Buildings with an Attitude

Personality traits for the design of interactive architecture

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Abstract. *In order to achieve interactive architecture it is necessary to consider more than the technological components of sensors, controllers, and actuators. The interaction can be focused to different interaction activities: instructing, conversing, manipulating, and exploring (we propose to call this the interaction view). Additionally, the purpose of the building may range from performing, sustaining, servicing, symbolising, to entertaining (we propose to call this the world view). Combined, the interaction view and world view establish 20 different attitudes, which are flavours of behaviour for the interactive building. Through attitudes interaction profiles can be established and criteria derived for the design of interactive buildings.*
Keywords. *Interactive architecture; design theory; Human-Computer Interaction; augmented reality; mixed reality.*

INTRODUCTION

Enabled by technological, social, and contextual developments we can see an increasing appearance of reactive and responsive building structures that are grouped under the term "interactive architecture" (Fox and Kemp, 2009). Such examples range from installations (for example the Hoberman sphere at Liberty Science Centre, Jersey City, New Jersey [1] or at Korea Aerospace Research Institute, Goheung County, South Korea [2]), facades (for example media facades like Graz Kunsthaus, Graz, Austria [3] or T-Mobile Headquarters in Bonn, Germany [4]) to buildings (for example the adaptive house project by Michael Mozer at University of Colorado, Boulder [5]). Most examples of interactive structures concern installations and media facades. In our view there is more potential for interactive architecture. A theoretical framework to assess this potential is missing at the moment. In this paper we aim to provide such a framework. In particular the field of interaction design (HCI, electronics product design, and so on) has established a rich vocabulary to qualify different types of interaction.

We consider something to be interactive when the system in question in some way takes the user into account. This can take the form of a service (elevator control, climate control, machine control, and so on), a responsive system (for example Ned Kahn's various installations [6]) or a more autonomous presentation (for example the 555 Kubik installation in Hamburg 2009 [7]). In the highest level, an interactive building would engage in a dialogue with the user (building and user responding to each other in a meaningful way). Up to now, there are no examples of such a dialogue, however.

Interactive architecture has potential to improve aesthetic aspects of buildings and functional aspects. In terms of aesthetics, it can provide a more meaningful and tailored experience to users than is possible with non-responsive buildings. In terms of function, interactive architecture may provide better services than current buildings as it has the potential to better respond to changes in building facilities and user demands. Being responsive however, usually involves a higher change cost than regular buildings. Therefore the gain obtained through interaction should be higher than the change cost and running cost (Achten, 2011).

Types of engagement

There are several ways of engagement between an interactive building and a user. A user can be actively engaged with the system for example by controlling it, pushing buttons, or performing particular actions to make the system do something. In that case we call the user "active." It may also be the case that the user is not actually telling the system to do something, but that the system through observation, measurement, and decisions infers what the user wants and then acts on this. In that case we call the user "passive." Concerning the system, it may be involved with a specific user or group of users – in which case we would call it "direct system involvement" – or the system could be concerned with a generic user or group of users (no one in particular) – this we call "indirect system involvement."

In the case of passive users and direct system involvement, we can characterise the engagement with the user as a "perfect butler" (the user does not have to state their desires and the system aims to fulfil them automatically). When the system involvement is indirect and the user passive then the system acts in an "environmental" way (the user's desires are fulfilled as a background function of the system). When the user is active and the system is directly involved then the engagement is like a "partner" (user and system are engaged in a direct dialogue). Finally, the engagement between an active user and indirect system involvement can be typified as a "wizard" (the user has needs, and the system realises these needs without the user needing to know how to achieve this).

Technological components of interactive systems

Interactive architecture is enabled by the combination of technologies, specifically: sensors, controllers, actuators, and materials. The sensors register the environment, controllers make the decisions what should happen with the system, actuators are the tools or routines that make the action possible, and materials realise the action in the world. We like to point out that having these technologies available has wider implications than achieving interactive architecture. Interactive architecture is a particular case in a broader class of systems which are challenging traditional borders between the physical world and digital world. In particular the technological components enable the following:

- Awareness of the environment. Specifically, the environment consists of the outside world, the user, and other systems. The outside world can be climate conditions, surrounding traffic, and so forth. The user consists of everyone who can have some kind of relation (symbolic, functional, recreational, etc.) with the building. Other systems can be different components of the building or within the environment.
- Respond to conditions. Through their embedded routines, building system components can actually decide which action should be taken in order to achieve their own goals or those goals as perceived in the environment via sensors and inferred through the controllers.
- Actively change the environment. By means of the actuators and realised through the materialisation the building system components can affect change in the environment, respond to users, or cause change in other system components.

Towards interactive architecture

Within the domain of architecture, those that have the most experience with responsive technology are the installations experts. Up to now in most building projects the spatial-material composition of the building is developed by the architectural team and the behaviour maintenance part of the building by the installations expert team. In our view this division is not tenable anymore. Architects need to understand the implications of this technology and they need to incorporate it in the design process from the very start. This most likely means that the concept of architecture has to be expanded not only to include composition, materials, aesthetics, and performance, but also building behaviour, interaction modes, ways of engagement, and so on. In short, the architectural design team not only has to take care of space and function, but also of the personality of a building. In our view, this is not something which can be done as an afterthought following the (traditional) design process.

To the best of our knowledge there is no theoretical framework for such an approach; perhaps Tschumi's notion of event-cities (1995) comes closest in terms of architectural theory. It provides insights in the nature and impact of events for otherwise a "static" notion of architecture. For making these notions operational however, multi-agent theory (Weiss, 2001) would be a promising candidate. The defining characteristics of an agent (awareness, ability to manipulate the environment, communication with other agents, pro-activeness) are very close to the characteristics of interactive building components. In our view the work of Milgram et al. (1994), in which a gradient between augmented reality and augmented virtuality is outlined, is helpful to understand interactive systems in general. What seems to be missing is an approach to outline the basic behavioural starting points for interactive buildings. We feel the challenge lies in designing buildings with an attitude.

ATTITUDE: WORLD VIEW AND INTERACTION VIEW

Interaction is more than the technical components (sensors, controllers, actuators) that allow a responsive dialogue between the actors of environment, building, and user. It has a temporal component through dynamics of the actors, and ways of engagement (wizards, butler, environmental, and partner). These aspects do not dictate however one single way how to realise such systems - a building may act as a Wizard in a dialogue kind of way, instructing the user, or rather aim to entertain or explore possibilities. Additionally, the interactive system can be focused on performative aspects, or rather play a symbolic role, or aim to be sustainable. For the design of an interactive building or system therefore, it is necessary to decide on a stance towards the kind of behaviour and focus. In other words, it is necessary to have an 'attitude.'

We define an 'attitude' of a building as follows. An attitude is the basic concern of a building towards its general environment and how it performs, and the way it communicates this concern with users. The basic concern we propose to call the "world view" of the building, and the way of communication the "interaction" view. The world view derives from architectural design and basically describes the general purpose of a building (system). These purposes are performing, sustaining, servicing, symbolising, and entertaining (Table 1). The world views are not mutually exclusive but give an indication of priority for the control structure.

The "interaction view" of an attitude is the way how a building (system) engages in a dialogue with the user. These are derived from the domain of interaction design, in particular the basic interaction activities defined by Sharp, Rogers and Preece (2007). They identify four basic interaction activities that underlie all other possible forms of interaction: instructing, conversing, manipulating, and exploring (Ibid, p. 64) – see Table 2.

The combination of world view and interaction view in a matrix results in 20 different attitudes of building (system) design for interaction (Table 3).

The majority of buildings that use responsive systems do this for optimising performance of the building (in particular responding to external and internal energy loads). Such buildings act as *Assistants* (in the case of contemporary HVAC design) or *Specialists* (in the case of performative buildings). Examples of contemporary HVAC systems (*Assistants*) are in abundance - most modern day build-

Attitude component "world view"	Description
Performing	The building dynamically adapts so that one or multiple criteria (e.g. lighting, acoustics, and isolation) are optimised.
Sustaining	The building dynamically adapts so that it requires the least amount of energy and/or produces the least amount of waste.
Servicing	The building dynamically adapts so that a desired set of demands of the users (e.g. air-conditioning, lighting, installations, and communication) are fulfilled.
Symbolising	The building dynamically adapts so that it represents a (communal) meaning (e.g. state, religion, history, and art).
Entertaining	The building dynamically adapts so that it supports a social event (e.g. concert, theatre, mass, and wedding).

Table 1
World view component of an interactive building.

Attitude component "interaction view"	Description
Instructing	The building and user inform each other so that new knowledge, behaviour, or experiences are generated (e.g. wayfinding, egress, and information systems).
Conversing	The building and user exchange information to construct a (temporary) narrative (e.g. shopping, teaching, and observing).
Manipulating	The building and user exchange actions so that characteristics of either are changed (e.g. maintenance, security, and cleaning).
Exploring	The building and user exchange actions and information to try out different functionalities and experiences (e.g. browsing, searching, and playing).

Table 2
Interaction view component of an interactive building.

	Instructing	Conversing	Manipulating	Exploring
Performing	Trainer	Fellow	Specialist	Explorer
Sustaining	Mentor	Helper	Scout	Discoverer
Servicing	HAL	Host	Assistant	Technician
Symbolising	Icon	Peer	Chaplain	Guru
Entertaining	Idol	Buddy	Crew	Improviser

Table 3
Twenty attitudes of interactive buildings.

ings have installations that respond real-time to the needs of the user (Montgomery and McDowall, 2011). Performative buildings (*Specialists*) incorporate responsive systems that aim to optimize one or more objectives: daylight use, energy consumption, visual connections, and so on (Kolarevic and Malkawi, 2005). A good contemporary example of a *Specialist* is the Prairie House (2011) by Orambra [8]. The Prairie House features a responsive shell that can shrink and expand the internal volume so that energy demands can be greatly reduced.

From the matrix it follows that there are more types of behaviour possible for buildings and installations than *Assistants* and *Specialists*. Below the various attitudes are briefly characterised (Table 4). These characterisations are helpful in the design concept development of interactive buildings (Achten and Kopriva, 2010).

INTERACTION CONCEPTS THROUGH ATTITUDES

The attitudes provide guidelines for the interaction design of an interactive building or system. A building during its operation is not limited to one attitude

Table 4
Concise characterisation of attitudes.

	Characterisation
Trainer	The *Trainer* cares about building performance, and wants to instruct. The *Trainer* assists the user so that they find the optimal use of a building for some criterion. İt may do this by showing performance data, trends in building use, and advise on more efficient/ effective ways of behaviour. The *Trainer* is a good choice when the performance criterion is well understood.
Fellow	The *Fellow* cares about building performance, and wants to converse. The *Fellow* engages with the user in a dialogue to find optimal use of a building for some criterion. It can do this through mutual exploration, offering suggestions, or inquiring about the goals of the user. The *Fellow* is a good choice when the means how to obtain optimal behaviour is not well-known, and the optimisation criterion is not of critical importance.
Specialist	The *Specialist* cares about building performance, and wants to get the job done in the background. The user expresses needs to the *Specialist* which in turn proceeds to optimize the building (system) so that some criterion is optimised which will fulfil the need(s). The user does not need to know how the need will actually be fulfilled. The *Specialist* is a good choice when user comfort should be automated without much engagement from the user.
Explorer	The *Explorer* cares about building performance, and wants to probe different solutions. The *Explorer* assists the user to try out various combinations and settings of the interactive building so that an optimal use is obtained. The *Explorer* does this in a more controlled fashion than the Fellow and has more restrictions in the possible combinations that are offered. The *Explorer* is a good choice when the way how to obtain optimal behaviour is not well-known, while at the same time there is a desire to obtain this behaviour.
Mentor	The *Mentor* cares about sustainability, and wants to instruct the user. The *Mentor* instructs the user how to obtain the most sustainable behaviour of the building. It can do this by showing environmental impact of the user's behaviour, current energy demands, and possible ways to reduce the impact. This feedback may be accumulated over a longer period of time to show the influence of the user. The *Mentor* is a good choice when the purpose of the building is to raise awareness of environmental issues.
Helper	The *Helper* cares about sustainability, and wants to converse. The *Helper*, much in the same way as the Mentor, informs the user about environmental impact of his/her behaviour. Feedback is given in a more dialogue kind of way, in which impact and advice is shown real-time. The *Helper* is a good choice when awareness of sustainability should be stimulated, and a low level of environmental impact is desired.
Scout	The *Scout* cares about sustainability, and wants to reach that goal autonomously. The *Scout* takes instructions from the user, and adapts the building in such a way that the needs of the user are fulfilled while at the same time obtaining the lowest environmental impact. The *Scout* works in the background, and shows feedback only when the goal has been fulfilled. The *Scout* is a good choice when the user wants to obtain a particular performance of the building, but has no need of information of the environmental impact.

Discoverer	The *Discoverer* cares about sustainability, and wants to explore various options to obtain this goal. The *Discoverer* sets out with the user to try out different options for the building behaviour so that optimal environmental impact is obtained. It can do that by offering solutions and providing feedback about the chosen impact and possible alternatives. The *Discoverer* is a good choice when the user wants to be informed but not forced into a particular direction.
HAL	The *HAL* cares about servicing, and wants to instruct. The *HAL* follows general instructions and specific instructions of the user and aims to show how optimal services can be obtained for the building (system). It can do this by advising on optimal modes of behaviour or ways of improvement. The *HAL* is a good choice when users want to improve actively comfort levels of the building.
Host	The *Host* cares about servicing, and wants to converse. The *Host* takes cues about the needs of the user through a dialogue (getting commands from the user, through asking, or interpreting actions) and aims to set the service levels in such a way that they meet the needs of the user. Throughout the interactions, the *Host* provides feedback to the user. The *Host* is a good choice when levels of comfort need to be achieved with the user involved in the controlling.
Assistant	The *Assistant* cares about servicing, and wants to set the levels of servicing right autonomously. The *Assistant* works more or less in the background and aims to set optimal levels of servicing of the building (systems) without too much involvement of the user. It can do so by following internal settings for the building, responding to sensor information, and actions of the user. The *Assistant* is a good choice when systems need to be fully automated with the user's involvement left to the minimum.
Technician	The *Technician* cares about servicing, and wants to investigate multiple options to reach the service levels. The *Technician* aims to provide high service levels, and tries to obtain these level through exploring various settings alone or together with the user. The *Technician* is a good choice when the user needs to be guided into several options to support his/her use of the building.
Icon	The *Icon* cares about symbolising, and wants to instruct. The *Icon* has a representational goal which it strives to achieve through instructing the user. It can do so by showing the user possible ways how to achieve particular effects of symbolising or timing of activities. The *Icon* is a good choice when optimal behaviour for a symbolic function is desired through supporting the user.
Peer	The *Peer* cares about symbolising, and wants to converse. The *Peer* establishes a (conversation-like) series of interactions with the user with the aim to fulfil a symbolic function. It is less directive than the Icon since the need to obtain the symbolic function is not so critical. The *Peer* is a good choice when the user needs considerable freedom of choice and is not concerned about optimal behaviour.
Chaplain	The *Chaplain* cares about symbolising, and wants to fulfill the tasks in the background. The *Chaplain* takes cues from the user, either directly or through observation, and aims to fulfil the symbolic function more or less autonomously, without user involvement how to achieve the representation. The *Chaplain* is a good choice when a representational function needs to be maintained automatically.

Table 4 continued
Concise characterisation of attitudes.

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Guru	The *Guru* cares about symbolising, and wants to explore various options. The *Guru* explores in an interactive way with the user possibilities to achieve the symbolising function of the building (system). İt is more experimental and playful than the Peer, since the focus is less on the resulting symbolic power but more on the process of trying out options. The *Guru* is a good choice when the user needs freedom of exploration and does not require critical levels of symbolism.
Idol	The *Idol* cares about entertaining, and wants to instruct. The *Idol* takes cues or commands from the user and informs his/her about best ways for entertainment. İt can do so by showing examples of optimal performance. The *Idol* is a good choice when the user wants to be entertained and advised about the best course of action.
Buddy	The *Buddy* cares about entertaining, and wants to converse. The *Buddy* aims to entertain the user through a dialogue kind of approach in which various options are offered and considered between building (system) and user. The user has more freedom of choice then with the Idol, while on the other hand there is less care for optimal entertainment. The *Buddy* is a good choice when the user likes a more informal approach from the interactive system.
Crew	The *Crew* cares about entertaining, and wants to handle things by itself. The *Crew* is an autonomous system that takes orders from the users or operates on its own and aims to get maximum entertainment for the user. There is a low level of feedback to the user. The *Crew* is a good choice when things have to run automatically without the user needing to know what is happening.
Improviser	The *Improviser* cares about entertaining, and wants to explore. The *Improviser* investigates various options together with the user to obtain an optimal entertaining experience. It can do so by trying out options or responding to input from the user. The *Improviser* is a good choice when the user wants to engage in an interactive process of exploration with the building (system).

but may shift through various attitudes according to the required need. For example, a sports stadium when sporting events take place may be performing or servicing combined with manipulating and exploring, but when there is a concert it may be entertaining combined with conversing or exploring.

The design of interactive architecture should involve a choice by the parties involved what kind of attitude(s) the building should have. For the design this has consequences because specific attitudes have different requirements on system design. For example, system response times for the Sustaining world view may not need to be as fast as those for the Entertaining world view. Instructing systems need to have a feedback facility to explain the user the consequences of their actions, whereas this may not be required for conversing systems. An *Assistant* may run in the background, not bothering the user (acting as a Wizard), whereas a *Technician* would be more involved with the user (acting as a Partner).

It is important to note that attitudes are not as strictly separated as for example a classification system, in which the classes need to be mutually exclusive. They should be interpreted more as flavours in which accents are placed on performance indicators of interactive systems.

DISCUSSION

Attitudes provide a set of behavioural concepts for interactive architecture. The current set of attitudes is based on a theoretical study. Through application we will see whether the current distinctions are productive, whether they will prove to be too refined (with a need for less attitudes), whether more definitions are necessary (more attitudes), if they should be redefined (they prove to be impractical), or not used at all (they actually do not help). This will be investigated in two ways: first, a retrospective analysis of existing buildings in terms of attitudes; second, the design of interactive building (systems) based on attitudes. In the first strategy the consistency and descriptive power of the attitudes is tested. In the second strategy the discriminative and driving power of the attitudes for design is tested.

The attitudes are the result of combining world views with interaction views. Although we aimed to define the world views (performing, sustaining, servicing, symbolising, and entertaining) as distinct as possible, it may be the case that there are too many distinctions. In particular the distinction between performing, sustaining, and servicing may prove redundant and could be captured with one heading (although it is possible to argue that a performative building need not necessarily be sustainable nor provide the best service levels, and similar arguments could be stated for sustaining and servicing buildings as well). The interaction views (instructing, conversing, manipulating, and exploring) seem to be more stable.

It may appear from the matrix that all attitudes are considered equally important, or that they are supposed to appear in reality in equal proportion. This is not the intention of the matrix however. Most likely some attitudes will be in more demand than other attitudes. The point we want to raise with the matrix is twofold: first, that a concept like attitudes is worthwhile to explore within interactive architecture, and second, that there are more attitudes possible than the currently dominant *Assistants* and *Specialists*.

We hope that the work presented in this matrix is helpful to an improved understanding of the potential of interactive architecture.

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