

Designing Web-Connected Physical Artefacts for the ‘Aesthetic’ of the Home

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ABSTRACT

Web-based technologies are often built to capitalize on the flexibility and fluidity that is supported by the internet, with the value of ‘access anywhere’ underpinning a blurring of boundaries across home and work. Yet the home is well known in HCI to have a unique set of qualities that can usefully be drawn upon when designing to support domestic life. In this paper we ask what it means to design *domestic* web-connected technologies, placing the aesthetic and material properties intrinsic to the home and home life at the centre of our design exploration. We present three concepts that were selected and prototyped from a broader process of research-through-design: *Tokens of Search* provides tangible handles to web resources; *Hole in Space* connects the home intimately to a remote place; and *Manhattan* enables the tangible exploration of events in the community, putting the home at the centre. Discussions in the paper consider not only how aesthetics is articulated in the material and digital properties of the artefacts, but also how a consideration of the properties of the home can create a potentially new design space to explore.

Author Keywords

Research through design; domestic; tangible; search.

ACM Classification Keywords

H.5.2

INTRODUCTION

The third wave of HCI was a response to the spread of technology from the workplace to our homes and everyday lives [4]. With the increasing proliferation of mobile devices and cloud-based technologies, this spread might now be seen more as a blurring of boundaries: personal mobile devices are used at home and at work, the ‘bring your own device’ to work movement represents a radical shift in typi-

cal IT policies, and email and documents can be accessed in both locations (as well as the spaces in between), whilst the applications that they run on are hosted ‘in the cloud’. The benefits of this flexibility, fluidity, and portability are obvious, yet a design process that places access-anywhere at its centre misses the opportunity to build upon an alternative set of values: those associated with designing for a *particular place*. In this paper we ask what it would mean to design *domestic* web technologies; those specifically created for the material and aesthetic properties that are intrinsic to the home and home life.

This approach has been strangely overlooked when it comes to the web, yet it is one with a long history. After all, it is well known that the home has a unique set of qualities that can usefully be drawn upon in technology design. Perhaps one of the challenges of designing for this space is that the domestic environment is not all about *doing* things. To really design for the home means moving away from the concept of ‘task’, to a consideration of how the physical environment itself is actively constructed in a way that supports its occupants’ values, needs and ways of being. This approach has been described by Leonardi et al. [19] as appreciating the home as a “territory of meaning”, a view that resonates with the work of Miller [24]. We draw on Miller’s work in particular in this paper. He asserts that people and materials establish a microcosm within a household, and that the ordering of the patterns of the relations of people and materials can be understood as an ‘aesthetic’. Harmony, order and balance, as well as dissonance, contradiction and irony, are generated in and through the material qualities of the domestic environment.

This paper presents a design exploration that resulted in the development of three web-connected artefacts for the ‘aesthetic’ (following Miller [24]) of the home. *Tokens of Search* provides tangible handles to web resources; *Hole in Space* connects the home intimately to a remote place; and *Manhattan* enables the tangible exploration of events in the community, putting the home at the centre. Our contribution is twofold. Firstly, we demonstrate how placing the aesthetic of the home at the centre of the design process for web technologies results in novel experiential concepts and opportunities for new kinds of uses. Secondly, we explore

further what constitutes the ‘aesthetic’ of the home for the design of interactive domestic artefacts.

BACKGROUND

While the home has been studied within the HCI community since the ‘90s [37], it remained a largely neglected domain until the concept of the ‘Smart Home’ was articulated at the beginning of this century (e.g. [15]). Studies exploring this concept have been predominantly technological, with an emphasis on thinking of the domestic environment as a computational ecology.

This techno-centric view of the home has been critiqued in a number of ways. Harper [14], for example, notes that while many modern domestic technologies were foreshadowed by the idea of the Smart Home, the way people have adopted these technologies and integrated them into their domestic practice was not. Taylor et al. [36] went further, observing that the concept of the ‘Smart Home’ presented intelligence as a property of the environment rather than of its inhabitants. They argue that making a home truly ‘smart’ entails designing to support the people within it, those who “imbue their homes with intelligence by continually weaving together things in their physical worlds with their everyday routines and distinct social arrangements” [36:383].

Web at home

While the vision of the Smart Home is largely unfulfilled, technology has become an integral part of domestic activity in many households [20]. The spread and diversification of web use in homes has been propelled by the uptake of internet-enabled devices and the availability of web connectivity through broadband and Wi-Fi. This proliferation has led much of the research on web use at home to focus on how existing devices, such as mobile phones [26] and notebooks [31], are used in this environment. When it comes to creating new web technologies for the home, the Smart Home vision becomes apparent once again. Maekawa et al. [22] present a ubiquitous sensor network that monitors daily routines within a household and connects them to a web search engine, with the result that, while cleaning clothes for example, a message could be displayed about how to best remove stains. Surie et al. [35] adopt a similar approach, displaying information in various screens throughout the household, and automatically triggering various devices to function based on the actions of inhabitants.

This activity-oriented approach is certainly familiar in research on web use (e.g. [33], [18]). Yet Lindley et al. [20] have recently argued that the notion of ‘web activity’ has limitations when unpacking how the web has become an integral part of everyday life. In the five modes of web use that they present, only one relates to practically-oriented action. Their observations indicate that the web is also a way of constituting leisure time, and frequently provides a backdrop to (or escape from) the ‘activities’ that one is supposed to be engaging in. This suggests a design space that moves away from the notion of web-based activity, and

instead considers how we can design for the way that the web is integrated into domestic practices, and domestic spaces, more broadly. Concepts which provide examples of how this might be accomplished include Gaver and colleagues’ PhotoStroller [10] and Prayer Companion [9], both of which draw on web content and present it via artefacts that are carefully designed for the homes that they are embedded within: a care home and a nunnery.

The PhotoStroller and Prayer Companion are both physical artefacts, and as such they resonate with a wealth of HCI research that has demonstrated the importance of materiality and *place* in the organisation of home life [6]. Building on this, recent work by Odom et al. [28] has indicated the importance of knowing *where* virtual possessions are; doing so gives a sense of reassurance and feeling of ownership of them. Relatedly, design research around the concept of technology heirlooms has indicated the value of being able to position digital content amongst other material things in the home [27]. Together, this work suggests the value of designing to enable digital media *to find its place* in the domestic environment; to be at home.

The ‘aesthetic’ of the home as a design space

In its broadest definition, Aesthetics is a branch of philosophy that examines the character of our experience of not only art but also of the natural environment. The term was first introduced by Baumgarten in 1735, to indicate “the study of sensory experience coupled with feeling” [1:12]. He argued that this provides a different type of knowledge from the distinct, abstract ideas studied by logic. Aesthetics has previously been considered as a pragmatist perspective on materiality, and it has functioned as an alternative to cognitive views for understanding design practices and environments [2]. In this paper, an understanding of aesthetics is also informed by research into material possessions, and contemporary anthropology.

Csikszentmihalyi and Rochberg-Halton’s study of the ‘meaning of things’ [7] revealed that the domestic space accommodates objects with a range of values, amongst which utilitarian values were considered less important than other types of meanings, such as memories, style, and experiences. The study draws on Dewey’s work and demonstrates that aesthetic experience is not only relevant to works of art, but also to other things, such as plants or books, which occupy domestic space [7].

Another view is provided by the anthropologist Daniel Miller [24] who discovered that people set up the material environment of their homes in a way that establishes a *whole* that builds upon patterns of relations. He called the whole an ‘aesthetic.’ To Miller the ‘aesthetic’ comprises perceptible visual aspects as well as the deeper patterning of people’s relationships with their material environment and with each other. An ‘aesthetic’ may help to convey something of the overall desire for harmony, order and balance, but it may also communicate reasons underlying dissonance, con-

tradition and irony. This approach to an ‘aesthetic’ is appealing as it captures the essential relations that characterise the physical and social landscape in a household and renders the most significant relations alive.

For the design of interactive artefacts for the home, a deeper understanding of aesthetics is important when moving beyond ‘expressionals,’ which are artefacts as bearers of expressions rather than function [12]. A holistic perception of the ‘aesthetic’ involves the consideration of how people in their households display orderliness with regards to their material landscape and how they interweave artefacts into their interactions.

According to Postrel [30], aesthetics is often approached as *authenticity*. She enlists two opposite ways to consider authenticity: outside-in, which sees authenticity as impersonal and generic; and inside-out, which recognises authenticity as personal and local. Characteristics of the first type of authenticity are purity, tradition, and display of history. Postrel argues that outside-in evaluations tend to underline an objective and unchanging character of what is considered authentic. In contrast, inside-out authenticity is characterised by formal harmony, balance, or delight; connection to time or place; or self-expression. These are subjective and dynamic characteristics, and are relative to the people who perceive, and to the purposes they bring into situations.

This paper argues for a consideration of the ‘aesthetic’ when designing for the physical landscape of the home, with an orientation towards understanding relations between people and things. It considers how both materiality and interaction are situated in daily practices, and explores how purposes and identities may be enacted through web-connected material artefacts.

RESEARCH THROUGH DESIGN

We report discoveries from a project that investigated new opportunities to design web-connected artefacts for the home. We explored what constitutes the ‘aesthetic’ of the home for the design of interactive domestic artefacts through a process characterised as *research through design* [40]. To support aesthetic discovery the process was grounded on three strategic principles:

- a) being deliberately biased on what to consider,
- b) using versatile organised settings to guide designing,
- c) appreciating the evolving character of judgement.

The following exposition of the process displays how the aspects of designing characterised by the above principles were intimately intertwined throughout the process. The process resulted in many designs, three of which were developed further and are described in more detail here.

Engagement into the ‘aesthetic’

The two-year project (09/2010-09/2012) featured three main phases: concept design, prototype building, and field

studies with prototypes. Concept design began with ideation workshops in autumn 2010 and continued through co-design with mock-ups and prototyping all the way until the field studies in mid-2012.

Although it may be counterintuitive to have concepts that are not completely fixed before moving into the development of functioning prototypes, taking this approach left space for learning during the technical development and the user studies, and allowed us to incorporate the lessons learnt into the concepts themselves. Hence, the design concepts became the central carriers of what was learnt during the process about design opportunities for the web-connected artefacts. They were repeatedly returned to and revised, and ultimately became part of the design concepts.

In addition to concept development, a significant part of the process was dedicated to the construction of the prototypes, from mid-2011 until mid-2012. Field studies were run over the spring and summer of 2012.

Choosing what to consider

Through the project, our attention was turned to people and what matters to them in their domestic settings. Materials and patterns for interior design as well as smart materials were reviewed inasmuch as they were considered to contribute to the discovery of opportunities for the design of domestic web-connected artefacts.

Concept design was initiated in a series of four workshops, each of which was grounded in preliminary investigations of different kinds. The first workshop utilised a study of 24 households [19], presenting findings in the form of A4-sized hand-drawn portrayals of people and their homes. The second workshop was based on a taxonomy of web use [19]. The third workshop employed a design probe [23] study of five households and authored video portraits of the studied people in their home. The fourth workshop utilised an exercise to empathise with extreme characters, and to build an imaginary style with a blueprint of their homes.

We chose to work with methods that merged personal sense-making with the exploration of the prepared materials. The workshops were driven by collaborative sketching, pastiche working, and portrayal. Rather than treating the preliminary investigations as raw data, the team worked in an empathetic fashion with the materials, injecting their personal insights, aptitudes, and experiences into what use they made of these. Several methods, such as ‘Extreme Characters’ [8], ‘Pastiche Scenarios’ [3], and ‘Video Portraits’ [39] were tailored for the purposes of the project. Space in this paper does not allow us to present the full details of these, but to exemplify the approach, the use of video portraits is described below.

Video portraits were co-authored with volunteers in different kinds of households in the Helsinki Metropolitan area. The participants were chosen from different areas and varying socio-economic backgrounds. They first documented

their daily lives over a period of one week with a probe diary, which included questions and project-related design tasks. Then they were interviewed and recorded on video. During the interviews, the material landscape of the home was also documented. The video materials were edited into portraits that depicted one person at home. Five portraits, each approximately 45 minutes long, were prepared.



Figure 1. A screenshot of a Video Portrait.

In the workshop where the portraits were used, workshop participants watched the videos, discussed their discoveries, ideated potential domestic web-related appliances, and shared these with the whole project team. The workshop led to several ideas, which laid the foundation for prototyping later on. The workshop participants also resorted to their personal experiences and knowledge of the home when articulating their impressions and observations about the video portraits. Building on personal experience was an important aspect of the idea generation in the multi-disciplinary and multi-cultural project group, bringing yet another resource upon the imagination for the home. It is important to see that the ‘stuff’ that became considered in the project embodied a substantial amount of content and character stemming from the project team itself. This was not treated as a problem, but rather, as a resource.

Miller [25] uses the notion of ‘stuff’ to discuss the dilemmas related to how people find meaning in things. As part of everyday living, meanings evolve and are highly locale-dependent. This resonates with Postrel’s [30] articulation of the need to understand aesthetics in terms of authenticity, as a local and subjective phenomenon. The central dilemma that Postrel and Miller both bring forward is the interplay between the universal and the particular. The problem is to bring the details of the everyday into dialogue with generic forms, and to be committed to both extremes: the universal and the particular.

Versatile organised settings to guide designing

The strategy adopted in the project to address this dilemma was to study people and gain insights to their experiences, in order to arrange multiple events with different materials and varying agendas. Within these, particular experiences were juxtaposed with various contexts, different minds, and schemes of varying generality, but the desired outcome, to

design web-connected domestic artefacts to fit the aesthetics of the home, was held constant.

The generation of ideas, as well as their elaboration and review, was conducted in different environments, with different sets of people participating, and with varying procedures. This enabled the team to instigate different *frames*, as Goffman [11] uses the term, to approach the challenge. For example, each workshop was set up differently with regards to materials, contents, participants, and process. The place was chosen away from the office, three times in a folk museum exhibiting historic domestic artefacts, and once in a wood workshop. Variations were made with the intention of providing a broad range of different kinds of inspiration and information for the generation of ideas. The material and conceptual settings were arranged in particular ways to align with the attainment of the goals of each session.

In order to exemplify the process, let us consider the fourth workshop. It was organised in a wood studio equipped with various materials to quickly mock-up ideas as tangible shapes. The workshop participants were from a wide variety of backgrounds, including graphical design, furniture and spatial design, industrial design, human-computer interaction research, electronics engineering, computer science, sustainability, textile design, and psychology. The event was enacted according to a prepared script that the facilitator of the session followed, which gave a structure for action and achievement. It is possible to state that designing was framed by the space, by the physical mock-up materials, by the participants, and by the agenda and scripting of action. All these aspects functioned as organised settings that influenced what was expressed and how, including how things were juxtaposed with each other.

Forming judgment on designs

A central argument by Miller [25] is that it is not only we that make stuff, but stuff that makes us who we are. Explicit choices are made in order to display oneself in the desired way. The project can similarly be understood as an organism desiring to be displayed in a certain way through the material it evokes. It was the design team that made decisions pertaining to form, functionality and materials, which ultimately became the prototypes. They needed to cultivate their taste with regards to the particular agenda of the project in order to make apposite choices.

The challenge in the creative process is the dialogue between construction and evaluation. It only becomes possible to make judgements once there is something to be judged. Judgment grows in response to learning more about possibilities. Postrel [30:116] writes, “*If the meaning of aesthetics is to signal identity, and if that meaning arises from history, experience and personality, then aesthetic authenticity cannot lie in some pre-existing definition of truth. It must come instead from the match between form and desire. Authenticity is thus what “seems right.”*”

Judgment in this case was based not only on the domestic sphere, but also on the academic realm of human-computer interaction research. The project team had to make discoveries that appealed to academics as well as to the envisioned users of the prototypes. Moreover, the project team needed to investigate which web technologies would enable the desired kind of design.

To substantiate the argument, let us consider the evolution of one of the concepts, Tokens of Search. The idea originated in the fourth workshop in the wood studio. One of the participants presented an idea with a tangible mock-up, with small beads that could be associated with content and then tossed into a bowl for its later recovery. The generic idea was very easy to present, but it turned out to be the most difficult to realise as a particular design. Specific choices on the character and material form of the system, the technical platform, and the interactivity, all raised complexities.

The tokens were initially created of ceramic. The team members liked these poetic, jewel-like and fragile things. They foresaw how household members could communicate by placing the tokens in different places as reminders. Nonetheless, these were discarded due to their fragility and the difficulty of attaching RFID tags properly to them, and finally they were replaced with 3D printed similar shapes, which were judged as more appropriate for the purpose. These carried the poetic character of the ‘knot in the handkerchief’ as a reminder, they could be carried in pockets without getting broken, and they could accommodate an RDIF easily. They could be distinguished by different paints and shapes. Simply, they “seemed right”, although only after the experience of the ceramic failure.

During the process almost 200 design ideas were generated and reviewed with regards to the project agenda. The generation and selection of ideas with the most potential took place during the first 8 months of the project. In spring 2011 ideas were filtered to 46, which were then documented and reviewed carefully through an internal web-based review. Based on the review, 24 ideas were chosen for further discussion and documentation in a catalogue. This included concepts such as the *Token Bracelet*, a piece of jewellery not unlike a charm bracelet, and the *Inner Circle*, which would be a tool aimed at only your close or inner circle of friends and family. These catalogued ideas were elaborated and filtered further, with the result that three were chosen to be employed as instruments for the investigation of how to create aesthetic web-connected artefacts for the home. These were *Tokens of Search*, *Hole in Space* and *Manhattan*.

THE RESULTING DESIGN CONCEPTS

The three final design concepts explore different areas of the web, enable different kinds of uses, and afford different kinds of physical configurations. *Tokens of Search* explores what will happen if a household can start sharing web links in a tangible form. *Manhattan* collects information about

events around the household from web event repositories, and it displays these on its surface in the form of tangible blocks. *Hole in Space* provides a web-mediated view into another place and encourages physical engagement. Together these design concepts explore the potential for designing web-connected artefacts for the ‘aesthetic’ of the home and delivering new kinds of experiences that utilise the resources of the web.

Tokens of Search

Tokens of Search is a system that transforms web links into physical forms. Central to the system are tangible handles, the tokens, which bring the web out of the virtual world into the physical landscape of the home. This system is the most open of the prototypes in its support for appropriation. The role of the system in the household can vary drastically, depending on the web links that people choose to use, whether they are shared with others, and where they are placed. Tokens may point to a single web page or a collection of links, may be left in various locations around the home, and the device itself may also be situated where household members desire, be this in a hallway, kitchen, or living room (see Figure 2).



Figure 2. Tokens of Search prototype.

The physical designing was guided by two principles: 1) allow for versatile placement in the home, and 2) make tokens unique to support the negotiation of their meanings.

The prototype that exemplified the design concept included a wooden tray, a set of tokens, and a 9-inch slate computer. The tray was made of Finnish curly birch. Its shape was 3D modelled by an industrial designer, it was CNCd, sanded, oiled, and polished to communicate being a valued artefact that can be placed in a publically visible location at home. It featured characteristics that associate it with Postrel’s objective ideal of authentic aesthetics [30], as it embodied ‘pure’ real wood, it was finished according to ‘traditional’ means of handcraft, and it displayed its ‘history’ through the form that revealed its origin in the artful use of computing and drilling machinery by a trained designer.

Three different kinds of tokens were included: knots, bindables, and stickers (see Figure 3). The *knots* are painted and varnished 3D-printed shapes resembling real knots of

thread. They contain an enclosure for an RFID glass capsule, which is identified by a reader embedded into the wooden tray. Each token was made unique by the combination of its colour and shape. The *bindables* contain a small 3D-printed part for the RFID tag and a thread loop enabling them to be hung from or attached to material things. The *stickers* are plain bulk inventory RFIDs. They can be attached to postcards, books, and other objects in the home, and as soon as they are attached, they become physically identifiable too. Stickers were included to enable users to freely assign web links to the stuff in their homes.

The simplicity of the original idea for Tokens of Search proved deceptive. Different implementations appeared to exclude important benefits of their alternatives. The first version of the prototype was designed to require an attached RFID reader. The association of web links with a token could be achieved only through physical interaction with the token. The requirement for having the RFID reader always available was considered problematic. Thus an alternative design was implemented. It was based on having a web browser that would function as a window to the links associated with a token. The design resulted in there being only one RFID reader at the tray. The system was designed to communicate with a dynamic website through a WebSocket delivering real-time feedback from the RFID reader. Many web browsers could be active at once and deliver the contents of an active token.



Figure 3. Three different tokens: sticker, knot, and bindable.

A user study was conducted in three households to find out the implications of the browser based idea. Having only one place for reading the RFIDs appeared to limit the utility of the system dramatically for the users. This motivated a redesign that was based on the use of a resident application (see Figure 4) running on each of the households' computers. The data in the new version was synced across program instances using a WebSocket and PHP-MySQL implementation in the backend. The GUI was visually associated with the appearance of the tray and of the tokens.

The interaction design was guided by two design drivers: 1) support effortless assignment of a web link to any token, and 2) enable easy viewing and management of the content of tokens, even without the RFID reader. Imagined uses included the tokens as a vehicle for connecting to repeatedly used websites, for example, for diet or sports tracking, or web radio stations. Envisioned uses for the stickers included attaching these to holiday postcards, to support access to related blogs or journals created during a family trip. Other

uses, such as sharing notes or files via tokens, which would require cloud implementation, were also considered.



Figure 4. The graphical user interface of the resident Tokens of Search application on a user's computer.

In the final design a user could assign a web link to a token by dragging and dropping a URL from a web browser onto the Tokens of Search application window (as in Figure 4). A token could be selected by scrolling through visual representations on-screen using the cursor, or be assigned by showing a token to an RFID reader attached to the computer. The system was designed to support only one-to-one associations between tokens and web links in order to maintain simplicity through the interaction design.

Commentary

The idea of making tangible handles to web content has already been implemented and studied in different systems, e.g. WebStickers [21] and MyState [13]. These systems have been studied in the workplace, or focus on narrow areas of the web, such as Facebook. Tokens of Search was an exploration in a domestic context to give tangibility to almost any web-based digital and imaginary object. The system can be easily extended with the emerging support of mobile NFC to also cover the mobile scenarios that were discovered in our field studies.

With regards to the subjective and objective aspects of aesthetics as outlined by Postrel [30], the Tokens of Search design concept addresses the objective aspects of purity, tradition, and historicity, and the subjective aspects of 'formal harmony, balance, and delight,' 'connection to time and place,' and 'self-expressiveness'. The tray is reflected in the imagery used in the software GUI, and the overall shape and size of the tray and slate bear resemblance with each other. However, the industrial materials used in the slate and the natural appearance of the tray can be perceived to introduce a conflict in the harmony. The choice to leave the slate quite naked reflects the practical compromises and time constraints of the project. Further enquiry is needed to learn how well the prototype will build connections with a particular place, and to investigate if people find the tokens meaningful with regard to self-expression.

Hole in Space

Hole in Space creates a living connection from the home to a particular remote place that matters to the household members. These places, such as summer cabins and other locations with a strong personal bond, could be experienced through the device. The system creates an interactive visual stream from a webcam augmented by news headlines from distant-local news agencies and distant-local radio stations broadcasting through the web. Via its visual stream, *Hole in Space* conveys changes in daylight and weather thus allowing the household members to peripherally live with the distant place and experience how its overall atmosphere changes over time: the shines, storms, snows, and mists, as well as gradual seasonal changes in colour saturation.

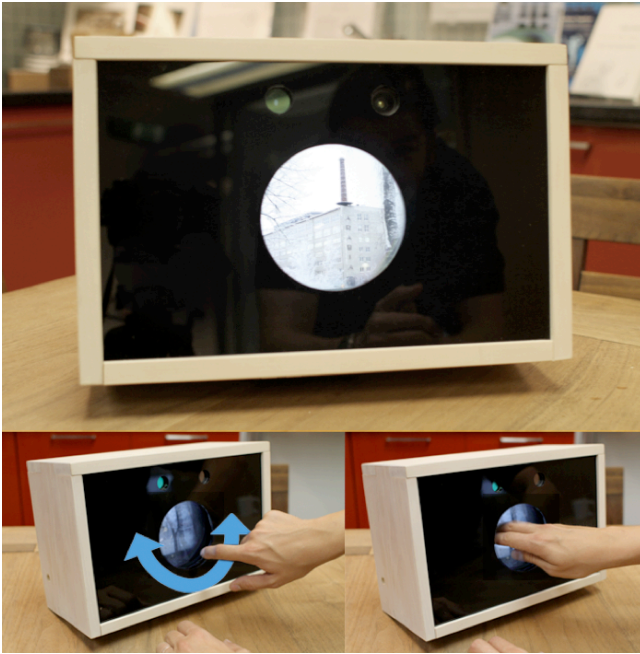


Figure 5. Hole in Space prototype and the tangible interactions enabled by the device.

The *Hole in Space* prototype was realised as a rectangular wooden box with a hole on one side that affords a user to peer into it to view the visual stream. The wooden frame, carefully handcrafted, features elegant dovetail joints and a birch-embracing natural wax finish. The black acrylic cover features a large hole to provide a restricted view of the remote location. The form and interaction style were designed with communal areas of the home in mind.

The front cover of the prototype conceals a set of sensors, a microcontroller, fans, and a tablet PC (Samsung Series 7 Slate) supporting a range of interactions. Capacitive sensing inside the rim of the main aperture in the front cover is used to detect a user's fingers moving along its edge (see Figure 5). An IR sensor detects when the user places a hand inside, and an OpenNI¹ compliant depth-sensing camera tracks the

proximity of users to the prototype. An additional system takes pictures from a webcam at a fixed interval (every 10 seconds) and stores these for the tablet PC to download and display. The device connects to Internet radio stations, and uses weather information from a web API².

Three design drivers guided the interaction design: 1) behave in a calm-but-responsive manner, 2) deliver a lead-in into full engagement, and 3) support fleeting interactions in an intimate way. The calm-but-responsive implementation invited users to interact with it by providing the lead-in into full engagement (see Figure 6).

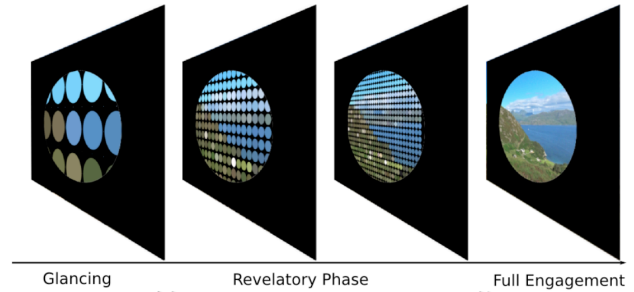


Figure 6. Modulation of visual information conveyed by the image based on user proximity.

This lead-in is built of an amorphous glance-pattern, which grows increasingly fine as the user approaches the device. The lead-in follows the principle “see more by looking closer”. As the user approaches the prototype the number of pixels displayed increases. Existing pixels shrink while new ones grow. This process continues until the user is approximately 30 cm from the prototype when the image is displayed in its full resolution. The harmony of the colours in the glance-pattern was achieved by uniformly sampling the pixels of the full resolution image. The resulting colour selection reflects broader changes in the original image such as cloud cover, time of day and seasonal features. An overcast day in Scotland creates a greyish pattern with individual circles of colour. In contrast an autumn day from a summer cabin in Northern Finland comes in various shades of red, orange, green, brown and blue.

The users are expected to use the device for short periods, and the interaction with the device was designed to call for intimate physical engagement. The fleeting encounter with the device is mediated by a tangible interface. Once at the hole, the user can browse news headlines as well as control radio stations by swiping a finger around the rim. When the user places a hand inside the hole, fans provide a physical sense of wind strength. The fan speed is modulated by web-based weather information from the distant location.

¹ <http://openni.org/>

² <http://www.wunderground.com/weather/api/>

Commentary

Studies of web-mediated experiences at home have explored being connected with other families and family members [16][32], but less so with place. Attachment to a place is a particular sort of relationship. A place does not communicate or tell stories, rather it is left to the person to perceive, interpret and read from what is made available through the device. The Hole in Space device draws from feelings of attachment and the evocation of nostalgia, and is perhaps the most sensuous of all the three prototypes that we built. It invites intimate encounters via a calm and harmoniously saturated view.

The wooden box with its dovetail joints can be seen as authentic, according to Postrel's [30] objective aesthetic qualities. The joints are handcrafted through traditional means. However, the laser-cut acrylic, which bears the mark of artificial construction, may be seen to work against a perception of the whole unit as an authentic aesthetic artefact. The subjective aesthetic qualities that Postrel enlisted do not fit well for an evaluation of Hole in Space, as it is essentially a living artefact that changes over time and in the course of interaction. Thus, evaluating its aesthetic quality would require further studies of how it fits the particular 'aesthetic,' in the sense of Miller [24], of some households.

Manhattan

Manhattan is a device that displays local events around a household and aspires to instigate an awareness of the imminent happenings around it. The events are gathered from web repositories and displayed through illuminated blocks that function as tangible indices to the search results. Once a column is pressed, event data from a particular area are displayed on a touch sensitive screen at the centre. Further details of the events are retrievable via the touch interface at the top-centre of the device.

The physical shape suggests the device be placed in a central location of the home, allowing multiple persons to explore it together. The box-like casing of Manhattan was painted white to avoid conflict with the colours of the home and to guide attention to the illuminated columns that inform about events. The illuminated blocks were made of translucent acrylic. Once events are found, mapped, and assigned to a particular column, it is lit up and raised. The events will then literally stand out from the environment.

The columns are illuminated by RGB LEDs and moved by individually controlled linear stepper motors. The casing encloses a mini-PC, two microcontrollers for handling the motors, LEDs and push buttons. Part of the system runs on a web server scavenging data from specified websites. It maps discovered events based on their address and generates a latitude and longitude value for each one, from available geospatial web resources. It also encodes the event data into XML formatted data structures, which are then retrieved by a Java application that runs on the mini-PC. The Java application communicates with the physical hard-

ware in order to deliver the desired visual and tangible result (see Figure 7).

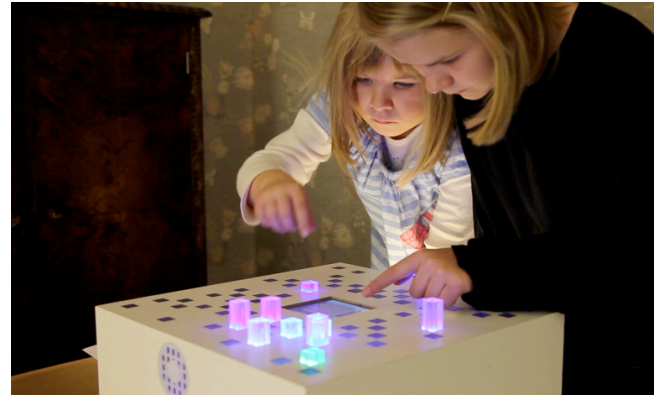


Figure 7. Manhattan prototype in use.

The design of Manhattan included co-design with a mock-up of the device in three households. Through this we learned that families can be frustrated by noise generated by products and toys, irritated by blinking lights, and that the lights of the device should only be on during the active hours of the family, at best from 5 – 8 pm. We decided to attempt a design that would subtly inform users about the availability of new events every hour, during the active hours of the day. Following the radar metaphor, we made a representation that appears to swipe through the blocks on the surface when there is new data, following which the blocks are raised or lowered and coloured accordingly.

Through the co-design we learned that the sources for event data that really matter for people may not be available through common event repositories on the web. Hence, we designed the system such that it would have a web interface for configuring the sites to be included for event search. We also learned that some households, such as those with grandparents, may be closely connected with other locations (such as their grandchildren's home), and others might live near locations where the notion of event information simply was not sensible. For example, for a family that lived by the shore, the area of the surface that would be mapped onto water would never contain events. Thus, the area to be mapped should be configurable, and allow for non-continuous areas. This could be managed via a web-based user interface, separate from the physical design, which also allows the minimalist design of the box to be retained. With an HTML5-based web interface, users could set their preferences for mapping more conveniently than through the small display in Manhattan.

As a result of the study we concluded the interaction design should be guided by three design-drivers: 1) inform about updates calmly, 2) provide configurability through an external web interface, and 3) use simple and learnable perceptualisation.

Commentary

Spatially distributed information is typically displayed on-screen, thus lacking the material tangibility that is characteristic of many artefacts at home. For example, the Whereabouts Clock [5] presents family members as graphical icons linked to the location of their cell phones. Spindler [34] developed prototypes exploring the tangible augmentation of table-top displays. His focus was on professional and public contexts, not the home, and his investigations addressed novel interactions with data rather than the system's aesthetic presence in a particular space.

We explored how to represent events in a tangible way, using a physical artefact as an alternative to a screen. The aim is to connect and give presence to events around the home in an embodied way, so that these become part of the 'furniture' of the domestic setting. Manhattan has a radical design where information is firstly encoded with physical elements, in terms of their movements and disposition in space. Moreover, lighting is used as an additional modality. Digital information in the form of text is presented through a touch screen. Elements have both mechanical movements and colour lighting. The result is that Manhattan has less the presence of a technology system and more of an artefact that is present in the periphery of one's attention.

When considering the aspects of aesthetics by Postrel [30], Manhattan does little to address the objective ones of purity, tradition, or historicity. The box is plain white MDF board and looks somewhat like domestic appliances – just another whiteware for the home. As a whole, it conveys a picture of an industrially manufactured domestic entertainment device. However, the device appears to provide some grip for the subjective aspects of aesthetic authenticity: formal harmony by blending in with other whiteware whilst also introducing colourful expression; connection to time and place through its data and interactivity; and self-expression by displaying only event data for places about which the people in the household wish to be associated with and involved in. It connects to Miller's [25] emphasis of the role of the subjective self that becomes constructed, reified, and altered in dialogue with and exhibited through the materials that one chooses to have around.

CONCLUSION

We explored opportunities for designing web-connected physical artefacts for the home. Three design concepts were created through a process where studies, portrayals of identities, and personal experiences were interwoven into concrete articulations of interactive ideas for the home. *Tokens of Search* provides tangible handles to web resources; *Hole in Space* connects the home intimately to a remote place; and *Manhattan* enables the tangible exploration of events in the community, putting the home at the centre. The material expression of these concepts through the prototypes conveys their multi-sensory appeal, but as we have argued, aesthetics is more than this. Materiality is central to the

ways in which people express and generate their identities in dialogue with their possessions (cf. [28],[17]).

The concept of aesthetics was addressed mainly through the works of Miller [24,25] and Postrel [30]. This enabled us to gain a conceptual grip on aesthetics at home in a way that rendered domestic aesthetics a resource for design. However, their work addresses interactivity only modestly. Further studies into the aesthetics of interaction (cf. [29]) could enable richer insights into the design of domestic web-connected artefacts. Our work is a starting point here. For example, it reinforces the importance of calmness, although not in the sense of creating technologies that are invisible (cf. [38]). The design concepts are calm in that they avoid drawing attention through sounds or sustained animation, they support fleeting interactions that require little cognitive effort, and they can be understood at a glance. But they are also designed to *be seen* and further, to enable the expression of self and of family through their integration into the material landscape of the home. Thus, they can support continued engagement and intimate encounters, as well as sharing and sociable use through their public availability [27]. Understanding these aspects of physical computing, where places and forms matter, may become increasingly relevant as 3D printing tools emerge.

The explorations presented in this paper illustrate how, by placing the aesthetic of the home at the centre of the design process, novel design concepts for web technologies can emerge. The shift from access-anywhere to integrating the web into the domestic landscape raises numerous challenges for design. Most complex of all are those that relate to the social and material aspects of home life, which address the question of how interactive artefacts, that resonate with the aesthetic of the home as a whole, can be created.

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