ABSTRACT: In Interaction Design, we are presented with an opportunity to return to the designed object as a subject of enquiry with a new perspective. We suggest a reconsideration of form as the starting point for developing a deep understanding of computational things and an approach to dealing with their inherent complexity. Understanding the object as composed of both spatial and temporal form, we can use materials to design a ‘surface’ for experience that extends beyond the three-dimensional object. Presenting both theoretical considerations and design examples, we aim to discuss the potentials of a new perspective on form as a basis for design research and education.

KEYWORDS: interaction design, design research, design theory, design methods, form, material, aesthetics.

INTRODUCTION
It is sometimes said that design has shifted from product to process, from object to experience. With the convergence of digital media and computation into our everyday things, new and rapidly multiplying forms of information surround us and, in turn, change how we relate to our surroundings. Critical issues emerge in terms of understanding the transformation of relations between people and artefacts. With respect to the development of such a discourse in design research, interaction design serves as an interesting example of an approach to computational artefacts where it’s not the object itself but the way we experience it that is the central issue.

This shift from object to experience is but the most recent extension of a historical design discourse. The last century witnessed, in the form of the modernist project, a widespread reaction against preoccupation with surface and decoration as well as a renewed ambition of design as an expression of technological and social progress. Over the years, design discourse has been developed to include new methods to examine the role of the object in social practices, cognition and communication processes [2, 9], and within complete experiences of use [12, 15]. Central issues in the developing discourse have concerned transformations in notions of ‘surface’, ‘form’, and ‘experience’ in relation to the design object.

As our everyday things also become computational things, we must yet again work deeply with questions of how traditions in design and technology need to be developed to address these new design issues. In the current situation, where methods, practice, and pedagogical models are rapidly converging, there is a need to re-establish and further develop both a theoretical and practical common ground in the domain of interaction design.

In relation to these critical notions of form and experience, we present here our approach to dealing with the complexity of computational things along with examples from diverse projects to illustrate aspects of the discussion. Perhaps contrary to predominant perceptions, we think there is reason to believe that interaction design turns our focus back towards the designed object itself rather than further away from it, and that taking the object as a subject of enquiry can lead to a better understanding of the emerging problematics. Our starting point is that the object we’re about to design in many ways is unknown to us – and to design a thing, we need to understand what it is.

THE UNKNOWN OBJECT
When designing a classic design object such as a chair, there are long traditions embedded in the practices of designing and using chairs that are not easily escaped. When designing a computational thing, however, not only the object but frequently the entire object category will be new to us. The effect is that our understanding of the objects we set about designing is extremely limited. Lacking such a fundamental understanding of the object, studies of possible situations of use, the needs and desires of potential users, and methods from other domains of practice have become tools for navigating an unfamiliar design space.

Studying the designed object itself has seemingly been given less attention. While our knowledge of technology is increasing rapidly and dramatically, our understanding of the computational object – as it appears before use and
FORM RECONSIDERED

There used to be a more or less direct correspondence between the complexity and the size of a thing. More complex inner workings usually entailed a bigger object and thus a larger surface for expression and explanation. To a great extent, the mechanisms of early technology were visible to us and so their surfaces were in many ways self-evident. Consider, for instance, an old train where the force is visibly transferred from the engine through the wheels and levers. Even modern technologies like the computer, to some extent, had such a surface in the beginning when the device itself was the size of a building.

With miniaturisation, all this changes. There is no longer any correspondence between the complexity of the surface and the complexity of the inner workings of an object. According to Maeda, this has two fundamental implications: for the user, it is no longer possible to judge the object by its exterior; for the designer, there’s a dramatic reduction in space available for expression. These are conditions for the need to work with dynamic surfaces – he writes: “The contemporary solution to the reduction in design volume has been to compensate for physical space with virtual space./…/ Hence, although we might consider an object restricted in a spatial sense, its dynamic surfaces allow the object to transcend those restrictions through expression along the never-ending dimension of time” [10, p. 25].

The idea that there is no longer any direct correspondence between the spatial surface and the complexity of the object, and that the solution lies in moving into combinations of spatial and temporal form, points us towards the basic reasons why computational things are complex – namely that the ‘surface’ for expression we are working with is more than three-dimensional. To approach a deep understanding of this new surface for expression, we need to analyse how it is made up and how the basic materials are used.

If we start with computational technology as a material, its primary form elements all have to do with time and the temporal structures that are created as programs are being executed [13]. Thus, this material not only makes it possible for designers to work with temporal form, it requires us to do so. These temporal structures, however, need to be given some kind of spatial manifestation. At the level of actual computational processes, the hardware and low-level programming, there are technical constraints on how this can be done, but on the more abstract level of how the thing finally appears to us, there are significantly fewer restraints.

One way of approaching this multi-dimensional surface, therefore, is to consider it to be made up of the temporal form stemming from computational processes and the spatial form elements used to manifest them. As discussed above, the expressiveness of the spatial surface of objects is insufficient for dealing with the underlying complexity and so our focus needs to shift towards how to use temporal form to express this. This also explains why any attempt at reducing this complexity to what can easily be presented on a spatial surface is likely to fail, or at least generate a range of inconsistencies in terms of representation.

Another consequence is that, to some extent, it is not possible to separate form from interaction, since temporal form is manifested through spatial form elements in use. A new role...
for studies of ‘use’ of computational objects becomes necessary – even though we might not be primarily interested in the needs and desires of ‘users’, interaction processes becomes central since the (temporal) form we are interested in will only manifest when the object is used. Thus, we need new methods for working with situations of use and interaction in the design process, not necessarily to uncover the needs and desires of users, but to investigate issues related to the form of computational things (cf. [5]).

The notion of an interplay between spatial and temporal form provides an alternative account for why computational things are so complex to design that does not reduce this question to the fact that the technology itself is complex. Since the technology itself puts few constraints on form at the level of appearance to users, it is clear that at least some of this complexity thus comes from the interplay between spatial and temporal form.

STUDYING FORM

We have been examining spatial and temporal form in order to build a deeper understanding of material, expressions, and appearance of computational objects in use. As a starting point, we have been working with two ways of approaching ‘form’ in the design of computational objects. First, we investigate how combinations of materials create new possibilities for expression. Second, we explore the form of an object from the perspective of interaction, i.e., how the relation to and appearance of an object might change over time as a response to use and user.

In taking the computational object as a primary site of enquiry, the first approach investigates the possibilities for form from the basic material combinations and qualities outwards whereas the second approach brings characteristics of use and context into the formation of the object. Working, thus, from the inside out and vice versa, we approach an understanding of the computational object as built from spatial and temporal form aspects that are fundamental to both materials and to use.

From the perspective of materials, the issue of temporal and spatial form concerns not only how to manifest computation, but how to consider combinations of materials that build the object. In the computational object, traditional materials such as plastics and textiles must be treated in combination with computational materials, thus fundamentally changing the way we relate to them (cf. [6,7]). In this way, traditional design materials can act as a kind of looking glass for investigating the potentials of computational technology, a means of exploring the range of spatial expressions for immaterial processes [7]. At the same time, computation introduces new form elements and so our perspective on a primarily spatial surface shifts towards an interest in behaviours and transformations over time.

As an intersection of spatial and temporally-based materials, the nature of the object not only comprises new material possibilities and expressions but also a range of experiences that emerge through use over time. Since the spatial surface itself lacks the extensive expressive possibilities needed to expose and explain the inherent complexity of the object, it’s no longer possible to ‘interpret’ computational objects by just taking a quick look. In considering that the understanding of an object is something that unfolds over time, it’s clear that the object will need some time to present itself to us, and people will need to start to ‘use’ it in order to find out what it is. From the perspective of use, we can investigate what it means to design a relationship with a computational thing that will last and develop over time – in effect, an object who’s form is fundamentally constituted by its temporal manifestation.

Approaching the computational object from perspectives of materials and use, we examine the object from the inside (materials) out and from the outside (interaction) in. Since form as both a spatial and temporal notion challenges existing ideas about how we use materials, we can work with form on the basis of how materials can be used. Since this notion of form also challenges the way we think about what the process of ‘interpreting’ an object needs to be like, we can also work our way into form on basis of how we relate to and experience the object. In taking the object as a site for enquiry, we examine an intersection of materials and interaction that are both spatially and temporally based, and consider the resulting implications for form.

DESIGN EXAMPLES

In order to ground a discussion of the problematics of form in the computational object that has been investigated, we here present some illustrations drawn from recent projects the studio has been involved in. These are design examples that have been developed as research and design projects with diverse collaborators and stakeholders (for specifics, refer to the Acknowledgements section below), involvement with education through particular curricula (e.g., [16, 17]), and expertise drawn from multiple disciplines. While the configuration of each project is thus quite particular and with questions of their own which are not addressed here, they give insight into notions of spatial and temporal form as a basis for, e.g., combining different design disciplines and materials, as well as for dealing with the embodiment of processes and interactions with objects. Thus, rather than illustrating a single coherent investigation, each example represents different design situations and outcomes where the interplay between form elements has become central. At the PLAY studio, we have been working with a conceptual framework for investigating the nature of the computational object is from two perspectives:

- On one hand, we conduct experimental studies of material combinations and emerging dynamics of expressions, and explore the potentials for in relation to objects.
- On the other hand, we conduct experimental studies of interactions and behaviours over time and explore the resulting implications for form.

In this way, our approach circles around the notion of form, exploring deeply the emergent expressions and interactions
which have expanded and raised new challenges for the design object. Our work takes these two approaches as a methodology for conducting an enquiry into form, material and object, with the intention of producing examples to develop a deepening understanding of form.

The Information Deliverer

In the Information Deliverer [7, 18], we focused on expressing and amplifying the complex relations between spatial and temporal aspects of information processes. In a series of “abstract information appliances” [5] made for the Borås Art Museum, we explored what the art of using computational things might be like by taking basic information-handling acts – such as reading, writing, opening and delivering information – and isolating, re-interpreting and amplifying them in ways that could invite reflection upon how we relate to technology. Textiles and textile objects were used to create such new interpretations, investigating how particular expressions of materials are used to manifest computational processes and acts of interaction.

The installation consisted of ten 2 meter-high tubes, under which computer-controlled fans were used to 'deliver' about 50 pieces of information printed on textile pieces during the course of each day of an exhibition. Over the course of the day and the installation period, news collected in piles, where reading involved a UV-lamp as a navigation instrument for locating and making text visible. Here, information delivery involved the behaviours of textile pieces in air flows and an accumulated landscape of news. Reading information, thus, become a matter of trying to make sense of the complex structure of all these pieces using a designated instrument to read a few pieces at a time.

In this way, the project re-thinks how and what materials are used in the design of an information appliance. The complex patterns of how the fans are turned on and off by the computer controlling the process of delivering information created unique patterns of flying fabric. Between the tubes, a spatial structure developed out of escaping pieces of fabric which came to rest as a trace of information 'delivery' until someone (re-)moved them. In this sense, the whole installation becomes a 'display', an object presenting the results of computational processes on a spatial surface, in this case illustrating the rather complex interplay between temporal and spatial form elements over time.

The Interactive Pillows

In the Interactive Pillows [18], we examined the implications for temporal form when introduced into the expressions and techniques established within the textile domain. Working closely with the qualities of material construction, traditional textures and electronic components were combined in a fabric and shape to seamlessly inhabit the intimate domestic
The interactive pillows come in pairs and are connected wirelessly to one another though located at a distance, for instance in the homes of distant family members. Leaning against, touching, or hugging one pillow activates its pair – a soft, textured pattern, created by electroluminescent wire integrated into the textile weave, glows ambiently to represent remote presence.

Experience reconfigures the notion of ‘form’ in the pillows. On one hand, the primary modality of the object is, literally, to act as a pillow, particularly since the necessary synchronicity in both locations is only occasional. Additionally, it’s a precondition for interaction that the pillows work by means of their familiar shape and appearance, inviting natural behaviors in sync with the rhythms of domestic life. On the other hand, through computational interventions in the basic materials forming the objects, the pillows take on additional properties when actually in use. Beyond the object category given by its spatial characteristics, the ‘pillow object’ effectively takes on additional role of a ‘lamp object’. Further, the meaning of this new role is communicative - the immateriality of light signals an extension of the use of the object across space, of sharing a similarly immaterial temporal dimension with another.

The interaction technique is quite simple in the pillows as a result of integration of the material (weaving technique and shape) and immaterial qualities (dynamic pattern and communication). Combining the materials into a single spatial surface with a clear primary role opens possibilities for additional modalities to be revealed through use, since it is in use that the computation and temporal materials come into play.

**Sonic City**

In the project Sonic City [3, 11, 19], the focus is on temporal and spatial conditions as materials, where interplay between these is designed to form a new kind of experience. As a starting point, we investigated the possibilities for media content that would reflect and change in relation to people’s natural behaviours and in everyday life, in contrast to the static experiences available through common consumer electronics. A system of bodily and environmental sensors was developed and mapped to a small processing device, which generates music in real-time based on personal and local conditions. With Sonic City, even a mundane activity becomes a sort of musical composition - taking a walk, for instance, generates a personal soundscape through natural rhythms and conditions along the route. Thus, content is a co-creation of an individual and their surroundings – in this project, the implication is that lived time and real space are not only materials in the composition of the experience but are active factors in the production of the experience.
Since the experience itself is integrated seamlessly into the basic materials of everyday life, we also had to reconsider notions of form – the typical boxes and button interfaces for music content were not relevant in this sort of lived experience. Instead the form that the interaction itself takes was examined. In the prototype, the selection, characteristics, and location of sensors on the body are the tangible connections between lived and digital experience – they are designed as ‘plug-and-play’ elements that enable choice through selection of connections and flexible physical extension of the sensors to any place on a wearable garment. Thus, content and its relation to local and personal factors can be actively discovered and altered tangibly. In this, Sonic City rethinks the nature of the device, literally extending the form of interaction with content ‘outside the box’ and in a way that relates to the everyday and active nature of the experience.

**Tejp**

The Tejp project [8, 19], explores how temporal qualities can shape the social and spatial form for a communications system. In the project, a series of audio tags were developed as simple devices for recording and listening to 20 second-long messages. Intended to be numerous, disposable, and readily available, the tags can be placed in public places where play back occurs when people approach them and messages can be recorded over. Designed deliberately for public appearance, audio tag boxes present technology in a harmless manner and blend (nearly) seamlessly into street infrastructure, their ‘voice’ often being the first point of contact with the system. As an open platform for expressing presence, the tags are a platform for many-to-many communication, where content is limited only by duration and medium.

Using simple, recycled components, the technological constraints are negligible in the design of the Tejp tagging system – enabling a shift in design focus to the use experience as it evolves through adoption in and adaption to public spaces. The tags act as an evolving sounding-board for a locality, where expressions are input in one’s own time and space but output unexpectedly and publicly – such that new patterns of local conversations can result, such as ‘call-and-response’ forums that take place over extended periods of time. The detachable tags are easily removed for re-placement in relation to other existing things in the environment, giving a spatial dimension to messages. Multiple tags can be situated in relation to one another, enabling a narrative structure distributed over the time and space of people passing by. The central actor in the communication experience is time – the limitation on the length of message, the short-term ‘memory’ of the system through continual message replacement, and the asynchronicity of an
experience that is designed for continual spatial and temporal reconfiguration. In the audio tags, the design of form is in the explicit creation of a system with minimal fixed elements beyond the length of the message – the rest of the ‘system design’ is left to the evolving and open-ended nature of public expression, where distribution over time and space becomes the primary material.

**CONCLUDING THOUGHTS**

The wider notion of form advocated here can provide a basis for understanding the complexity of designing computational things. While this complexity certainly has to do with the technology itself, it is also the case that emerging design problematics – objects with ‘surfaces’ that extend beyond three-dimensional form, where the main expressiveness comes with temporal form elements – are complex in themselves, especially if we try to approach them with traditional ideas about form and the idea that it is primarily the spatial surface that explains and expresses the object.

Through analysis and by example, we have tried to illustrate certain relations between form and experience. For instance, when we introduce new form elements, we also create openings for new interpretations of familiar objects. Through embedding potential temporal expressions into the surfaces of the interactive pillows, the domestic object is transformed into a communication device. In Sonic City, temporal form factors challenge our expectations of the spatial form elements of an object as the device is literally brought out of the box. In both, the notion of space is still important, but in terms of the dynamic space of the object as it responds to temporal and contextual information.

With respect to the treatment of temporal expressions, Tejp and the Pillows represent two different approaches: where Tejp sequences expressions over time, the Pillows distribute expressions across space. The way the temporal dimension is treated thus implies two different interaction models: in Tejp, a conversational, turn-taking model and in the Pillows, immediate shared presence through gestural interaction. These examples illustrate that there could be a clear connection between the way temporal form is treated and the resulting experience in use.

In relation to the spatial distribution of materials, the Information Deliverer illustrates how a space builds over time as a result of computational processes controlling the movement and distribution of spatial materials. This, however, also includes the changes made to the surface as users employ ‘instruments’ to read the information, sifting through information at their own speed. Thus, spatial form develops as a result of temporal form. Whereas, in Sonic City, computational material in the form of sensors are distributed over body-space for (re-)configuration of temporal, sonic expe-
rence. Further, since spatial form controls computational processes (through sensor input), temporal form develops through mobility through city space. Both are examples of how form needs to be addressed both inwards and out (from materials to form) and vice versa (from interaction to form).

All four examples also illustrate the rather important fact that the ‘form’ that we are interested in here is not entirely determinate. Whereas starting points are clear, aspects of what will happen afterwards remain open. Not only does temporal form change over time as different interaction processes take place, the spatial form also changes – in the Information Deliverer, the transformation is permanent; in the Pillows it is temporary. This, again, points us to the previous observation that the form of the computational object depends on both the materials that build the thing as well as the ways we interact with it.

In this paper, we have raised the notion of temporal and spatial form in design as an approach towards addressing new challenges with computational properties in everyday objects. Since such objects are in more respects indeterminate in terms of both materials and use, we propose a design research approach based on ‘the object as experienced’, or use considered in terms of both spatial and temporal dimensions. While ‘use’ is central in interaction design practice and pedagogy, it is necessary to recognize a difference between the problem of form in design, which is what we have addressed here, and the use of objects that come about as people make them a part of their activities. Each approach requires the development of frameworks relevant to practice, theory, and education in this convergent domain where design meets technology. Since ‘use’ is one of our primary ways of working with the (temporal) form of computational things, we believe that such a wider notion of form could be the basis for such a framework for design.

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