaces. In an early stage of the ambientROOM, Ishii and Ullmer’s team designed phicons that could be moved into the proximity of an audible display thereby conveying ambient information of web-page activity. In this way they suggest that a company owner could use the phicons to have the sound of heavy rain indicating how many netizens were visiting his company’s website (Ishii & Ullmer, 1997, p. 239). Along with the critique of the ambientROOM we include the insufficient ideas of spatiality as exhibited in VR installations such as VR cubes [26]. Holo-benches and Panorama. Although interaction and sharing happens in a spatial configuration, the projections are all optimized for only one privileged set of shutter-glasses. This means that all participants will have a slightly different perspective on the projected image, which by no means can be compared to how different perspectives of real world objects work. When someone in the physical world is standing opposite you, you will by means of kinaesthetic empathy expect that he or she is looking at the opposite side of an object. However, in VR installations all participants will only experience a slight offset of the projected image different from that of the person with the optimized glasses. This makes physical pointing at digitally projected objects almost completely impossible.

In contrast to the TUI model, we argue that it is not so much information as it is the interpersonal relationships between people sharing a space with their bodies that is important for designing Collective Interaction. In line with the insights raised by Djadjiningrat et al. [2] we claim that the design driver behind TUI is biased by an information-centric perspective and that it needs to be balanced with a perceptual-motor based design approach; hence our emphasis on coupling Collective Interaction with Kinesthetic Empathy Interaction in our pursuit of a fifth paradigm (Figure 1, e) that sees the computer as architecture. Not in the sense of spatial interfaces that can be individually configured but instead as shared space. None of the characterized design paradigms embraces the notion of spatial sharing. In the following section we look toward architectural theory to find thoughts and ideas that can inspire such a fifth paradigm.

2.2 Notions of architectural space

Ever since Vitruvius, the body has served as a key conceptual category for understanding the experiential dimensions and qualities of architectural space. Our claim is that an architectural notion of bodies in space has much to offer the design of collective interaction in pervasive environments. It seems therefore relevant to ask where, in architectural theory, we are able to find such a notion. Modern architectural theory can be roughly divided according to two conceptions of space grounded in the body. While the first school of thought takes it point of departure from the individual body, the second school conceives of the body as a starting point for collective and social experiences.

Among some of the proponents of the first conception, we find Norberg-Schulz [20], Rasmussen [25], and Pallasmaa [9][24]. What these authors share – despite their many divergent beliefs and theoretical assumptions – is an interest in uncovering how a look toward qualitative aspects of subjective experience is able to enrich the design of architectural space (In contrast to Vitruvius who conceived the body as a system for deriving quantitative proportions for spatial elements in architecture such as columns, arches, etc. For instance, by drawing on phenomenology, Pallasmaa develops a nuanced view of how architecture ought to be designed in order to engage richer bodily and sensuous experiences. More specifically, he presents a framework for designing tactile, auditory, and olfactory dimensions, apart from visual form alone.

Yet, in so doing, Pallamaa seems not to grasp the full range of phenomenological insights. An adequate notion of space comes not from separating the senses, but rather from realizing that they work interdependently of each other to form coherent meaningful experiences. Moreover, as Merleau-Ponty eloquently demonstrated in Le Visible et L’Invisible [17] this binding together of sensuous inputs from the five senses into one integrated experience rests to a large extent upon the workings of kinaesthesia. Kinaesthesia – or ‘propriopception’, which is a term that is sometimes used interchangeably – is the body’s sensing of itself moving through and sensing the world. It shouldn’t be confused with either of the other senses.

Kinaesthesia is the ability that enables us to sense the rear of our car when reversing into a parking space. It is not felt movement or visual perception per se, but an awareness of how the whole body’s experiences are extended seamlessly into the fabric of physical space. It is also kinaesthesia that enables us empathetically to feel ourselves in the place of other people, how they perceive and feel the world. This means that, at the kinaesthetic level of experience, there is such as no clear-cut distinction between a perceiving subject and the perceived object, between the subject and other subjects. Rather these epistemological polarities arise only as a result of higher-level cognitive capabilities such as identification and categorization.

If the idea of kinaesthesia is taken seriously we end up with a totally different view of the body’s significance for the design of architectural space. This has been a central topic put forward by Spuybroek (1998, 2004) who argues that kinaesthesia is a bodily felt awareness that tie movement and perception together in our experience of space. According to Spuybroek, architects typically ignore this experiential condition in the design of architectural space. Hence, architects usually divide space into a ‘ground plan’ for movement, functions and programming, whereas everything relating to perception takes place in the ‘elevation’, that is the shaping of the building’s visual form. This design ideal separate movement and perception instead of respecting their inseparability. In his bold attempt to move beyond this ideal, Spuybroek introduces a new interesting notion of topological space based on the idea of motor geometry. As seen most vividly in the H20Expo, by avoiding any clear-cut boundaries between ground floor and elevation, this topological space is designed in order to address kinaesthesia and proprioception first; how the body in its kinaesthetic feeling anticipates its own future actions and experiences in a built environment. Moreover, Spuybroek argues that the surfaces of this architecture are more apt to engage kinaesthesia if pervasive technologies and interactive media are built into it thereby resulting in what was designated as ‘hypersurfaces’ in the late 1990s.
What distinguishes Spuybroek from the other authors in this group is not only that his notion of architectural space is based upon kinaesthesia, but also that he sees pervasive technologies as a unique design material for engaging the body’s kinaesthetic feelings. However, like the rest of the group, Spuybroek never extends his analysis beyond the individual body. More precisely, he conceives of kinaesthesia as playing a role only in the experiences between the body and the architectural surfaces, not between bodies moving and sensing each other in this shared space. However, collective experience between bodies has been the focus of attention in the second group where the two key proponents are Mitchell [18] and McCullough [16].

Both writers are devoted to discussing how and what ubiquitous computing might learn from architecture, and are pointing towards potential pitfalls when and if ubiquitous computing is embedded in our physical environment. Both writers urge the designers of ubiquitous computing to take into account the social life that architecture facilitates, and thereby also encourage the community of ubiquitous computing to go beyond the strong emphasis on individual use and control of computational artifacts.

In his book e-Topia [18] Mitchell launches a critique of a synthetic feeling of togetherness that can be created by using new computer technologies. In the early days of civilization dwelling and wells served as natural gathering points by providing a scarce resource and thus promoting social gathering and interaction. According to Mitchell the advent of ubiquitous computing our future social places will be both physical and virtual, what he denotes as “Smart places”. Mitchell [18] takes an architectural point of view and sees these places not as uniform and dimensionless but instead as spatial extensions that engage our bodies. The specific physical contexts that they are situated in and their spatial and material configurations come into play as they are occupied and controlled by a particular group of people. They can range from being intimate and private, to engaging larger groups of people globally. They are simultaneously embedded in physical spaces subjected to the law of the physical world while at the same time providing remote interconnection. To keep the qualities of public gatherings and social interaction – whether these places are virtual, physical or a combination of both, and serve their purposes they must allow both freedom of access and freedom of expression. This is a direct critique of the one-to-one interaction that the PC represents. Screens, such as the PC and the videoconferencing screens, often demands attention and function as a dominant electronic character in social interaction. Wall-size video projection is often used to create the illusion that geographically separated rooms have been merged and the dividing surface is made transparent by the projection. However effective this illusion might be Mitchell can’t help comparing them to prison visiting rooms where interaction takes place through glass wall separating the prisoner from the visitor. By breaking the boundaries of the one-to-one person-machine dialogue represented by screens, it opens up the possibility of “smart places” engaging people through the sensory system and thereby attracts attention on multiple levels. They are places where physical action influences computational processes and where computational processes can evoke physical changes.

By the concept of “Embodied Predispositions” presented in his book “Digital Ground” [16] McCullough describes how physical space enables people by subtle variations in positions of human bodies to express nuances of e.g. power and opportunities of which the digital world is bereft. His examples range from the powers of the corner office, being a prominent place for the exchange of information, as it provides different places for sitting, better views than most offices let alone natural light and air; the careful physical sizing of closing rooms for salesmen, and the haggling among diplomats over the shape of council tables. Body language matters, and physical space creates the facilities for these games to play out well or ill. Both Interaction design and Architecture is interested in “cognitive background”; in the words of McCullough, this is “the cumulative perceptions of enduring structures that fundamentally shape human abilities”. Building upon the work of Yi-Fu Tuan [31] McCullough describes the body as being “your first and last site, your center and your scale”, in the words of Yi-Fu Tuan “the body imposes a schema on space”. We confront a problem or turn our back to it; a classic trick in the houses of landlords, emperors, princes etc. is to make tall entrance doors with high positioned door handles to make us feel small, when we come begging for money. In supermarkets we are more likely to buy goods that are available on our right side in the walking direction. But not only size and orientation of bodies matter distance does too. It is hard to maintain a conversation on the weather conditions with a stranger in a bus during peak hours, as being 15 cm away from a face suggest other possibilities. Nightclub managers know it, the more crowded the place, the better the party. Dogs sniff and circle and until 20 years ago architectural spaces were build to accentuate the subtleties of interpersonal relationships. Since then computational artifacts have entered the scene, so far however, it has mainly been preoccupied with the individual relationship to information technology. If ubiquitous computing is to be successfully embedded in actual livable spaces it needs to account for the relationship between bodies and space. In the following section we’ll develop the perspective further with reference to the caricature in Figure 1 e and illustrate it by design examples in section 3.1.

2.3 The fifth paradigm: Spatial Sharing

The architectural space is a contextualization of bodies in the same place. By our point of departure in the descriptions, critique and the pinpointing of strengths of the dominant schools of thought in architecture in the above section 2.2 we describe how spatially embedded ubiquitous computing might be designed. The design ideal is Spatial Sharing; designing for a contextualization of bodies where the computer, in line with architecture act as the common place for co-located people; the computer, thus, is staging human activity in the same way as architecture is staging human activity. Human activity needs to be fully appreciated as both 1) the actual concrete bodily sharing of the space, and 2) the individual consciousness of sharing a space with other people, and 3) the feeling (sensing) of what the other bodies might feel. As such this is a merging of phenomenological and psycho-geographic understanding of space, place and architecture. Taking on this approach the computer extends the traditional architectural space adding to the framing of human-human-interaction as the focus is on cultivating bodily relations between the participants. The physicality of the artifact, installation or environment slides into the background to give room to the interaction accruing between the participants accentuating the space created between the participants via the computer/ architecture.

By regarding the computer as a contextualization of the joint place of bodies we have the opportunity to cultivate shared space by utilizing knowledge gained in Collective Interaction and Kinesthetic Empathy Interaction. The computer behaves like architecture in the sense that humans share it. It is not my space but our space and we find ways to negotiate the sharing based on our common “cognitive background”. The computer provides a space for an activity, e.g. trying to browse through pictures by an interactive piece of furniture [22]. Extending architectural space by the use of computers. Exertion interfaces
Empathy Interaction is to provide means for people that enable consciousness that is associated with but not necessary present in others. The interaction space affords a shared process of recognizing kinesthetically what is sensed visually, auditorily, or tactiley and by including the kinesthetic empathic as aspect in the interaction, the collective interaction space is emphasized as a forum where decisions made by one participant continually depend on the reading of the actions of others. The interaction space affords a shared kinesthetic consciousness that is associated with but not necessary present within social and collective interaction.

The purpose of both Collective Interaction and Kinesthetic Empathy Interaction is to provide means for people that enable them to achieve a shared goal or by working against and prohibiting the achievement of the goal. The participants have to come to an understanding on what the others are doing and in cases where the participants are in direct competition with one another the possibility of making use of deceptive actions emerges. Deceptive actions or feints are used to trick an opponent into thinking that one action is being employed when really they are doing something completely different and is commonly used within sports e.g. basketball and handball [12]. If performed correctly this will buy them a little extra time and can be the difference between success and failure. These types of obstructive actions can also be used in situations where people are collaborating on reaching a shared goal to tease the other people or to indicate discontent with the direction the shared effort is taking.

3. Computers experienced as architecture

We take on the notion of spatial sharing inspired by architecture to explore the potential of designing for multiple bodies in space thus exemplifying the combination of Collective Interaction and Kinesthetic Empathy Interaction in three design cases: iFloor [13], TacTowers [15] and BodyQuake [7]. Both concepts: Collective Interaction [14][23] and Kinesthetic Empathy Interaction (KEI) [5][8] begin in multiple co-located users negotiating a shared goal for the interaction and sharing the interaction mechanisms for achieving that goal. Along the lines of [16] and [31] the actions of the individual are not solely rooted in on his or her own intentions, wants or desires, but dependent on which actions the other participants choose to engage in, collaboration is both sought and enforced. This interaction differentiates from other types of interaction e.g. Singe Display Groupware (SDG) [30] primarily because the participants share not only the output channel but also the input channel. SDG [30] has proposed an interaction model that supports collaborative work among co-located people. However, this model relies on a keyboard and mouse used in combination as input device dedicated to each individual user and a shared display as output. In such a setup the users may independently provide input to a system whereas in Collective Interaction and Kinesthetic Empathy Interaction the input channel is designed so that it embraces input from several participants simultaneously and meaning is constructed in collaboration with others. The input channel may consist of a number of interaction instruments that are logically coupled through the interaction thus encouraging the users to organize their actions according the action of others. An example of this is the physical interactive game Collabolla [19]. It is a classical PacMan game with physical controllers used as input. Two users collaborate through Kinesthetic Interaction to move PacMan around the screen. In this game setup, one user controls up/down while the other person controls left/right. This setup forces the two user to cooperate and reach a shared understanding of what needs to be done to archive the shared goal of completing the game.

Whereas Collective Interaction more broadly frames the collective experience between multiple co-located users, Kinesthetic Empathy Interaction focuses specifically on bodily empathy in the interaction. Thus creating a space where the primary interaction is between the participants and where the interaction with the artifact, installation or space becomes secondary. Along these lines an interaction space is created between the participants where it is crucial to be able to read react and build on each other’s movements. To do this, participants use their kinesthetic empathy, the empathic part of humans’ innate bodily intelligence and memory. Through the process of re-cognizing kinesthetically what is sensed visually, auditorily, or tactiley and by including the kinesthetic empathic aspect in the interaction, the collective interaction space is emphasized as a forum where decisions made by one participant continually depend on the reading of the actions of others. The interaction space affords a shared kinesthetic consciousness that is associated with but not necessary present within social and collective interaction.

The application of designing for multiple co-located people negotiating a shared goal for the interaction and sharing the interaction mechanisms for achieving that goal. Along the lines of [16] and [31] the actions of the individual are not solely rooted in on his or her own intentions, wants or desires, but dependent on which actions the other participants choose to engage in, collaboration is both sought and enforced. This interaction differentiates from other types of interaction e.g. Singe Display Groupware (SDG) [30] primarily because the participants share not only the output channel but also the input channel. SDG [30] has proposed an interaction model that supports collaborative work among co-located people. However, this model relies on a keyboard and mouse used in combination as input device dedicated to each individual user and a shared display as output. In such a setup the users may independently provide input to a system whereas in Collective Interaction and Kinesthetic Empathy Interaction the input channel is designed so that it embraces input from several participants simultaneously and meaning is constructed in collaboration with others. The input channel may consist of a number of interaction instruments that are logically coupled through the interaction thus encouraging the users to organize their actions according the action of others. An example of this is the physical interactive game Collabolla [19]. It is a classical PacMan game with physical controllers used as input. Two users collaborate through Kinesthetic Interaction to move PacMan around the screen. In this game setup, one user controls up/down while the other person controls left/right. This setup forces the two user to cooperate and reach a shared understanding of what needs to be done to achieve the shared goal or by working against and prohibiting the achievement of the goal. The participants have to come to an understanding on what the others are doing and in cases where the participants are in direct competition with one another the possibility of making use of deceptive actions emerges. Deceptive actions or feints are used to trick an opponent into thinking that one action is being employed when really they are doing something completely different and is commonly used within sports e.g. basketball and handball [12]. If performed correctly this will buy them a little extra time and can be the difference between success and failure. These types of obstructive actions can also be used in situations where people are collaborating on reaching a shared goal to tease the other people or to indicate discontent with the direction the shared effort is taking.

3.1 Design examples

In the following, we present three design cases that illustrate the overall concept of spatial sharing building comprised of combining Collective Interaction and Kinesthetic Empathy Interaction and investigate the principles for collaboration through interaction.

3.1.1 iFloor

iFloor is an interactive floor surface that facilitates a space for communication and encourages collaboration between users in a public library setting. It is a Question and Answer installation that exploits the users knowledge and curiosity of exploration and is designed to trigger co-located people to engage in conversation thus promoting social interaction. Instead of a dedicated input device, the users collectively provide input into the systems just by being present in the library. This ensures that the broad range of people visiting the public library can appropriate the system. It affords the users, in collaboration, to browse and discuss questions and answers produced by the users themselves. The users collective share a curser that they manipulate across the projected floor surface through movements and position of the body (Figure 2). As the cursor rolls over the Q/A containers, the message is enlarged allowing for the users to explore the contents in full. As within the SDG model of interaction [30], the mobile phone or email is used to pose and answers questions.

Figure 2: iFloor

The interaction is based on simple camera tracking, measuring the threshold between black (the shadow of people at the rim of the floor) and white (the floor surface). The application tracks people’s position and movements and translates it into what is
the opposing player acts as defense as in the real game of handball. The offensive player (B, see Figure 4) controls the “ball” represented by the red light signal, and his objective is to get the ball into the purple goal zone. The opposing player (A, see Figure 4) has two “blocks” (blue lights) that are used to defend the goal zone and corner his opponent. To place a block, the defensive player hits one of the sensors facing him and which is placed on the middle part of the ball. If the red light is hit into one of two blocks, the game is over and the athletes changes roles.

Figure 3: Two handball players using the interactive training equipment, TacTowers

Figure 4: Illustrate the game "Blocker". Player A is trying to prevent player B from hitting the read light into the goal zone by placing blocks around the playing field.

TacTowers invites the use of deceptive actions in order to gain headway and beat the opponent. Feints can be made by, for example, pretending to hit the ball in one direction and then in a split-second changing direction. The athletes need to anticipate the position, direction and speed of the 'ball' while using split vision skills to constantly monitor the opponent. TacTowers creates a space where the primary interaction is constructed between the players and the interaction with TacTowers becomes secondary i.e. background to battle between the two athletes. The focus is on how the relation to other people, as well as stimuli from the surrounding environment, can affect the movements generated through the interaction.

3.1.3 BodyQuake

BodyQuake (Figure 5) is interactive playground equipment designed to encourage movement through Kinesthetic Empathy Interaction. As with running, jumping and hopping, BodyQuake experienced as magnetic forces attracting the cursor. A string is projected onto the surface connecting a user to the cursor. This string is used to visualize the connection and control that each user holds over the cursor. Since the cursor is moving towards the edge of the display and follows the users as if magnetic forces where pulling the cursor, a single user is unable to navigate the floor as they would just drag the cursor along the edge of the interface. Whereas, two or more people in collaboration are able to collectively explore the whole surface by balancing the magnetic forces. The cursor has its initial position in the centre of the floor but as soon as someone steps up to the edge of iFloor the string connects the person to the cursor and the cursor slowly starts moving towards the person. Stepping out of the camera-tracked area (the white rim surrounding the projection) causes the string to disappear and the cursor to move towards the center again. The responsiveness of the system affords playful actions, e.g. holding out the arms to increase body surface thus obtaining several strings and creating a stronger attraction of the cursor. The iFloor interface encourages the users to negotiate where to move in order to move the cursor to reach a shared goal. They have to cooperate in order to move the cursor in a desired direction. However, a situation may develop where the users are not in agreement on where the cursor should be moved and one person may choose to obstruct the process by purposely moving the cursor away from the goal the others are trying to reach.

This kind type of interaction interface is in line with the “smart places” that Mitchell [18] advocates for Creating a physical interaction forum promoting social engagement holding qualities of an architectural space as a contextualization of bodies in the same place. iFloor is staging human activity in the same way as architecture provides a shared context for human activity. It spurs an individual consciousness of sharing a space with other people.

3.1.2 TacTower

The TacTowers concept [15] (see Figure 3) builds on the principles of Kinesthetic Empathy Interaction. It is a piece of interactive training equipment intended to train psychomotor skills, such as tactics and decision-making, of elite handball players. Handball is a highly interactive sport where close body contact is allowed and where it is crucial for the athlete to be able to read and decode the movement intent of others. TacTowers trains the one-on-one combat situation that occurs within the game. The player are placed face to face either on opposite sides of the equipment or on the same side to enable them to read and react on each other’s movements thus reinforcing their kinesthetic empathic relations. The TacTowers create and facilitate a architectural space of interaction where the movements made by one player can be decoded and utilized as grounds for deciding which action to apply next. Through kinesthetic empathy, movements of others are interpreted and meaning is constructed based on past training and experiences.

TacTowers is made up of four towers, each with eight plastic balls stacked on top of each other. Each ball functions both as an interaction surface, consisting of two touch sensors, and an RGB display. Hitting a touch sensor placed at the top or bottom of a ball sends the light signal up or down a tower. Hitting a sensor on the middle part of a ball will send the light signal horizontally in the direction of the impact. When placing the towers on in a line, the towers form a distributed display. Peripheral awareness is trained due to the fact that the players not only have to focus on what the opponent is doing but also on the digital movements displayed in the equipment. Different training games have been developed for TacTower, one being “Blocker”. In Blocker, one person has an offensive role while
trains and develops gross motor skills and requires both balance and coordination. In the interaction with BodyQuake the players have to fight, compete and at times cooperate in different interactive games. As within TacTowers, the movement decisions made by the participants are affected and determined by actions of others. This promotes a mutual awareness between participants and encourages them to use their innate kinesthetic empathy to read and react to the bodily engagements of others. The players are competing to reach the same goal, for example, being the first to reach ten hits as in the game 'Catch me if you can...'. In some games it can be favorable for two players to combine forces to beat the third player. The objective is for the players to avoid being hit while at the same time attacking the others. Since the interaction always takes place between three players, the challenge is to be able to keep an eye on both opponents while at the same time keep track of ones own Quaker.

Figure 5: Three players interacting using BodyQuake

BodyQuake consists of three Quakers that the players stand on. The Quakers become an extension of the player’s bodies and at the same time functions as their tool in the interaction. Each Quaker consists of five green hit-zones and one orange attack-zone. During a game the players score points, displayed on the handle, by hitting the hit-zone of another player with his own an attack zone. A player is able to rotate the outer ring and tilt the unit to try to create a favorable situation where a hit is possible either from below or on top (see figure 5). When a strike is successful, the hit-zone will light up for three seconds and for that period of time it can’t be used for scoring. The person who is hit will feel a short vibration in the handle.

An example of a game played on BodyQuake is ‘Bomb Away’. The objective is to pass a bomb, represented by lit hit-zones, to one of the other players before the bomb explodes. Who ever are left with the bomb, when the time runs out, has lost the game. The bomb is passed to another player by hitting the hit-zones with an attack-zone. This game encourages the players to anticipate the movements of the others in order to avoid being passed the bomb. This emphasizes the mutual kinesthetic awareness of the participants. The Quakers are constructed in such a fashion that it isn’t possible to withdraw from the game since the players at all time is vulnerable to hits by at least one of the other players. This forces the players to be alert to the movement actions of the other and encourages them to keep moving in order to disguise movement intent. As with TacTowers, BodyQuake facilitates a space of interaction where the bodily relation to others is paramount.

4. DISCUSSION

Our three design cases have demonstrated the central design principles underlying Collective Interaction and Kinesthetic Empathy Interaction. Further, we have argued that these forms of interaction represent a new more general paradigm in interaction design: Spatial Sharing. By focusing on how people interact through computational artifacts in a shared space we align ourselves with recently developed frameworks of co-experience and embodied interaction.

On the face of it, it may indeed seem as if our approach is similar, for instance, to the one laid out by Battarbee [1]. However, there are some crucial differences that need to be emphasized. First, Battarbee typically focuses on co-experience being created by people situated in physically distant locations (for instance through their mobile phones). As a consequence, the body of the user is never considered to play an important role, but remains a virtual representation on the visual display. In contrast to this view, we take our point of departure in interactions between bodily co-located users. Secondly, in contrast to Battarbee’s framework, we include kinesthetic empathy interaction as a new aspect on the margin of people’s consciousness that can be designed for. Thirdly, according to Battarbee co-experience wouldn’t be possible without the presence of the product. We agree that the product is key to co-experience, but a too narrow focus on the product neglect how it can be used for negotiating a shared space. In TacTowers, for instance, it was shown that the interaction with the product itself becomes secondary, so as to give way for the players to create a space for negotiation between them.

Our approach also shares many theoretical assumptions with those underlying Embodied Interaction, notably how this framework has been developed by Dourish [3]. What distinguishes Dourish from other proponents in that field is that his notion of embodied interaction embraces both physical bodily and social interaction. In this sense, one could ask whether Embodied Interaction does not already cover our approach? However, it is worth noticing the subtle, yet central differences. First, Dourish uses the notion of direct bodily interaction in line with Tangible User Interaction, i.e., as a paradigm that promotes a design ideal that focuses on intuitive use of computers through graspable interfaces. This ideal is further grounded in phenomenology, notably in Heidegger’s two concepts of ‘vorhanden’ and ‘zuhanden’. While these concepts concern the prosthetic relation between man and his artifact, they say only little if anything about how man relates to other people through this artifact. We argue instead for a need to focus on how collective interaction can be enabled by designing computational artifacts that engage co-located bodies and its kinesthetic feelings. It is through our body’s kinesthetic feelings that we are able to place ourselves not only among other things, but also among other bodies in the world. Furthermore, in his discussion of the social aspects of embodied interaction Dourish favors examples of interactive systems mediating a space for collaboration and co-experience. In contrast, we argue for moving beyond the medium-centric view of the computer replacing it with a new approach that sees the computer as architecture.

By listing these comments we wish to direct attention toward what we consider to be valuable themes for future work. Co-experience and embodied interaction are useful for developing a more nuanced view of interaction, but various new dimensions need to be added if these framework should gain solid footing in interaction design research.
5. Conclusion
In this paper we have identified and presented the interaction design paradigm of Spatial Sharing based on designing computational artifacts as architecture. The concept is grounded in merging different schools of architectural theory. Both architecture and interaction design is concerned with the understanding of our “cognitive background” for making appropriate design decisions. Three design examples have been presented to illustrate how the paradigm of spatial sharing can be used to describe and guide the design of socially engaging spatial interfaces and interactive installations. We have discussed how the concept and paradigm of Spatial Sharing remedies some of the shortcomings of the notion of Co-experience. Interaction design still has a range of things to learn from architecture in particular with regard to the details in working with the concept of Spatial Sharing is still underused and offers grounds for future investigation. However, we claim that this endeavor can be based on the findings of this paper and that it provides good basis for this through the concept and paradigm of Spatial Sharing.

6. REFERENCES