Interaction design is increasingly about embedding interactive technologies in our built environment; architecture is increasingly about the use of interactive technologies to reimagine and dynamically repurpose our built environment. This forum focuses on this intersection of interaction and architecture. **— Mikael Wiberg, Editor**

Deconstructing Human-Building Interaction

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Interaction design, and HCI more broadly, has a history of entwinement with reflections and concepts from architecture and urban design. At least seven encounters are notable:

• in the area of ubiquitous computing, where digital artifacts are physically embodied and situated within the environment;

• in the notion of cooperative buildings, where concepts from HCI and CSCW were extended from desktop interactions to the consideration of a building's physical fabric and the consequent structuring of social activity;

• in the explorations of media spaces, where physical distance was collapsed through video and other forms of media connection, leading to debates about the nature of space vs. place;

• in the development of the idea of design patterns for interaction [1];

• in the exploration of the very question of space in HCI, for example: when dimensions and proportions of the displayed digital material are at issue, for instance in Fitts' law; when space is a direct element of design, for example in virtual reality and full-body interaction; and when the spatial situation is an input to the interaction scenario, as in context-aware applications;

• in the design, development, and inhabitation of virtual worlds;

• in interaction design's learning from the legacy of architecture to combine function and form [2] and to study the symbiotic relationship of people and artifacts.

From the other side, in architecture, there have been numerous attempts to understand the incorporation of digital elements into buildings and urban design [3,4].

This mutual learning, however, has often remained at a distance. While the disciplines of architecture and interaction design have met on many occasions, the instances of concrete collaborative projects are rare. *Architects and interaction designers do not "meet" enough.*

Rem Koolhaas, at Venice Architecture Biennale 2014, Elements of Architecture, stated that:

elements such as the elevator or the escalator have never been incorporated into either the ideology or the theory of architecture. Now, with new digital intersections, digital hybrids, digital combinations, the risk is that architecture is simply incapable of thinking of its entire repertoire.

He discussed this concern further with Tony Fadell in a panel at *Vanity Fair*'s Summit [5], concluding with the need for broadening the tangible exchanges among the two domains.

The reason why a rather old idea that virtual and physical spaces should be designed in an integrated fashion has been revisited in recent years can be rooted in two facts: the technological advancement in areas such as sensor and actuation systems, IoT, and robotic architectural elements; and the new user expectations and environmental concerns that call for new life, work, and mobility styles.

With the notion of *human-building interaction* (HBI), we seek to initiate new collaborative projects that can address the physical, spatial, and social opportunities and challenges that emerge as built environments become increasingly interactive [6]. In our CHI 2016 workshop "Future of Human-Building Interaction," we took the first step by bringing together experts from the fields of HCI and architecture and providing them with an occasion for collaboratively creating and sharing the vision for HBI. The following section describes some of the material produced during the workshop.

Insights

- While the disciplines of architecture and interaction design have met on many occasions, instances of concrete collaborative projects are rare.
- Designing HBI consists of providing interactive opportunities for occupants to shape physical, spatial, and social impacts of their built environment.

RESEARCH DIRECTIONS

Designing HBI consists of providing interactive opportunities for the occupants to shape the physical, spatial, and social impacts of their built environment [6].

Grounded in this definition, we began the workshop with reflecting individually on our questions and concerns about the future of HBI. Then, by analyzing the list of questions, we tried to capture a classification that manifests some of the essential research directions. The result is summarized here.

Interfaces. In addition to the interaction styles and techniques

Rem Koolhaas and Toney Fadell discussing design in the digital age.

IMAGE BY MONIKA ARCZYŃSKA

through which occupants enact change in buildings, there are questions about how buildings or their services communicate among each other (building-building and service-service interaction).

Agency. How can smart environments embrace inhabitants' agency? For example, once the Nest thermostat learns occupants' thermal preferences, it adjusts automatically according to the time of the day. The recording of the preferred thermostat setting, however, is regulated through interaction with the occupants. Does this model offer enough control to the users? What models of agency could we appropriate from other disciplines like economics? How can we reconcile the complexity of human decisions with the efficiency that the automation systems promise?

Security and safety. The increasing integration of intelligence into buildings, coupled with the fact that they are gaining more agency, raises security and even physical safety concerns in case of failure or misuse.

Compatibility of design processes. How can the iterative process of designing technologies that have relatively short lifespans become compatible with the design and construction process of buildings with a significantly longer life expectancy? Similar questions can be asked about the maintenance and post-occupancy interventions. How do we involve end users in this dual design process?

Adoption. What are the barriers to the adoption and diffusion of a new HBI solution? What occupancy and insurance contracts can incentivize the adoption of new regimes of habitation?

Governance. Building construction norms and standards may not accept certain changes, in terms of technologies embedded in buildings or new forms of controlling them. How can HBI designers foresee and avoid such cases? What changes need to be made in the standards?

As buildings become more intelligent, the need for certain physical affordances seems less evident.

Epistemology. The development of HBI entails promoting the production and exchange of knowledge in the framework of a multidisciplinary domain. What scholarly methods can researchers in architecture and HCI use together for scientific inquiries? What media can carry HBI knowledge (text, visual illustration, tangible mock-ups)?

A GLANCE OVER THE RESEARCH LANDSCAPE

Here we introduce a glossary of terms that are pertinent to the future of HBI. Each term points to the challenges and opportunities afforded by a new emergent class of data-infused reactive architectures. Taken together, they begin to build part of the research landscape of HBI, suggesting the need for new interaction paradigms and technological explorations.

Habit-action. Currently, buildings

are expected to provide seamless comfort to mostly passive users. The focus is on automatically meeting users' needs, relying on doomed-to-be-false generic global comfort conditions. Instead, we advocate encouraging users to actively participate in reaching their individual needs and even questioning/changing these needs for the better.

Building body-brain balance. As buildings become more intelligent, the need for certain physical affordances seems less evident. For example, why do we need a handle on an automatic door? This, we believe, is an interaction design question—how much manipulation liberty users should have in parallel with automation.

Antisocial engineering. Rather than shaping behavior through persuasive pervasive technologies, networked systems supporting both buildings' digital service layers and the control of their actuations will give rise to hackable buildings. These will be exploited in competitive appropriations by inhabitants, neighbors, and the maliciously inclined.

Digital patination. The capability for sensing inhabitants' actions and interactions will become increasingly embedded within the building fabric itself, through the use of smart materials and surfaces. This will create digital traces of activity, which could be mined to support new kinds of remembering and reuse of events and activities within the space.

Awarenessergy. Comfort and services need energy. Instead of being pushed to be economical, users have the right to know where energy comes from, what it is used for, and to what amount, so as to save it wisely or spend it joyfully.

Databitation. In addition to walls and roofs, building users increasingly inhabit data without being naturally sensitive to it. The sheer quantity of this data calls for new interface paradigms.

Home-biosis. The symbiotic relationship between inhabitants and their buildings will be driven by developments in home automation and AI, which will give buildings a new kind of agency and autonomy. This will require and support the development of new kinds of caring relationships between buildings and their occupants.

HBI AGENDA

With the CHI 2016 workshop, we brought together researchers with diverse backgrounds and perspectives to discuss a series of possibilities and provocations around the notion of HBI. That was the first attempt at opening up the idea to the community, and should be continued in the format of workshops or panel discussions within architecture or HCI conferences, or even as a standalone event.

We suggest developing HBI sub-agendas at three levels of abstraction:

- designing instances of interactive experiences that match the user's mental model of the building, as well as developing ethnographic methods to study how people perceive and interact with buildings, for example by analyzing their in-door trajectories or mobility routines,
- constructing intermediate-level bodies of knowledge, including design heuristics and strong concepts, and
- developing theoretical foundations that can contribute to the general understanding of our interactive experiences with(in) built environments at the individual and social levels.

We would like to emphasize the importance of the first sub-agenda, especially for the development of HBI in its early stages; that means initiating concrete projects where architects and interaction designers collaboratively create interactive spaces.

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