
Future of Ubiquitous Home Interaction with OUI Interiors

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Abstract

Herein, we survey a number of the latest Organic User Interfaces (OUIs) and discuss how these novel designs can be adopted to help build the next generation of domestic ubiquitous environments (smart homes). Our focus is specifically on domestic spaces, considering how surrounding surfaces (walls, floors, tables and ceilings) and interior objects (furniture, home accessories, appliances and fixtures) can, and might, through the use of smart materials, become organic and adaptive user interfaces that may interactively and reactively change their colours, textures, or physical appearances. We believe that the future of Human-Building Interaction (HBI) will utilize OUIs to enhance user experience in domestic spaces in a way that adapts living environments to fit inhabitants' idiosyncratic and personal preferences. Moreover, we begin to sketch out a few of the challenges to building digitally interactive furniture and objects such as supporting sustained user engagements over time and designing for daily use with both meaningful digital and physical representations.

Author Keywords

Organic User Interfaces; Ubiquitous computing; Human-Building Interaction; Internet of Things (IoT); interactive furniture; slow technology.



Figure 1: History Tablecloth [10]



Figure 2: EmotoCouch [11]



Figure 3: Shape-changing Bench [5]



Figure 4: Long Living Chair [8]

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction to OUI Interiors

Organic User Interfaces (OUIs) represent the third generation of display interaction paradigms and have recently seen increased interest amongst the wider ubiquitous computing (Ubicomp), and human computer interaction (HCI) research communities [3]. Essentially, OUIs are non-flat, flexible displays that include sensing capabilities, which in combination allows for more intuitive interaction in everyday environments. Within the paradigm of OUIs, everyday objects can be capable of both displaying information and being used as interactive interfaces, which can have flexible shapes and, beyond that, dynamically change their appearance, color, or physical form. OUIs use, for example, cameras, inertial measurement units (IMUs), capacitive sensing or thermal conductivity to detect user input interactions. OLED, e-ink, servo-motors or miniature steerable projectors are typically employed as output modalities. Equipped with such sensing and actuating capabilities, OUIs enable a range of interactive responses to user input that aim at leveraging the nuanced and complex ways in which humans already interact with and manipulate regular everyday objects.

The central idea of building 'OUI Interiors' is to turn everyday objects in private homes, such as furniture and interior accessories (e.g. mirrors, lamps, objet d'art), into interactive OUIs that can change their appearance dynamically either passively or actively responding to interactions with (or between) home occupants. By augmenting these objects with basic

sensing and actuation capabilities they can sense and respond to presence, movements, or gestures through alterations of their appearance or shape with the goal of exploring how this might engage, motivate and inspire inhabitants and stimulate or provoke new artefact-related meanings for them.

Exemplar OUIs

OUIs have the potential to play a key role in next generation interaction scenarios, especially in domestic environments where users increasingly interact with embedded technology in their everyday life routines [6]. As such OUIs also play an important role for the dawning age of the Internet of Things (IoT). Examples of existing domestic OUIs range from surface computers [1, 2, 8, 16], interactive furniture and accessories to the multitude of different types of e-paper, e-textiles and other deformable and malleable OUIs [12, 13, 18].

Previous work on interactive furniture include EmotoCouch [10], shape-changing bench [5] and Long-Living-Chair [14]. Each of which was designed as an interactive piece of furniture with the aim of studying users' experience of such responsive designs. EmotoCouch [10] was designed as an emotion color-changing couch that changes the color of its embedded LED into several emotional states with the aim of studying how furniture can be dynamic –rather than static- and potentially expressing emotions and how this might affect home occupants by delighting, comforting, exciting them or encouraging social family activity. Shape-changing Bench [5] is a horizontal bench seat that changes its height and angle using embedded linear actuators to explore sense-making and users' experience with its affordance, transition

and interpretation of such a physically dynamic object. On the other hand, Long Living Chair [14] is a rocking chair that detects and stores –in an internal memory– the frequency and pace of its usage along the months and years. Focusing on this single function, and promoting slow interaction, Long Living Chair acts as any normal chair in the sense of affordance, aesthetic and interaction. Thus, encouraging users to forget it is actually digital and allow it to blend in the background avoiding any over or under-use while evaluating user experience of such a delighting and comforting artefact.

Examples of haptic decorative accessories are History Tablecloth [4] and Interactive Decoration for Tableware [9]. History Tablecloth [4] is an electronic plastic lace-like tablecloth designed to glow its artful printed patterns when objects are left on the table, with a halo that grows over time. The aim of designing the interactive History Tablecloth was to create a domestic resource of social interaction, encouraging home occupants to explore, speculate and wander, providing them with engaging opportunities for new activities and enrichment of existing routines. Alternatively, Interactive Decoration for Tableware [9] explored designing patterns and motives that are both visually appealing and digitally meaningful. Hypothesizing that decorative patterns are ubiquitous features of domestic objects, their idea was to employ the decorative patterns in everyday objects into visual codes to trigger interaction instead of the unappealing aesthetic and alien look of barcodes and QRcodes that make them insufficient to be embedded in everyday objects i.e. furniture and home accessories. Interactive Decoration was proposed with the aim of investigating how designers will be able to design complex interactive patterns yet stick to the rules at which the digital

scanning applications can be able to interpret, by exploiting the differences of how humans and systems construct patterns from images.

Some benefits of interactive and shape-changing interiors have been discussed in related prototype installations [4, 5, 13][4, 5, 10]. By generalizing the concept of interactive and shape-changing interior design, we can get a step closer to the ultimate ubiquitous Weiser dream [17] providing inhabitants with benefits at both the emotional and physical level. The emotional and psychological effect of changing interiors, i.e., colours, lights, shapes and textures, could have significant impact on inhabitants, potentially leading to improved quality of life through novel, possibly serendipitous experiences and sensory stimulations.

The Challenges for OUI Interiors

In the sections below we begin to sketch out some of the challenges that will need to be addressed to deliver our vision of domestic environments suffused with OUI Interiors.

Sustaining user engagements over time

Since recent waves have been pointing towards slow technology, OUI interiors should be designed, developed and evaluated in the context of living long. OUI objects that can last for at least a lifetime, if not for multiple generations have the potential of being more successful, used and embraced into people's homes, as other domestic objects, for lifetime. However, when it comes to technology, designing sustaining devices that 'lives long' is not an easy challenge, due to the exponential rate of growing

technologies, materials and designs. Nevertheless, designing for slowness has its advantages of supporting experiences of pause, contemplation and reflection - rather than efficiency and productivity- in addition to permitting somehow enhanced user interaction. Possible ways of designing slow interactions is creating emotional attachments to technologies, keeping the original aesthetic of everyday object, developing intuitive interactions and create ubiquitous technology that blend-in, surround users and fade in the background, then it could remain used and interactively live across multiple generations and lifespans.

Designing for daily use (intuitive interactions)

Designing for daily use requires designing intuitive interactions that are somewhat spontaneous and familiar to the user. That is; easy to learn if not unrequired, easy to use and recall as daily actions that people are already familiar with. OUI user interaction SMaG Model [11] suggests that intuitive interactions include multitude of human implicit and explicit actions ranging from hand manipulations to speech recognition and air gestures. Hand manipulations resembles users' handling of daily objects, both non-deformable and deformable. Non-deformable hand-manipulations include -and not limited to- grasping, flipping, bending, tilting, rotating, stacking, clapping, hitting and different types of touch interactions i.e. swipe, tap, knock, ..etc. Deformable hand-manipulations include shape-changing interactions with objects such as folding, squeezing, pulling, poking, stretching, wrinkling and different types of shape-changing interactions.

Air gestures are various sorts of touchless interactions (such as sign language) include waving interactions,

eye tracking, facial expressions mouth manipulations (such as blowing), body movement and posture. Given the flexibility and genericity of the SMaG interaction model for OUIs, designers are free to introduce and employ different intuitive techniques of user's implicit or explicit interactions with everyday objects.

New materials

With the latest availability of miniaturized and inexpensive sensing, computing and actuator facilities (for example, Microsoft's Gadgeteer [15], Raspberry Pi [7], Leap Motion [19]), or miniature steerable projectors, to e-paper and e-fabrics virtually every object in a domestic environment could be transformed into an OUI. However, we must not ignore the fact that a significant number of domestic objects are covered with fabrics i.e. sofas, cushions, curtains, carpets, linens, etc. Therefore, it is quite a challenge for OUI interiors needing to rely greatly on e-fabrics that still rather nascent and in need of development to satisfy the domestic OUI designs that will appear over the coming years.

Developing for Domestic Spaces

As much as designing and evaluating any system in the wild can be much harder, requiring more care and sensitivity, there are potentially huge benefits to developing OUI Interiors and evaluating them in actual real homes. This however has significant implications for ethics, reliability, support and complexity. Family life is messy, dynamic and may include special occupants i.e. children, disabled, the elderly, etc. If studies of smart homes have told us anything, it's that we need to understand people and how they want to

live their lives before we can really understand how technology can best be designed to suit them. Consequently, interfaces should be designed with a different set of values and functionalities in mind when set to be deployed in the domestic setting.

Data in shared environments

One of the main challenges of building ubiquitous environments is capturing and responding to, probably implicit, multi-user interactions raising questions of how will the system handle a multiple occupancy space? Will it be able to distinguish users, or not (and at what points is this necessary)? Discretely linked to a person or aggregating data from multiple users? All of which create difficulties –yet interesting challenges– and implications for the design and development of OUI Interiors.

Conclusion

Organic User Interfaces (OUIs) is a new paradigm for building interfaces that might take any shape and are possibly shape-changing either actively or passively. Such interfaces employ intuitive inputs and are designed for daily user interactions that are both implicit and explicit. Designing OUIs for domestic environments suggests a great deal of potential and benefit for home occupants, giving everyday objects the ability to be responsive and interactive, in addition to their retained original physical affordances and manifestations (functions). If designed carefully, with a cognizant of concepts of slow technology, OUI Interiors have the potential for sustainability and long life. However, challenges that face OUI Interiors needs to be addressed wisely for successful designs to come.

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