Inspirational patterns for embodied interaction

The concern of this work is how knowledge based on design experience can be developed, disseminated, articulated and acquired. We propose the notion of **inspirational patterns**, or **i-patterns**, which refers to abstractions of core ideas and essential elements from a class of coherent examples, pointing to promising regions in the design space. Most current work on patterns concentrates on proven solutions to recurring problems; i-patterns, on the other hand, are oriented towards the innovative and inspirational.

The design domain of interest to us is **interaction design**, which can be roughly defined as design with digital materials. More specifically, we focus on the intersection of tangible interfaces and social computing that is called **embodied interaction**. We present nine i-patterns for embodied interaction, as follows.

¶ Virtual information is tied to positions in the material world.
¶ Virtual bookmarks are tokens of positions in the material world.
¶ Material objects are tokens of virtual information.
¶ Virtual information »has« material properties.
¶ Virtual information »forms« objects in the material world.
¶ Material object qualities influence interaction qualities.
¶ Heterogeneous virtual information fuses into a few sensory parameters.
¶ Interactive and broadcast media combine to form a positive spiral of participation.
¶ Virtual information and functions are limited to certain times.

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INTRODUCTION

A question of long standing in design theory is how knowledge based on design experience can be developed, disseminated, articulated and acquired. The discipline of interaction design—which can be defined loosely as design with digital materials—is no exception in this regard. Our research group has worked for several years with design of what we call mixed-media objects and environments, where the physical and the virtual aspects of a product, service or space are designed in concert and (hopefully) contribute to a coherent use experience. Our results in terms of user satisfaction as well as recognition among interaction designers and researchers seem to suggest that we have indeed developed some amount of useful design experience in this field. A question of growing importance for us, then, is how this experience can be articulated and put into play in the discursive knowledge construction system that is the interaction design community.

In more general terms, the design experience we draw upon in this paper falls squarely within the emerging interaction design domain known as **embodied interaction**. Paul Dourish [11] coined the term »embodied interaction« which, broadly speaking, refers to interaction with computer systems that inhabit our world—a world of physical and social reality—and that exploit this inhabitation in the way they interact with us. Based on a platform of phenomenological philosophy, Dourish defines embodied interaction as

> the creation, manipulation and sharing of meaning through engaged interaction with artefacts.

In terms of academic fields, Dourish places embodied interaction at the intersection of tangible interfaces and social computing. One might add that the heterogeneous field known as ubiquitous computing, pervasive computing or ambient computing comprises many issues and examples that would fit the definition and intentions of embodied interaction.

In order to set the stage for subsequent discussion and provide some understanding of the nature of our work in embodied interaction, consider the *Kliv* system [4] for managing and sharing practical knowledge among fellow healthcare workers in intensive care. A social and technical process is put into place whereby an intensive care staff member with particular expertise in, say, the use of a certain piece of equipment records a video where she shares her knowledge with her colleagues. Our work shows it to be crucial that the video is recorded and managed by her fellow workers rather than by professional video production staff. By printing a barcode on paper and affixing it to the piece of equipment, the video is connected to the right place in the work environment. Colleagues can now access the video in the context of their daily work by scanning the barcode with a reader attached to a PDA. *Kliv* will be discussed further below.

Figure 1: The CoWall.

Another of our examples is the *Cowall* [15], a mixed-media database for inspirational learning within a pedagogical environment of project-based work (refer to Figure 1). The idea is that physical objects representing different projects are presented in an open and extensible structure of transparent cubes. Each object is RFID-tagged, and serves as its own index into a set of digital information (images, movies, sounds, text, etc.) drawn from the project where the object appeared. The learners play with the objects and the related digital media, create collections of physical and digital material, share their findings, and bring printouts and web links away from the *Cowall* for reference and further use.

The intended contribution of this paper is to discuss the design-theoretical issue of how design experience can be made into useful knowledge for other designers and would-be designers. The approach we have chosen is to articulate **inspirational patterns**, or **i-patterns** for short. The i-patterns are similar to examples, yet different in the sense that they are somewhat abstracted and purified. The aim of an i-pattern is to capture the core idea, the recurring and perhaps essential elements of a specific example or class of examples.

We think of an i-pattern as intended for other designers. Unlike most current patterns work, we do not require an i-pattern to be based on successfully deployed solutions to recurring design problems. Our intention is to broaden the repertoire of the design community and contribute to a discursive and emerging understanding of the design domain, rather than to provide tools for problem-solving.

Based on our work in Kliv, Cowall and numerous other projects, we use the design domain of embodied interaction as our example domain. First, we discuss i-patterns as design knowledge in relation to what is known from the field of design studies. We also discuss the relation between i-patterns and other contemporary work in patterns as a design-knowledge representation. We then move on to the specific domain of embodied interaction, introducing our method for articulating i-patterns based on the collected design experience of our research group, and present a small »catalogue« of nine i-patterns for embodied interaction. The paper closes with a discussion of requirements on an i-pattern from the point of view of the discursive design community.

I-PATTERNS AS ELEMENTS OF DESIGN KNOWLEDGE

Schön [36] postulated in his influential theory of design that the designer uses a **repertoire** of ideas or examples to choose directions in the design space. Other significant work in design studies from the 1970s and 1980s also underlined the importance of examples and solution elements in design knowledge. For instance, Lawson [28] found that designers tend to work in a **solution-oriented** way (concentrating on sketching possible solution variations) as opposed to the problem-oriented work process of, e.g., engineers. Moreover, the **traditional teaching practices** in design schools—including an emphasis on sketching, studies of canonical designs, and group critiques of students' work—indicate the importance of examples, previous solutions, in the development of design knowledge. However, no systematic studies were made concerning the constitution of the repertoire or how it could be developed.

Recent design-theoretical work in the area of design expertise seems to provide some of the missing pieces. In a survey of the field, Cross [10:432, my emphasis] points out that expert designers have not merely been exposed to a large number of problems and solutions from their domain of expertise, but also that one of their key competencies is »the ability to mentally stand back from the specifics of the accumulated examples, and form **more abstract conceptualisations** pertinent to their domain of expertise.« This proposition is empirically supported by Ball and colleagues [3] who demonstrate in an experiment that expert designers exhibit more **schema-driven** than case-driven analogical reasoning, whereas novice designers show the reverse pattern.

The currently available research in design studies, then, seems to support the intuition and the educational tradition that one component of an expert designer's knowledge is more or less abstracted structures capturing the essence of (presumably many) examples that the designer has been exposed to. Following the terminology of cognitive science, Lawson [29] calls such structures **schemata** in his tentative theoretical framework of design expertise.

We view a design community (such as interaction design) as a **discursive structure**, where knowledge is created, developed, rejected and revised in an ongoing debate between members of the community. Our assumption is that the level of abstracted structures, schemata, what we have called **inspirational patterns** or **i-patterns**, is a meaningful level of discourse in a design community.

It has to be recognized, however, that expertise is likely to be domain-dependent in interaction design as it is considered to be in other fields of expert performance [18, 16]. To put it simply, there is no reason to expect an outstanding productivity application designer to be good at designing games (even though both domains can be said to belong to interaction design). It seems to us that **embodied interaction** is a useful domain delimitation. It has a reasonably clear definition at the intersection of tangible interfaces and social computing; its community of academic design practice is fairly clearly delimited; our own design experience seems to indicate that learning carries across from one design project to the next within the domain.

Hence we have undertaken the task of articulating and disseminating a seed for debate: a number of suggested i-patterns for embodied interaction. It is our hope that they will be appropriated, used, criticized and extended by other members of the discursive structure that is the interaction design community.

I-PATTERNS AND OTHER PATTERNS

As generally acknowledged, the notion of a pattern language originated with the work of architect Christopher Alexander in the 1970s. Alexander and his colleagues [1] aimed at identifying and articulating certain spatial configurations in buildings and towns. Such configurations are called **patterns** and they typically work as a way of resolving conflicting interests, or forces. For instance, the pattern of a Sitting Wall resolves the conflict of dividing two spaces without disconnecting them. When patterns are interrelated in a structure of small-scale, detailed solutions within the frameworks of more general configurations, they are said to form a **pattern language**.

In the view of Alexander et al., successful architectural patterns represent ways of supporting patterns of events that frequently occur in the place. Most importantly, the work of articulating and refining patterns is to be understood as a way of reconnecting to traditions of local planning, and hence of increasing **user participation** in the planning and design of their own environments.

The notion of patterns entered the IT community through the field of **software engineering**, where object-oriented programming was one of the main interests in the 1980s. To facilitate reusability of software objects, software engineering researchers experimented with pattern notations to describe programming constructs, elements of software architecture, in ways that would be accessible to other programmers. The most representative example is the book by Gamma and colleagues [22], colloquially known as »The Gang of Four.« This pattern collection emphasizes technical details and sample code, which clearly indicates a purpose different from Alexander's, namely to articulate and disseminate knowledge among professional programmers, rather than facilitating user participation.

In more recent years, the community of **human-computer interaction** has developed an interest in patterns. It is hard to characterize the presented work uniformly in terms of its purpose. Some authors return to Alexander's original intentions of facilitating user participation. A notable example is Borchers [5] who constructs a rather elaborate pattern language for interactive music exhibitions. Borchers works with three classes of patterns: one pattern language for the application domain, one for the design of user interfaces to interactive exhibits, and one for the construction of kiosk software. The application domain patterns capture some elements of musical knowledge for the benefit of the users—prospective blues musicians. The user interface design and software components patterns, however, are directed towards designers and developers. Other work, such as the pattern collection by Van Duyne and colleagues [38] for e-commerce website development, is more squarely oriented towards designers and developers. Arvola [2] presents a set of patterns for sociable use, i.e., the use of shared digital resources in professional and domestic social contexts. His work is clearly aimed at designers and developers, yet he uses Alexander's original pattern notation in every detail. Another twist is to use a pattern notation to capture and disseminate ethnographic findings from domestic field studies [8].

To summarize, the Alexanderian notion of patterns has been reinterpreted and broadened upon assimilation into the field of IT design and development. In current practice, a pattern can be aimed at facilitating user participation as well as capturing an element of professional designer/developer knowledge. What seems to persist, however, is the idea that a pattern represents a **proven and successful** design solution, an abstraction of previous examples and experience:

> The goals of an HCI Pattern Language are to share successful HCI design solutions among HCI professionals, and to provide a common language for HCI design to anyone involved in the design, development, evaluation, or use of interactive systems. [6]

This is precisely where our approach departs from the HCI patterns community. To be sure, the i-patterns we present are related to existing examples of interactive artefacts or design concepts. However, our notion of »successful« may differ from the HCI view where success is generally seen to depend on user acceptance and performance. Our selection of i-patterns and examples is rather oriented towards the innovative, the inspirational, towards inroads into new and promising parts of the design space of embodied interaction. Whereas some of our material represents tested approaches that work well in actual use, we also recognize the value of i-patterns and examples that exist only as concepts or fictions. This difference is deemed significant enough to warrant the introduction of the »inspirational« qualifier. The next section outlines how we went about in articulating the nine i-patterns for embodied interaction that we introduce.

RESEARCH METHOD

The knowledge contributions we present below—what we call i-patterns—are similar to examples, yet different in the sense that they are somewhat abstracted and purified. The aim of an i-pattern is to capture the core idea, the recurring and perhaps essential elements of a specific example or class of examples.

An i-pattern is intended for other designers. Unlike most of the recent patterns work in human-computer interaction, we do not require an i-pattern to be based on successfully deployed solutions to recurring design problems. Our intention is to broaden the repertoire of the interaction design community and contribute to a discursive and emerging understanding of embodied interaction, rather than to provide tools for problem-solving.

Our way of arriving at the i-patterns we present here was based on **iterative analysis**. A group of ten senior researchers and PhD students, all experienced interaction designers in the field of embodied interaction, met regularly over the course of a year in a series of seminars. The task of the group was to explore the possibility of identifying somewhat abstracted elements that would seem fruitful in terms of design knowledge dissemination.

At the seminars, the group worked collaboratively on a board where two types of notes were posted: interesting examples and prospective i-patterns. Examples were drawn from commercially deployed systems as well as research prototypes and digital art projects, and each example was described briefly upon introduction on the board. We examined examples of our own work as well as influential examples by other designers.

The most frequent mode of working turned out to be inductive-synthetic, as follows. A member of the group proposed an abstraction based on one or two examples on the board. If the group found the proposed abstraction worth considering, it was then attempted to find more examples that would fit the same abstraction.

Occasionally, the group decided to reconsider the whole board: to identify the most promising abstractions and perhaps remove some candidates, to sort the abstractions in various ways, to re-examine the relations between examples and abstractions.

Towards the end of the seminar series, a group of ten master's level students in interaction design were asked to each contribute an example and an abstraction based on their graduation projects. The students' contributions were added to the board and attempts were made to relate it to the existing material. However, some of the students' contributions were hard to reconcile with the style of thinking that the seminar had evolved at that stage.

In order to examine the quality of the group's work and judgment, the seminars were concluded with a simple **calibration** exercise. Group members were asked to study the nine conceptual design proposals for information appliances presented by Gaver and Martin [23]. The task was to study the proposals individually and assess the potential of each proposal for inclusion on the board—as a promising i-pattern, or something that could form the basis for an i-pattern. Each proposal was to be assessed instinctively and rapidly on a three-point scale (»strong potential for becoming an i-pattern«, »weak potential for becoming an i-pattern«, and »undecided«).

Six individual assessments of the nine proposals were collected and then discussed in a final seminar. It was found that the group members agreed on six of the nine proposals, when agreement was defined in terms of simple majority (at least four assessments out of six were the same). The concepts *Democratic Advertising*, *Intimate View*, and *Prayer Device* were assessed as being potential material for i-patterns. The concept *Gestalt Camera/Daydreamer* was assessed as not having i-pattern potential. The concepts *Dawn Chorus* and *Dream Communicator* were assessed as undecided. There were interesting qualities in both concepts, but the scope of *Dawn Chorus* was seen as limited and the *Dream Communicator* was too vague.

For the three conceptual design proposals that split the group, it was rather easy to suggest modifications that would make the assessment more homogeneous. *Data Lamp* would need further abstraction work, for instance in the direction of »visually dynamic light source for the home« or »personal claims for use of shared space.« *(De)Tour Guide* was found too broad and imprecise to be generative, whereas a direction such as »a tour guide with a certain element of detouring« would be more promising. The *Worry Stone* came across as a clear example without very much scope, and possibly a poor idea to begin with. The group felt that a simple twist could make the idea more interesting: »store and repeat all the dull chores I have taken care of.«

The purpose of the calibration exercise was to validate the presented work indirectly, by looking at the degree of agreement between individual group members' assessments. The procedure was far too informal to allow for statistical treatment. However, the exercise seems to support the claim that the i-patterns presented here are in fact a reasonable synthesis of collective design experience (rather than a mere summary of the dominant group members' views hiding the silent disapproval of the rest of the group). Hence it was decided to disseminate the outcomes of the work to a wider audience. In the next section, nine i-patterns are selected by virtue of their judged knowledge contributions to the interaction design domain of embodied interaction.

I-PATTERNS FOR EMBODIED INTERACTION

This section introduces nine inspirational patterns, or i-patterns, that we have identified for embodied interaction. Each i-pattern has a name, which consists of a terse but full sentence capturing the essence of the i-pattern. The name is followed by a few paragraphs of free-form text discussing the i-pattern and introducing relevant examples, which are also illustrated in the images.

¶ Virtual information is tied to positions in the material world.

The idea of the i-pattern is that virtual information is perceived as tied to material places or objects. The virtual information is accessed in the immediate context of the material place or object. This i-pattern is typically relevant in use situations where a material place or object is the focal point for the user's intention or the starting point for an interaction which possibly extends into the virtual realm.

Kliv is a project aimed at supporting learning and knowledge management in the context of medical intensive care [4]. In an intensive care unit, there is a fair amount of medical technology. It is difficult for a single nurse to stay updated on the best ways of using all the available devices. Typically, a division of labor develops where some people become local experts on how to use certain devices. In order to make their knowledge more available and useful to colleagues, the *Kliv* project developed an approach where local experts record their own instruction videos for the devices they want to tell their colleagues about (refer to Figure 2). For reasons related to commitment and ownership, it is important that the videos are recorded by co-workers rather than by professional video production staff. Each video is indexed by a unique barcode affixed to the device, and accessed through a PDA augmented with a barcode scanner. When a colleague wants to use or learn about the device, the supplemental virtual information is hence available (both physically and socially!) in the immediate context of the task at hand.

Figure 2: Producing and viewing an instruction video in Kliv.

¶ Virtual bookmarks are tokens of positions in the material world.

The core idea of this i-pattern is the possibility to bookmark places and objects in the material world in a way similar to how the virtual world is bookmarked in a web browser. Bookmarking is about creating a collection of personal virtual tokens referring to places and objects in the material world. The creation typically takes place at the location of the place or object in question. The tokens (the »bookmarks«) can be collected, carried, used for personal navigation, and perhaps most importantly, shared with others in social structures.

Most examples are so-called location-based services found in the fields of public information disseminated through the material world, such as museums, galleries and tourist information systems. It is straightforward to imagine how a social navigation structure can be superimposed on the material world in applications such as a restaurant guide where the bookmarks are annotated with personal reviews of the bookmarked restaurants, or combined with an anonymous rating service to provide a recommender system. Sokoler et al. [35] demonstrate in the *TactGuide* project how material-world bookmarks can support navigation of the material world, in situations such as finding your car in a large parking lot.

The *GeoNotes* project [17] concentrated on social navigation in urban environments. An important contribution was empirical observations supporting the commonsense notion that the relation between material and virtual space is not a simple mapping. For instance, in some situations a bookmark anywhere on a building should refer to the whole building rather than the exact spot where the bookmark was placed (in order to be visible to people approaching the building from the other side). A more general understanding of the relations between material and virtual space could, for instance, start from notions of ongoing mediation of situated interaction [32].

¶ Material objects are tokens of virtual information.

This is the symmetrical opposite of the previous i-pattern. Here, a material object serves as a token or an index to information in the virtual realm. An important issue concerns the material qualities of the token in relation to the character of the virtual information it signifies. A light and disposable material form may be more appropriate for temporary information of less-than-critical significance, whereas essential information of long-lasting value might be better indexed by a material token that has a solid and precious feel to it.

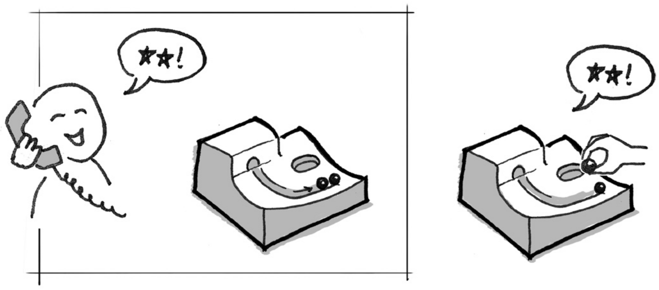

Figure 3: Principle of the Marble Answering Machine.

The *Marble Answering Machine* by Durrell Bishop (described in [9]) is the prototypical example, where incoming calls are tied to marbles that can be handled, preserved, shared or simply listened to once and then returned to the machine (refer to Figure 3). More recent examples of material tokens are found in the field of digital entertainment media for personal use, such as music, photos and movies. Moreover, the *CoWall* exhibit objects introduced above are mainly to be understood as material tokens of virtual information.

A general remark is that the notion of a token is not necessarily simple: There are many different kinds of tokens hiding in this i-pattern. Some examples of different relations between the sign and the signified include the token as an icon, the token as a symbol and the token as a container.

¶ Virtual information »has« material properties.

On mobile devices in particular, it is straightforward to create an illusion that virtual information on a display has material properties. By using sensors for motion and position of the device, the virtual information can be made to behave as if it had weight, for instance (refer to Figure 4).

Fällman [20] presents an arm-mounted device for accessing maintenance information. A maintenance technician can use both hands to work on the equipment in question, and the supplementary information is available on a display on the forearm.

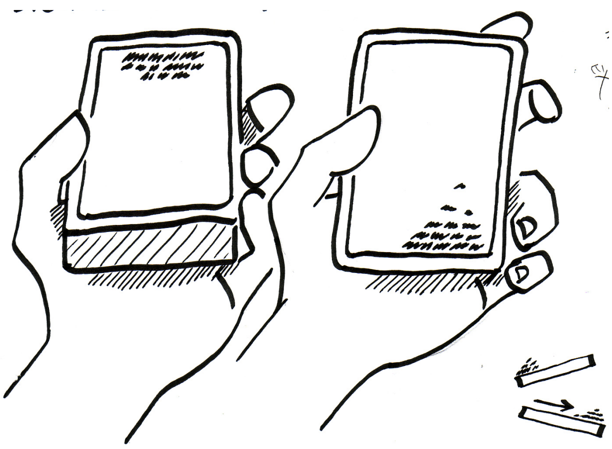

Figure 4: Principle of a tilt-sensitive PDA.

The material properties i-pattern is illustrated in the navigation technique, which is based on tilting the arm and the device for scrolling between pages of information. Similar ideas were introduced in the late 1990s for panning and scrolling information on regular handheld computers, with Harrison et al. [26] being one of the most influential sources.

A much more common class of examples of this i-pattern is found in the field of information visualization, where the information manipulation surfaces often draw on simulated material properties such as mass and inertia. The *Sens-A-Patch* interaction technique [30], for instance, is built around the idea of spatial persistency: that virtual objects stay in the spot where they are put, much like material objects would. The most obvious, even slightly overstated examples are perhaps the 1990s experiments by Robertson and colleagues [7, 33, 34], including the *ConeTree*, the *WebBook* and the *Data Mountain*, where information structures are presented in three-dimensional virtual spaces with very pronounced spatial properties.

In a sense, the ambitious »physics engines« of contemporary games aiming at visual immersion also illustrate the use of this i-pattern.

¶ Virtual information »forms« objects in the material world.

This is related to the previous i-pattern, but the main difference is that the virtual information in this i-pattern is moving out into the material world more explicitly. In the previous i-pattern, most examples seem to draw on the idea of bringing material properties into the virtual realm (as delineated by the edges of a PDA display, for instance). When virtual information appears to form objects in the material world, on the other hand, it acquires not only material properties but even material existence in a rather strong sense.

Augmented reality, which is a comparatively well-established field, provides the most obvious examples of virtual information as material world objects. Most augmented reality work has relied on visual superimposition of virtual information onto the material world through semi-transparent headworn displays. Other approaches include projection or, more recently, peephole displays as illustrated in seminal work by Fitzmaurice [19] and more recent adaptations such as Yee [40] and Fällman et al. [21]. In the *Slide Scroller* by Fällman and colleagues, for instance, a virtual information surface such as a web page becomes a static object on a tabletop. The object is revealed by dragging a viewing device across the surface of the table.

Figure 5: The Slide Scroller.

Figure 6: Interaction in first prototype of Vala's Runecast (images from Gislén [24]).

The inspection device, the *Slide Scroller*, was built by simply combining a PDA and an optical mouse (refer to Figure 5). The practical utility of the i-pattern for tasks such as viewing a web page on a PDA is questionable, but there are other applications, mainly illustrated in the field of augmented reality, where the i-pattern holds greater potential.

¶ Material object qualities influence interaction qualities.

It is common knowledge in industrial design that certain material forms and properties afford certain types of manipulation. For instance, a round shape with a smooth rim which protrudes only slightly from the surrounding surface and yet is clearly a separate object (in other words, a button) tends to be pushed rather than twisted. More generally, this i-pattern reminds us that when material objects are used as interaction points for mixed-media artefacts, then the material qualities of the objects should be aligned with the desired interaction qualities.

A simple example here is *Vala's Runecast*, an art installation and interactive movie on the theme of the ancient Icelandic prophecies in the Völuspa [37]. In the first prototype, described by Gislén [24], the user interacts with the Vala—the fortune teller—by moving rocks on a bed of white sand (refer to Figure 6). Since the rocks are rather heavy, the moves have to be made quite slowly and tentatively, which works well to reinforce the general enigmatic and reflective nature of the piece and the Vala's statements.

¶ Heterogeneous virtual information fuses into a few sensory parameters.

If virtual information from multiple sources is fused and mediated through a few sensory parameters—what is sometimes called extreme fusion—it can convey a sense of presence and connectedness to phenomena that would otherwise go unnoticed. Extreme fusion is typically deployed in the design genre of ambient communication, where the aim is to work in the corner of the user's eye: to provide more or less subtle information at the periphery rather than loudly demanding the user's full attention.

Jeremijenko's *LiveWire* (also known as *Dangling String*, discussed in [39]) has more or less become an icon of ambient communication, or calm computing as it is sometimes called. A string of rubber is suspended from the ceiling in the corner of an office. The string is connected to a rotor which rotates in proportion to the amount of data flowing through the local network at that location. When data traffic is slow, the string barely moves, whereas it spins and dangles more intensely during high traffic. The digital metabolism of the organization is thus made visible in unobtrusive ways that yet provide means for gradually learning to read the state of the department and the workload of the closest co-workers. A more instrumental example is the *Ambient Orb*, commercially available through Ambient Devices (www.ambientdevices.com), a desktop lamp which combines a number of data streams off the Internet into two sensory parameters: color and pulsation. As a rather charming reminder of the late 1990s, the default setting of the *Ambient Orb* is to trace the Dow Jones index of the stock market. However, it can be reconfigured through a web page to reflect the state of other data sources.

The piece *Nothing Remains The Same* by Peter Hagdahl from 2004 is a recent artistic interpretation of the extreme fusion concept, with ambitions slightly closer to the focus of audience attention. It consists of five screens expressing different streams of data. The »news« screen, for instance, monitors and analyzes headlines and texts from the cnn.com website. The news are analyzed by heuristic keyword matching and the current valence of the news stream—how much good news, how much bad news—shapes the visualization (Figure 7) by controlling the parameters of two dynamic particle systems. In principle, a blue sky represents only good news whereas mostly bad news yields an ominous sky with dark clouds moving rapidly. The texts used to drive the visualization also stream rapidly across the screen (barely visible in upper left corner in Figure 7).

Figure 7: The »news« screen from Nothing Remains The Same. (Image courtesy of Peter Hagdahl.)

¶ Interactive and broadcast media combine to form a positive spiral of participation.

Platforms for social computing increasingly involve mixed media, and in particular some cross-media combination of interactive media and broadcast media. In order for a community to grow and develop, this i-pattern highlights the importance of aligning the interactive and the broadcast aspects of the cross-media platform for the community. If the interactive forum involves tools (in a broad sense) for collective creation, then the output of the collective efforts should be appropriate for broadcast which reaches a wider audience, creates an interest in the interactive forum and its possibilities, and eventually leads to greater involvement in the interactive forum and a more powerful community.

Figure 8: The 3D avatar world of Avatopia.

The main example here is *Avatopia*, a cross-media forum in public-service TV plus web for young people's involvement in societal development and change [25]. The interactive forum on the web was based on 3D avatar technology (refer to Figure 8) and contained mediating tools for communication, debate, and influencing the public opinion. Moreover, a core idea of the concept was to offer tools for collaborative creation of animated film, using the avatar environment as a recording studio and generating output suitable for broadcast TV. The expectation was for the film tools to serve as a general outlet for collaborative storytelling, presumably with an emphasis on opinionated, critical and satirical pieces, and for TV reporting from inside the interactive forum. When broadcast on TV, such results would increase the audience interest in participating in the work going on in the interactive forum, and eventually contribute to a positive spiral of community development. (Unfortunately, the project was discontinued for financial reasons before the film tools could be deployed.)

¶ Virtual information and functions are limited to certain times.

This final i-pattern can serve as a step towards grounding the virtual in the material world. The idea is simply that information and events in the virtual realm are connected to the passage of real time in the material world.

Games frequently make use of the real-time connection. For instance, the golf game *Tiger Woods PGA 2004* contains tournaments that can only be played on certain days. Another example is the *Avatopia* virtual community mentioned earlier, where an early design sketch contained the idea of changing overall illumination with the time of day (or night) in the material world.

DISCUSSION

We have presented a small selection of i-patterns—i.e., abstractions that are intended to capture and disseminate generative design knowledge—in the field of embodied interaction. To us, the interaction design community is a discursive structure where knowledge is constructed through ongoing debate: contributions are put forward, assessed, elaborated upon, revised or rejected—and this debate is the very nature of knowledge construction in the community [31]. We suggest that i-patterns are suitable forms for statements in such a debate among interaction designers. Moreover, we suggest that the interaction design community is similar to many other design communities with respect to the discursive nature of knowledge construction. By extension, the use of i-patterns is proposed as a suitable form of articulation also in design communities other than interaction design.

A more or less obvious question to ask is why the i-patterns are as artefact-centered as they are. They describe properties and core ideas of existing and conceivable artefacts, but they do not detail intended use situations or discuss explicitly intended activities.

When abstracting from specific examples to core ideas, the abstraction process could, of course, be aimed in different directions. Our reason for abstracting towards core artefact ideas, rather than aiming to characterize use situations or activities, is to be found in the design-theoretical grounds for our work. More specifically, there is a class of theories about the nature of the design process which may be called matching theories. Broadly speaking, they suggest that when a designer faces a new design situation, she develops her initial direction by matching parts of her repertoire with the situation at hand. When an apparently suitable repertoire member is found, it is instantiated, contextualized and assessed against the situation at hand by sketching and other externalization techniques. As outlined earlier, the work by Schön and Lawson (among others) indicate that repertoire members are solution-oriented, or: artefact-centered. Hence our choice of artefact-centered i-patterns for designers to assimilate into their repertoires and use in new design situations.

What, then, is required when entering a statement in the debate—when presenting an i-pattern? What are the criteria for »publishable« work of this kind?

As pointed out earlier, our work departs from the HCI patterns mainstream in that we concentrate on statements that we intend to be inspirational and repertoire-widening for designers, rather than capturing proven successful solutions to recurring design problems. How can we argue that a certain i-pattern is worth considering if it is not validated in actual use? The argument has two strands, and they are closely related. First, the decision not to require validation from actual use does not mean that anything goes. The act of judging a potential i-pattern is where our **experience** as designers of embodied interaction is concentrated and articulated (refer to Holt [27] for a discussion of the relation between judgment and experience). The calibration exercise described in the appendix seems to indicate at least that the judgments in our group coincide to a greater extent than random chance would allow. When we claim that a certain i-pattern is worth considering, we also claim that we—as experienced interaction designers—view it as a signpost pointing to parts of the design space that we would like to encourage other interaction designers to explore.

Secondly, and following the argument of Dunne and colleagues [12, 13, 14], we acknowledge the value of conceptual design proposals as a means of contributing to a **discourse**. In Dunne's case, the discursive position is that of critical design where the aim is to stimulate reflection on our ways of living with technology. For our purposes, the point that Dunne and colleagues provide is that an i-pattern proposing a conceptual design needs not be based on implemented examples, as long as the other participants in the debate (i.e., members of the interaction design community) can envision the proposal, assess it and argue for or against it.

To conclude, it follows from the design-community-as-discursive-structure view that contributions in the form of i-patterns should fulfill at least three criteria.

- An i-pattern must be described well enough for the recipient to be able to **envision** it.
- An i-pattern must be **grounded** in the sense that it relates to examples, use situations or other entities in the world which are available for further studies.
- An i-pattern must be **criticizable**, which means that it can serve as a statement in an ongoing debate involving supporting and contradicting claims, elaboration, modification, qualification, rejection and so on.

We have attempted to make our contributions envisionable, grounded and criticizable. Whether we have succeeded is left for the reader—the participant in the discursive construction of design knowledge—to decide.

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