A Framework for Architecture as a Medium for Expression

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ABSTRACT

We propose a conceptual design framework for the classification and design of applications that augment architectural environments with digital information. The dimensions of the framework consist of the layers that compose architectural space (*façade*, *interior* and *structure)* and its embodiments (*expressive medium*, *responsive space* and *social actor*). We further introduce design characteristics for each application area within the framework. Accordingly, we describe two conceptual prototypes that we developed to investigate the validity of the framework as a conceptual design tool.

Keywords

Pervasive media, ambient displays, interactive architecture, responsive environments

INTRODUCTION

The application of architecture as a medium for expression can be traced back to the first days of human evolution. Ancient caves with featured paintings from that time represented an intellectual instrument to encourage discussion or storytelling [9]. The expression of architecture has changed over time, often in line with the various epochs of human history. For example the purpose of ceiling frescoes, which were highly popular during the Renaissance period, was to express storytelling and major beliefs of that period [5]. Put into a social context the intention of ceiling frescoes was to communicate the power and wealth of the proprietors to the people visiting the architectural space. Social contexts emerge from mutual coexistence of architecture and people sharing the architectural space. By changing the way people interact with each other and their environment, architectural spaces potentially develop an encouragement of sociability [4], i.e. the environment evokes conversations among people sharing the same space.

The term architecture not only refers to the physical structure of an architectural environment, but also spans interior design, décor and other spatially related disciplines like landscape architecture. Architectural environments have several layers of built components that reach beyond their pure physical structure [2]. *Pervasive expressive architecture* is defined as spatial representation of specific information relevant to the immediate environment or the people, who use that space. The advent of new information technologies, such as sensors, displays and networking technologies, allow for the exploration of new applications in that realm. Examples for application areas are: the representation of remote data (e.g. activity patterns of a distant loved one [18]), conveying information about other co-located people (e.g. interests of colleagues [11]), revealing user-specific details (e.g. to-do lists, physical parameters, etc. [17]) or visualizing information that was not visible before (e.g. energy consumption within a building, see Figure 3). Furthermore, spatial data (e.g. sound, see Figure 2) lends itself very well for visually mapping its abstract representations onto architectural spaces.

In this paper we describe a framework for the classification of pervasive expressive architecture. Accordingly, we present two conceptual prototypes based on the framework to investigate its applicability as a design tool.

BACKGROUND

It was not before the second half of the 20th century that architects and artists gained access to multimedia technologies that enabled them to augment architectural environments with digital information. The integration of media and architecture eventually led to the notion of *mediatecture*. Representatives of this paradigm are multimedia systems that extend architectural environments, typically in public or semi-public contexts. The NASDAQ Tower on Times Square, which displays financial news, market highlights and advertisements on a seven stories high multimedia display represents an example for this paradigm. Mediatecture applications affect their immediate architectural environment and therefore change the way people perceive and interact with their environment, e.g. starting conversations with other passers-by. More recently advances in information and communication technologies have led to the notion of *pervasive computing*, which is more environment-centric than traditional computing paradigms, such as desktop-based or mobile computing

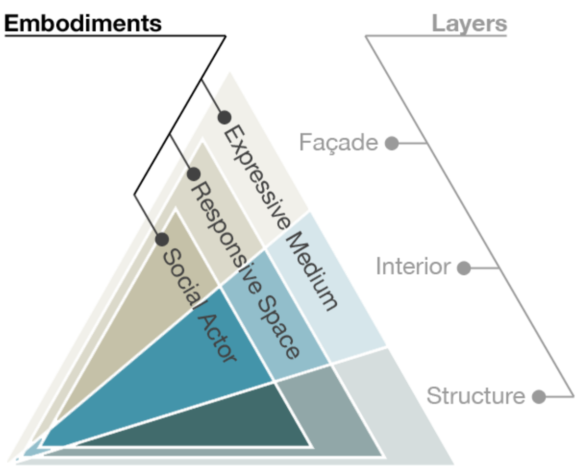

Figure 1. The dimensions of the framework: embodiments (expressive medium, responsive space, social actor) and layers (façade, interior, structure).

[16]. The well-thought integration of information technologies into everyday environments based on this paradigm has the potential of turning architectural space into an interface between people and digital information [20]. Both, mediatecture and pervasive computing build a conceptual and technological foundation for pervasive expressive architecture applications.

LAYERS

The layers that depict the components of architectural environments represent the first dimension for our framework. We based the instances for this dimension on Brand's classification of buildings into "shearing layers of change" [2]. Brand investigated how buildings change over time. He identified several layers of buildings and noticed that their longevity determines the pace of change. Rodden and Benford transposed this concept to the pervasive computing area [15]. They discussed Brand's classification scheme as means for understanding behaviour in the home and providing design guidance for the development of new applications in domestic environments.

For our framework we investigated the layers suggested by Brand not in terms of longevity but for determining potential layers of architectural environments for pervasive expressive architecture. We adapted the following layers for the framework:

- **Façade** is identical with the skin as described by Brand. This is the exterior surface, i.e. the façade, of a building. Mediatecture applications typically exploit this layer.
- **Interior** spans all fixed surfaces that are inside a building, like the walls, floors, ceilings, etc., but not their structural arrangement. Objects that Brand classifies into "stuff" would be partly based on this layer, e.g. a picture could be placed on a wall. An example for an application from this layer is a wall within a building that is augmented with digital information.
- **Structure** covers the foundation and load-bearing elements as well as what Brand calls space plan, which is the interior layout (i.e. the arrangement of walls, ceilings, floors and doors). Examples within this layer introduce new structural elements into the architectural space, such as a wall that acts as a display.

EMBODIMENTS

Current trends in the field of pervasive expressive architecture suggest a classification into the following categories of embodiments: *expressive medium*, *responsive space* and *social actor*. These categories are not mutually exclusive, but have a cumulative character. For example a responsive space always acts as an expressive medium as well. Figure 1 illustrates the relations between the different instances of the dimensions.

Architecture as **expressive medium** exploits the layers façade, interior and structure, as a medium for expression. They affect the way passers-by perceive their surroundings and potentially engage them into dialogues with others sharing the space. However they do not support direct or indirect interactions between passers-by and the architectural space. *Ambient displays* [10], which are information systems that communicate information in the periphery of human attention, are a well-known example for an application area within this category. *Pervasive expressive displays* apply the concept of ambient displays for visual representations of information within architectural environments. They should be calm, non-obtrusive and opportunistic, revealing information only for interested inhabitants or passers-by [19], in order to avoid distraction for other people in their vicinity. We therefore identified the following characteristics for applications based on this category: (1) *non-obtrusive*, (2) *informative* and (3) *socially engaging*. As an example consider the GroupCast display [9]. The display is integrated into the hallway of a building and does not require user interaction (non-obtrusive). It displays information about interest of people passing the display (informative), which might stimulate conversation between people sharing the same interests (socially engaging).

A **responsive space** is an environment that interacts with the people who pass through it [3]. Thus, this category describes spaces that allow for interaction between passers-by and their surroundings. Pervasive computing environments are equipped with sensors, embedded displays and networking technologies, allowing tracking of people, movement and environmental conditions. The aim of such interactive systems is to create a digitally enhanced social space, inviting people to interact with their environment as well as with each other. Once a user decided to interact with the system it should stimulate an engaging dialogue, maintaining the user's attraction and interest. In addition to the three characteristics of expressive medium, responsive spaces are therefore also (4) *interactive* and (5) *enjoyable*. An example for this category is iFloor [8], a system developed for a library setting. It allows visitors to post questions and send answers to each other. The items spread on the floor are controlled through body movement (interactive), which turns into a playful challenge when more than one person interacts with the floor (enjoyable).

A **social actor** is a space equipped with technologies that mimic typical behaviour of humans, animals or plants, such as physical features or emotions. Environments embodying social actor can invoke social responses from users [14]. They are perceived as social characters and evoke the feeling that they need our attention to survive, that we have to take care of them. Systems from this category rely on sensors and other pervasive computing technologies to communicate with people in a non-verbal direct or indirect way. In addition to the characteristics of expressive medium and responsive spaces, applications within this category are (6) *social* and (7) *adaptive*. For example the performative ecologies project [7] features three autonomous robots suspended from the ceiling that continuously search their environment for inhabitants and try to engage them in non-verbal communication by performing different gestural patterns (social). They further remember and teach each other about which performances were most successful (adaptive).

CASE STUDIES

In the course of exploring the different design dimensions of pervasive expressive architecture we prototyped the sound-responsive ceiling display and a persuasive ambient wall display. These examples allow us to verify the framework in investigating the design considerations for applications within this field.

Sound-Responsive Ceiling Display

The sound-responsive ceiling display consists of an array of 12 microunits that cover the ceiling of a room (see Figure 2). The system reflects the current distribution of the room's sound level through dynamically changing light patterns in real-time. A possible application scenario foresees the installation of the ceiling display in a café or bar, allowing visitors to judge the different sound levels inside the space by simply glancing at the ceiling.

Each of the 12 units is equipped with a microphone that features a directional characteristic (i.e. it reacts more sensitive to sounds received directly beneath the microphone) and a light emitting diode (LED). The units are connected to each other, allowing a basic networked communication between the units. Each of them broadcasts the measured value representing the sound level, which allows adapting the light intensity of each LED to the overall sound inside the room.

The motivation of this project was to investigate the potential of the architectural ceiling as a useful surface for responsive display. The objective was to develop a system that would serve as an ambient display for ambient sound and also allow for interaction between passers-by and the environment. The ceiling was chosen for its peripheral character, which supports a spatial representation of

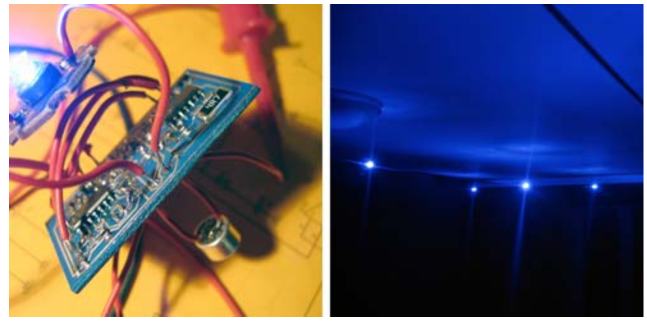

Figure 2. The sound-responsive ceiling display: one of the units equipped with a microphone and an LED (left) and the current installation of the system on a ceiling (right), reflecting the relative distribution of the sound level within the room.

ambient sound. Using these objectives as input parameters for the framework, the application accordingly represents a *responsive space* based on the *interior layer*. Therefore we used the characteristics (1) to (5) to guide the conceptual design:

- the application is *non-obtrusive* since the ceiling sits at the periphery of human attention;
- it provides passers-by with additional information, which is of *informative* nature*;*
- the represented information relates to individuals as well as groups sharing a space, potentially evoking dialogues between them, which means that it is *socially engaging*;
- it is *interactive*, since passers-by influence the visual appearance indirectly as well as directly; and
- the light patterns produced in real-time based on ambient sound in combination with the aesthetics of blue LEDs make the application *enjoyable* to use.

The project is still work in progress and we are currently developing a second revised generation of microunits. Nevertheless, the initial installation already demonstrated that this additional spatial information adds to the perceived quality of a room, while also inviting people who are inside the room to interact with the system.

Persuasive Ambient Wall Display

In this project we use a commercially available large screen LED display as an ambient wall display. The application features different visual representations, depending on the presence of people. In its idle mode it dissolves into the existing architectural environment to avoid constant disharmonic distraction (see Figure 3, left). The system is equipped with a camera for tracking motion and the presence of people. If people are present but distant the visualization changes to provide an actual representation based on energy data. If the display detects people in its immediate vicinity, it switches into a mode that supports direct interaction, enabling people to explore and navigate the representation. Another representation uses the low-resolution display to mimic breathing or the beating of a heart, where the speed is determined by the current energy

Figure 3. The persuasive ambient wall display (mockup): the display in its idle state, dissolving into the background (left) and an example for the notion of a *social actor* – a pulsing light that is connected to the current energy consumption and mimics breathing (right).

consumption within the building (see Figure 3, right). Thus, a relaxed and calm pulsing light tells of low energy consumption, while a nervously pulsing light signals atypically high consumption.

The goal of this project is to investigate the use of spatial ambient display for increasing energy awareness among people sharing a public space. Using these objectives as input parameters for the framework provided us with the following insights: The application has to follow the design constraints of *social actor*, since its purpose is to persuade people to use less energy and it therefore has to actively engage people in conversations. Further, it has been proven that computing systems mimicking social actors are a powerful tool for persuasion [6]. Since the display is augmenting a wall with digital information, it is situated on the *interior layer*, although the fact that the display is moveable would also allow its application as *structure*. According to the framework, the conceptual prototype was based on the design characteristics (1) to (7):

- the application is *non-obtrusive* since it is designed as an ambient display and only engages people into conversations that are in its immediate vicinity;
- it is *informative* since it provides passers-by with additional information about their environment;
- the representation of energy data potentially evokes dialogues between passers-by, which makes the application *socially engaging*;
- it is *interactive* since it allows passers-by to explore the representation;
- the aesthetic integration of a high technology display into the public everyday environment provides an *enjoyable* character;
- the *social* character is achieved through mimicking breathing or heartbeat; and
- it is *adaptive*, since it knows about the presence of people and adapts its representation accordingly.

The project is currently in its implementation phase. To assess the display's impact on people's behaviour and to further validate the framework an evaluation of the final system in its real context is planned.

DISCUSSION

The framework presented in this paper was particularly developed for pervasive computing applications that augment architectural environments with digital information. It provides researchers, designers and artists in this area with both a classification scheme and a conceptual design tool. The two-dimensional nature of the framework (i.e. layers and embodiments) allow for a classification of applications based on the pervasive computing paradigm that are situated in architectural environments. While the framework specifically aims at new applications, it can also potentially be applied for classifying historic examples of architectural art. For example, ceiling frescoes exploit the *interior* layer and represent an *expressive medium*. The purpose of compiling a classification of pervasive expressive architecture applications is that it can point out current trends and potential areas for future research, similar to a taxonomy [13].

The main strength of the framework lies in its applicability as a conceptual design tool. We demonstrated its validity in this respect by discussing two case studies and relating them to the framework. The framework worked well for situating the case study applications within the design space. The design characteristics that we introduced as part of the framework provided us with requirements for the conceptual design of the applications. However, further application of the framework will be necessary to evaluate its usefulness for other applications. Eventually this will also lead to a refined list of design characteristics to provide more extensive guidance during the conceptual design process.

A potential of the framework that we have not explored so far is its applicability for evaluating pervasive computing applications that augment architectural environments with digital information.

CONCLUSION

The main contributions of the framework presented in this paper are: (1) a categorization for applications that use architecture for expression based on two dimensions, (2) an analysis of the layers of pervasive expressive architecture and its embodiments, and (3) a set of characteristics for designing or evaluating applications from this realm.

The potentials of this new paradigm have not yet been fully explored, mainly due to the fact that the design space is extremely large. However, the field has seen a growing interest within the last years. Pervasive computing technologies are increasingly applied within architectural environments and concepts [7,8,11,20]. We therefore believe that the field will experience a shift from simple points of interactions scattered within architectural spaces towards fully adaptive, environmentally aware and socially reflective environments that involve inhabitants and passers-by in constant unobtrusive, subtle and informative conversations.

The application of the framework for the conceptual design of two prototypes proved its validity and usefulness for designing applications that exploit architectural environments for expression. The framework therefore not only allows a classification of applications retrospectively, but can also guide the development of new applications in this field.

ACKNOWLEDGMENTS

We would like to thank Gerhard Rzepa for his support with the implementation of the sound-responsive ceiling and Andrea Lau for providing valuable comments on an early draft of this paper.

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