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Peephole Experiences – Field Experiments with Mixed Reality Hydroscopes in a Marine Center

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Abstract
This paper discusses the principle of Peepholes in the context of aesthetics of interaction. The idea of Peepholes is to stimulate curiosity, imagination, and exploration by allowing users access to only a small part of a larger universe. The paper discusses the development and first evaluation of a concrete instance of the Peephole principle for a marine centre, where Peepholes are designed as mixed reality Hydroscopes to study a digital ocean universe with fish and other undersea phenomena. The design and evaluation of the Hydroscope installation is discussed and issues for future design are outlined. Following this discussion, we move to consider the concept of Peepholes in relation to interaction design and aesthetics of interaction more generally and outline four central dimensions of peepholes: the senses, the social, the spatiality, and the tangibility.

Keywords
Aesthetics of interaction, interactive spaces, Hydroscope, Peephole, interaction design.

Introduction
The landscape of interaction design and use is changing. Technology has long since moved from its traditional place in our offices to the realm of our everyday lives creating new domains for design. Concurrently, the material of design has changed

radically during past decades; the desktop computer has been surpassed as the only medium of design giving way to ubiquitous and mobile technologies. These developments have spurred a growing concern for the agendas and conceptualizations that guide the design of interactive technologies. Consequently, the scope of inquiry has broadened from issues of usability towards a wider understanding of people's everyday lives with technology. Domains of inquiry such as Experience Design [19], Aesthetics of Interaction [17], [14], Emotional Design [15], and Critical Design [4] have become commonplace in interaction design discourse.

In this paper we extend this trajectory with a particular focus on the aesthetics of interaction, i.e. how technologies may challenge, excite, and in general engage people in their everyday lives. We discuss the concept of Peepholes as a way of exploring mixed reality spaces and spurring imagination and engagement. Peepholes offer a limited glance into a larger context promoting exploration and imagination. Our discussion departs from a presentation of the Hydroscope prototype that was developed as part of our work on designing technologies for museums. We point to the Peepholes in general and the Hydroscope in particular as a promising means of spurring engagement, exploration and imagination. We report from our first evaluation of the Hydroscopes and move on the reflect more generally on the concept of Peepholes in interaction design.

Interactive Experience Environments

The context of this contribution is our work on designing technology for museums and science centers (the IXP project) at Center for Interactive Spaces. Within these domains there has been an increasing interest in exploring the use of interactive technology to facilitate engaging experiences. Early work within the domain of museums has been dominated by context aware applications that strive to provide appropriate information and help the visitor navigate the exhibition space (see [18] for an overview). Many of these have taken the form of PDA based services that complement the physical context of the museum (e.g. [12]). A more recent strand of research has begun to widen the exploration of the potential of technology in exhibition spaces. Sparacino [20] shows how a range of technologies was used to frame interaction and active participation in the exploration of the 'Puccini set Designer' exhibition. In a similar vein, the work within the SHAPE project has provided numerous examples of how technologies may be used to create new avenues for visitors to experience and contribute to the exhibition (see [5]). These contributions exemplify a move towards involving visitors actively in the exhibition and using interactive technologies to engage visitors. The broadened focus on technology for museums does however also broaden the spectrum of challenges for interaction design and related disciplines.

A range of contributions has shed light on how technologies and museum spaces are perceived and shape the experience (see [6] and [11]). These contributions address issues of interaction and co-participation [11] in museums and the role of assemblies of technologies to achieve coherent experiences [6]. In order to bring these insights into the process of design, several contributions propose a range of design sensitivities that may guide the design of technology for museums. These sensitivities range from very specific concerns for future technologies (e.g.

[3]) to more general sensitivities regarding participation and the social nature of the visit (e.g. [22]). Another strand of the research is the experimental inquires into the means by which visitors may relate to the exhibition space. Among these are ways in which visitors may contribute to the exhibition (e.g. [5]), different means of exploring exhibited material (e.g. [10]), and novel forms of interaction (e.g. [8]). Our aim in this paper is to contribute to the exploration of the means by which visitors may relate to the exhibition space. In particular we discuss the general concept of Peephole s as a way of exploring physical/digital (mixed reality) spaces. In the interest of designing technologies that facilitate engaging experiences, this concept offers a range of attractive characteristics that we shall outline in the following sections. We start our discussion with a presentation of the Hydroscope, which is an example of the concept of Peepholes developed for a marine centres.

Peepholes and aesthetics of interaction

The Hydroscopes exemplify the basic idea of Peepholes as providing a limited view into a context. Peepholes are snippets of a larger world that spurs imagination; we are left to wonder what is hidden in this world and what awaits us if we keep on exploring. Most people have experienced the curiosity that a hole in a fence or a crack in a wall generates. We are compelled to look at what is hidden beyond. As such, the basic idea of Peepholes is not new to design communities and related disciplines. In his artworks, Marcel Duchamp worked consciously with Peephole s as artistic means. At the opening exhibition of 'The art of this century' exhibition in New York in 1942, Duchamp arranged a collection of his works in such a way that visitors could only view them through Peepholes in the wall. In his most well known work 'Given: 1. The Waterfall, 2. The Illuminating Gas' form 1967, Duchamp created a wooden door with only two Peepholes revealing the inside images of the work. Duchamp's use of Peepholes was arguably an attempt to make visitors active participants in the artwork rather than a passive observer ([2]).

Other examples include Margo Sawyer's 1998 'Presence and Absence' from the Austin Museum of Art, where Sawyer created a brightly lit room that visitors could only view through Peepholes in two of the walls. Each Peephole provided a different view into the room and visitors have to make efforts to stretch and bend to reach the all the Peepholes. These examples show the use of Peepholes as a means to spur curiosity. More directly related to interaction design, The Drift Table [7] exemplifies the idea of what we term a Peephole. The Drift Table is a coffee table where aerial photography is displayed on a small screen at the center of the table. People may control the drift of the photographic material by distributing weight on the table surface. Similar to our conception of Peepholes, [7] stress the focus on exploration, curiosity, and reflection that the interaction offers.

Stounbjerg [21] unfolds similar ideas in discussing how the flâneur [23] is drawn to the opening; the interplay between what is visible and what is hidden. The flâneur strolls the city and becomes impulsively inspired to explore unknown parts. Here, the small openings to alleys and archades act as Peepholes that tempt the flâneur to change route. This aspect also draws attention to the secrecy and potential forbidden nature of what is hidden. Boys peep through the keyhole into the girls' locker-room and we catch a glimpse of our

Christmas present through the seams in the wrapping. Peepholes offer glimpse into the unknown, tempting us to go further into a forbidden or mysterious world. For the field of interaction design these aspects of Peepholes are attractive qualities. This is in particularly the case, as Interaction design has recently begun to explore a broader range of dimensions of our relation to technology. Areas of inquiry such as Experience Design, Critical design, and emotional design all call for devoting attention to the subtle, aesthetic and experiential aspects of our everyday life with technology. Our interest is in particular drawn to the Aesthetics of Interaction. This area inquires broadly into how technologies may challenge, excite, and engage people in their everyday lives (see [1] and [17]). The concept of Peepholes offers a promising principle for interaction designers devoted to the aesthetics of interaction.

To exemplify the concept of Peepholes, the following section provides a brief account of the context and design rationale of the Hydroscopes. We report from initial evaluations in context before moving to a more general discussion of the dimensions of Peepholes in relation to interaction design.

Designing for a Marine Centre

The is a marine center with fish and marine life from all over the world. Among the big attractions are large-scale aquaria with a variety of tropical sharks. The center is predominantly based on visual means and a special atmosphere is created around the different types of fish. For instance, the sharks can be seen from a glass tunnel running through the bottom of the tank where you get the feeling of being immersed in the marine environment.

The rationale for our design case was to explore a different range of means by which visitors could relate to fish and marine life. In particular, our design work came to evolve around exploring means of construction and exploration to provide visitors with a new perspective on the centre. The ideals driving our work were ideas of creating an addition to the exhibition that would be playful and engage visitors to actively explore and experiment with the fish and their qualities. Rather than explicitly communicate information about marine life we looked to create a space where visitors could imagine how marine life could be like. In a very literal sense we constructed a setup where visitors could experiment by constructing their own fish from individual parts and exploring it's qualities. Having constructed an imagined fish from different parts, visitors are able to release the fish into a digital ocean where it will live alongside the fish that other visitors have created.

Constructing fish with an RFID kit

To support construction of fish, we developed an RFID based construction kit with physical pieces with RFID tags embedded (see Figure 1). The physical pieces can be assembled to an imaginary fish on top of an RFID tag-reader, and when the user is satisfied with the constructed fish, it can be released into the digital ocean. The tag-readers are built into a special table with a dome display viewing into the digital ocean universe. The dome view is provided through a display on top of the table (see Figure 2).

Figure 1: Fish construction set with RFID tagged pieces

The construction set is developed on the basis of five different fish species, deconstructed into the following types of pieces: body, head, tail, front fin and back fin. Each piece is linked (by the RFID tag) to information and a digital fish part that appears on the dome display. On the dome display the partly finished fish is shown together with information about its physical strengths and weaknesses. This is supplemented with a graphical assessment of its abilities to survive.

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Figure 2: Construction table with dome display.

The construction kit and the table for assembling provide visitors with the opportunity for imagining and exploring marine life by means of construction. There are no correct fish to be constructed. Rather, visitors are urged to explore properties and reflect on fish and marine life by experimenting. When constructing the

fish, properties of the individual fish parts are displayed on the dome display at the center of the table (see Figure 3)

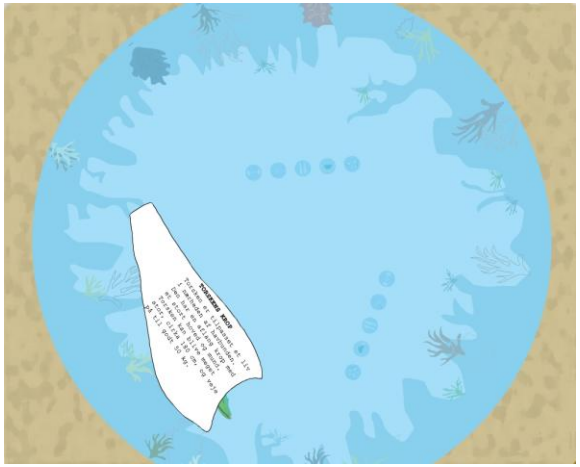

Figure 3: Screen dump from the Dome Display

When a fish has been constructed from the individual parts, visitors may release the fish into a digital ocean to live alongside the fish created by other visitors. In our first evaluation, visitors could release the fish into the digital ocean by placing a dedicated tag onto the tag reader.

Exploring fish in Hydroscopes

To view the fish in the digital ocean, visitors have to use the Hydroscopes that inhabit the exhibition spaces. The Hydroscopes enables visitors to look 'down through the floor surface' into the digital ocean. During the design process, several solutions for creating the digital ocean were envisioned. Initially, the digital ocean was conceived as a large projected floor surface, were the entire ocean was visible. This would provide visitors with an overview of the ocean and allow them to relatively quickly find different fish. The design of the Hydroscope however, promotes a somewhat different agenda. The hydroscopes do not provide overview and they do not make it easy for visitors to find fish or navigate the ocean. Rather, the hydroscopes were designed as a way for visitors to explore the hidden universe of the digital ocean. Instead of revealing the ocean and the constructed fish, it encourages visitors to actively explore the ocean and to imagine what is hidden beyond the range of the hydroscopes. The ocean is only visible through the Hydroscope and visitors have to move around this Peephole to explore the ocean (Figure 4). The only navigation cues are the sound of lapping waves depending on the depth of the water.

Figure 4: Movable mixed reality Hydroscope at the Kattegat Centre

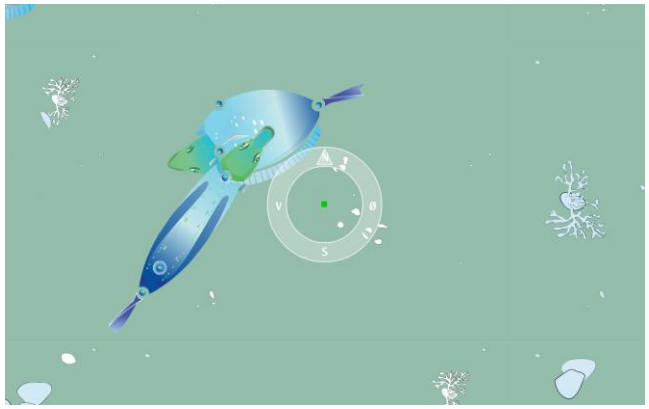

Figure 5: Screen dump from the Hydroscope

The Hydroscope provides glimpses of the underwater characteristics such as the bed of a river, low waters and deep waters. Dependent on the properties of the constructed fish, they will find their way to the most appropriate waters in the digital ocean. As navigating the hydroscope requires users to move it through the physical space, the connection is made between the physical layout of the locale and the digital space of the ocean. We have deliberately chosen not to mark the physical floor according to the mapping of the seabed visible through the Peepholes as the slow gradual discovery of different waterbeds is seen as an attractive pointer for spurring curiosity.

Figure 5 shows an example of what the user may see in the Hydroscope: part of the seabed, two constructed fish and a compass wheel to support the user in navigating the digital ocean. On the technical side, the Hydroscope consists of a laptop computer and large external screen and speakers. The tracking of movement is done by positioning a mouse on a rolling

ball in the centre of the Hydroscope. The outside of the Hydroscope is created from a large tire tube, a top that shapes the view on the screen, and an acrylic dome providing protection for the display.

Round and organic form were chosen to fit the setting and to enable user access from many sides at the same time in order to encourage collective exploration of content. The edge of the Hydroscope consisting of the tire tube allows for physical play. The Hydroscope hardware will survive kicking and pushing by the users.

Figure 6: Kids collectively pushing the Hydroscope

First evaluation

The first evaluation of the Hydroscopes was a two-day test setup at the Kattegat centre. For the test we had set up the table where visitors could create their own fish and two running Hydroscopes where visitors could explore their own as well as the fish created by others.

The approach chosen for the evaluation period was open ended with observations of use, semi-structured interviews on spot and discussion with visitors. The relatively open format was chosen to keep an open mind to unexpected issues and potentials in the setup that we could bring back into the next design iteration. There was a large amount of visitors at marine center during our initial evaluation and we received a considerable amount of feedback for the continued design process. The very nature of the marine centers – and most other museums for that matter – means that installations are often only tried once unlike domains such as the e.g. private homes where the issue of studying how technologies become appropriated over time is more pressing. As such, we decided that a two-day evaluation would serve the purpose of initial evaluation and exposing unexplored potentials in the setup.

The results of the initial evaluation fall within three categories concerning the depth of the installations, the context, and finally mapping. As the collection table and the Hydroscopes are fundamentally interrelated, all these issues relate to both.

Depth

A general concern that became evident through the evaluation was the need for more depth in the installation. The issue of providing depth allowing visitors to 'dig deeper' into the interaction has been stressed by McCarthy et al. [13] in their discussion of the enchantment of technology.

"An object or interactive system that is likely to evoke enchantment should offer the potential for the unexpected, give the chance of new discoveries, and

provide a range of possibilities. The greater the opportunity it offers for finding new aspects or qualities, the longer the enchantment may last. We can think of these characteristics as conferring *depth* upon a design." ([13])

We experienced that several visitors where initially intrigued by the concept and interaction with the Hydroscope. This was especially the case when visitors prior to using the Hydroscopes, had created their own fish. This clearly added to the motivation of finding ones own fish in the Hydroscope. However, having found the fish there was relatively little opportunity to dig deeper; how was the fish doing? Was it hunting other fish? How did it find food? Using the terms of McCarthy et al. [13], it was our experience that the enchantment with the Hydroscopes tended to gradually fade. The issue of depth will be a central concern in the ongoing process. This was in particular highlighted by the fact that visitors did in fact appear to search for more depth and showed initiatives of finding it. Several visitors talked to each other about where their fish was living, what it was doing, and how they had envisioned it. In this sense, the issue of depth refers on the one hand to a limitation in our initial setup. On the other hand, the issue does however also point to potential in our future work; visitors expressed curiosity beyond the initial fascination of the interaction.

Mapping

A second concern was the general mapping between the table and the Hydroscopes. From the beginning of our process, this mapping between the physical fish and digital sea was an issue of concern. In the current prototype, visitors released fish into the sea by placing a designated RFID chip on the table. As expected this mapping was far from optimal. Our concerns for the mapping where confirmed. However, potential for addressing the mapping issue clearly emerged. Many visitors spontaneously held on to the physical fish that they had created and looked for a place to release it (posters in the room explained that the fish could be released). One woman even brought the physical fish to one of the Hydroscopes and placed it on top expecting that the fish would be released. In many respects this was a very intuitive and logical act. In general it is our conclusion that a supporting installation is needed where fish can be released. Moreover, this installation should involve placing or in another sense using the physically constructed fish.

Context

Our third and final key result from the evaluation was the issue of providing context. A key design decision is to strike the balance between focus and context in the Peephole principle. On one hand, we do not want to provide a comprehensive overview of the digital ocean, as this would break the tension between the hidden and the visible. On the other hand, as practically no clues where provided for navigation building a concept of the context, the relation between the physical space and the digital ocean was not sufficiently present. In our case we found that we could benefit from providing some clues of context in relation to the Hydroscope interaction. Several people did not realize that the sea consisted of both deep and shallow areas. Moreover, people found it hard to navigate and to find their own fish as the number of fish increased and populated the relatively large sea. From our discussion with the visitors, several possibilities emerged. As the Hydroscopes emit sound, this could be used to provide clearer or more suggestive clues as to where the

Hydroscopes are and where other parts of the ocean or fish might be found. These forms of context would very much take the form of more or less precise clues that could spark further exploration. Another way of providing context that was discussed was the application of physical markers on the floor, e.g. stickers that indicated where to find the deep or the shallow waters. In their nature these would provide increased overview, however without providing the more playful clues that might be implemented by sound. A third option was the use of graphical indicators in the Hydroscope; this may be done by arrows pointing to different locations or text messages describing current location and suggestions for ways to proceed (e.g. "go north to find the deep waters"). The more general lesson regarding the Hydroscopes and the principle of Peepholes in general remains that of striking an appropriate balance between what is hidden and what is visible. This balance depends fundamentally on the design situation at hand. In our case, a slightly stronger sense of context or cues is needed in future setups.

The three themes discussed above where the central issues derived from our evaluation. However, our general expectations to the Hydroscopes and the Peephole principle were confirmed. It was our impression that the Hydroscopes did provide the sense wonder, imagination and did appeal the exploratory nature of the visitors.

Hydroscopes and the Peephole Principle

The Hydroscopes and the qualities that these promote exemplify the more general principle of Peepholes. As discussed in the introduction, Peepholes are not strange means in arts, design or interaction design. In this section we broaden our focus to consider a range of general dimensions of Peepholes. These dimensions may be regarded as a set of design spaces that are central in shaping interaction and experience in relation to Peepholes. In these spaces, a range of expressional means may be employed in shaping interaction.

From our studies we identify four central dimensions of Peepholes. Our area of study is interaction design, and as such our conceptualization derives from mixed reality environments. The dimensions are: the senses, the social, the spatiality, and the tangibility.

The Senses

The primary sense being triggered by the Hydroscopes is the visual sense viewing the sea through the Peephole display of the Hydroscope. But Peepholes in general may also appeal to other senses through auditory and tactile feedback. We may provide installations where users have to put their ear to a Peephole (or perhaps wear a traditional audio guide) to listen to an auditory universe. We may also develop installations, where people have to put their hand, arm or foot into a hole to explore physical forms or different materials. We may even imagine Peepholes that rely on tasting or smelling small parts of a larger context. Moreover, the Hydroscope involves several senses by appealing in parts to the auditory sense via sounds that act as cues to get people to navigate the Hydroscope to specific directions.

The sensory dimension provides an infinite number of opportunities for combining and shaping experiences. The distinct character of the Peephole principle is to maintain the tension between what is hidden and what is perceivable. This tension may be created in a variety of ways.

The Spatiality
It is very common that Peepholes are stationary holes as in doors or fences and the viewer has to wait until something interesting happens on the other side. In the physical world there may be no means of navigating the peephole - you just have to wait for activity on the other side of the hole. When moving to a digital world we may provide means of navigation in the universes behind the Peepholes. We may provide a stationary Peephole with means to 'scroll', 'zoom', 'fast forward', or otherwise move the content behind the hole. This would provide a quite different experience compared to a hole in a fence but would arguably hold other qualities. With the Hydroscopes we have chosen a Peephole metaphor that in many respects simulates 'natural' navigation – i.e. it builds on spatial arrangements and proportions.

When discussing navigation the context of navigation is important. If you are in boat it is natural to have an overview map of the sea with depths and other mappings of the seabed and perhaps sonic scanning systems that determines activity in the sea. If you are snorkeling you only have your senses and your navigation is determined by the visual, auditory, or tactile stimuli you get. The two approaches exemplify two different tactics for creating the spatiality of the peepholes and the context. For our Hydroscope application we have decided to aim at a snorkeling like experience and thus not provide the user with explicit representational means to step back and gain overview of the context. The only context cues provided are sounds that may drag your attention and the compass wheel that may help you to remember past navigation moves such that will be able to re-find things in the seabed. The relation to the physical space may also be said to provide a certain sense of context – the movement of the hydroscopes and as such the ocean that may be explored is limited by the spatial layout of the locale.

Thus, the dimension of spatiality covers a range of issues. The first one being the qualities of the Peephole itself; it may be stationary or moveable. Moreover it may be manipulated in a number of ways, involving size, shape and perhaps evens temporal mode. The second issue covers the Peepholes relation to the surrounding context and the representations that guide navigation. The amount and form of context may be varied depending on the extent to which it is desired that people can gain overview and navigate the space. Again, the distinct characteristic of the Peephole principle is to maintain the tension between what is hidden and what is perceivable. The third issue of spatiality relates in particular to mixed reality environments and concerns the relation between the digital and the physical space. In the Hydroscope, there is a relatively natural mapping between the space of the floor and the navigation in the ocean. We may however envision that this relationship could be distorted in a number of ways: proportions, dimensions etc.

The Social
The Peephole principle may cover both single user experiences and collective experiences. Many traditional museum systems are intrinsically single user systems e.g. traditional PDAs and audio guides. In a sense they immerse the user in their own world of experiences. In our experiments we have put a particular emphasis on supporting collective experiences around the Hydroscope Peephole (see e.g. Figure 6). The display is

big enough to be seen by several users, it can be viewed from many different angels, and the Hydroscope can be moved collectively. Thus the Hydroscopes appeal to communication among the people moving it providing other potential channels of experience than that of a single user device.
The potential social aspects of Peepholes may take a variety of forms. Among these may be the collaborative efforts of people that navigate the Peephole together. More subtle forms of social interaction may however also be envisioned. Peepholes may be envisioned to create peripheral awareness of activities or simply to spur conversation among participants. The social dimension of Peepholes does off course depend fundamentally on the nature of the design situation as communication and interaction are embedded in these settings.

The Tangibility
We have designed a robust physical instrument to act as a mixed reality Hydroscope having many of the same physical properties as real Hydroscope. This design choice is in accordance with the ideas of aesthetic interaction [17] where it is argued that involving the full faculty of your body generates more engaging experiences. Our first prototype was made on an interactive floor [9] where body movement is camera tracked. Here we created a completely virtual Hydroscope which followed the users' movement and created a hole in the water surface. However, this design allows the user to stand up and walk around in a more remote pose. This design did not stimulate the same kind of close contact with the sea surface as can be seen when children interact with the physical Hydroscopes (see e.g. Figure 6). This indicates that physicality and the possibility to move the Peephole artifact stimulates a more close contact with the content and thus a more engaged experience than a remote navigation in a virtual world.

The dimensions outlined above are a first step towards conceptualizing the properties and potential of the Peephole principle within interaction design. As these are based on our initial studies, further experiments are needed to elaborate on the dimension.

Conclusion
This paper has introduced and discussed the principle of Peepholes as a way of promoting aesthetics of interaction. We reported on the design and evaluation of a concrete instance of the Peephole principle – the Hydroscopes. Our initial field studies revealed a number of issues and opportunities that will be addressed in coming iterations. Building on our experiences we outlined a range of dimensions related to the principle of peepholes. We position the Peephole principle within aesthetics of interaction as a field of inquiry. Within this scope, our discussion of the Peephole principle may be seen as a contribution to recent focus on the expressional strategies and means that may be employed in the design of mixed environments.

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