Towards Sentiment Architecture:Exploring Media Architectural Interfaces

Moritz Behrens

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I, Moritz Behrens, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the work.

The timeless task of architecture is to create embodied and lived existential metaphors that concretise and structure our being in the world. Architecture reflects, materialises and eternalises ideas and images of ideal life. Buildings and towns enable us to structure, understand and remember the shapeless flow of reality and, ultimately, to recognise and remember who we are. Architecture enables us to perceive and understand the dialectics of permanence and change, to settle ourselves in the world, and to place ourselves in the continuum of culture and time.

Juhani Pallasmaa

Abstract

How should one go about designing for interactions with large programmable electronic displays? Part of the challenge is that there are currently only a handful of large interactive surfaces in existence, and so there is much to learn from each attempt to deploy interactive systems. Hence, the work outlined in this chapter contributes to HumanComputer Interaction (HCI) research as well as architectural research by juxtaposing existing interaction frameworks. These frameworks are concerned with the awareness of spaces mediated through information and communications technology (ICT), participants and their actions within these spaces as well as the physical properties of these spaces, which frame these interactions, and are surrounded by the physical built environment. We introduce the notion of media architectural interfaces (MAI), which is then supported through the description of the design, deployment and evaluation of two design studies, namely VEIV London and SCSD Sao Paulo. Finally, we discuss the multilayered interaction frameworks with regard to the conducted design studies and summarise the relevant communalities of these design studies in a taxonomy. The aim of this categorisation is to provide design implications for future MAI projects. Ultimately, this may support the design and development of novel and sustainable interactive systems in the domains of urban screens, media facades and media architecture.

This research commenced during my attendance in the MSc Adaptive Architecture and Computation programme at UCL The Bartlett School of Architecture in 2010/11. As part of the course module 'Cities as Interface" run by Ava Fatah gen. Schieck I came up with the physical I like button. This novel tangible interface, that until then existed only in digital space, allowed people for the first time to comment on experiences in situ and share them with their remote friends on digital social networks in real-time [Behrens2011] (Behrens, 2011). Back then I was trying to explore this innovative research not only from an academic perspective but also aimed to investigate how we could turn this research and its technology into a business. In this respect I was taking part in the UCL Advance ”StartUp Summer”, in collaboration with YouGov. In a team we developed a business plan for a venture that would implement feedback sensors in businesses to improve the business-consumer relationship. The result was a business plan that was pitched to potential investors. Based on these initial explorations I entered the PhD programme at The Bartlett. In the last three years I conducted a series of media artistic installations for festivals around the world. All these experiences feed into this PhD thesis. The largest installation, which will be part of this research is called the Sentiment Cocoon. The Sentiment Cocoon was the winner of a competition organised by structural engineering company Arup Ltd. in London. In the following it was realised under an extremely short construction design phase (10 weeks). As a result and worth sharing, there is much we have learnt as young practitioners ranging from winning a competition to actually planning and realising a design as well as making this part of research.

Acknowledgements

Thank you. Thank you! Thank you!!

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Chapter 1

Introduction

Chapter summary

In this chapter I will introduce my research, which will lead to the main research question and the subsequent question that will assist to answer the main research question. Further an outline of the thesis will be conducted. This chapter then concludes with the overall contribution the reader can expect from reading this thesis.

1.1 Motivation

Little is know about the effect digital technologies have on social interactions in urban space and eventually on our notion of architecture. Cities and their inhabitants are currently familiarising themselves with the socio-technological developments of the emerging digital age [Hemment2013]. Simultaneously, computer technologies increasingly affect architecture in the way that buildings turn into computer interfaces [Mitchell1996]. Today, information and communication technologies (ICTs) may be considered to be of structural, cultural and formal nature [Saggio2013]. Human behaviour is increasingly structured amongst others through information displays and ubiquitous mobile devices characterise our everyday culture. At the same time, architecture is adjusting to the requirements of novel ICT such as large digital displays attached to building facades. For instance, the flashy New York Times Square is an obvious example of where digital media technology has been materialised in architectural form. In essence, the urban environment today can be considered as a system that integrates the human, architecture and ubiquitous computing technologies [Fatah2006]. Within this system are large programmable electronic displays such as urban screens, media facades or media architecture. These novel ”digital” surfaces are gradually turning buildings into responsive media facades, which by using display technologies as an architectural material, radically alter the formal and informational character of the building [Fatah2006][Ebsen2013]. Whereas the notion of architectural facades has always been of informational value, although static, in the way that a facade was considered a social interface connecting the bourgeoisie (private space) with the surrounding city (public space) [Neumeyer2002], the advent of ICTs has allowed for new types of facades to emerge: information is literally not set in stone anymore [Haeusler2009]. Digital information also allows for the anytime exchange of information, such as the flickering advertisement billboards in an inner city, whilst at the same time, the nature of anytime and anywhere information access is changing the relationship between the public and private space. This has led to the development of novel forms of interactions between humans and humans, humans and computers, and humans and architectures. And although Manovich clearly states that the nature of humancomputer interactions (HCIs) is interactive per se [Manovich2001], architectural surfaces are by far not.

Having this in mind, one may ask how to go about designing for interactions with large programmable electronic displays? Part of the challenge is that there are currently only a handful of large interactive surfaces in existence, and so there is much to learn from each attempt to deploy interactive systems.

Hence, the work outlined in my PhD thesis contributes to HCI as well as architectural research by juxtaposing existing interaction frameworks that are concerned with the awareness of spaces mediated through ICT, participants and their actions within these spaces as well as the properties of these spaces, which frame these interactions, and are surrounded by the physical built environment. I introduce the notion of media architectural interfaces (MAI), which is then supported through the description of the design, deployment and evaluation of a series of design studies: VEIV London and SCSD Sao Paulo.

Finally, we discuss the multilayered interaction frameworks with regard to the conducted design studies and summarise the relevant communalities of these design studies in a taxonomy. The aim of this categorisation is to provide design implications for future MAI projects. Ultimately, this may support the design and development of novel and sustainable interactive systems in the domains of urban screens, media facades, and media architecture.

1.2 Key concepts

From urban computing to media architecture

Architectural research, such as Space Syntax research, has dealt with the relationship between architecture and human behaviour. The city is considered as an arrangement of architectural layouts that are defined through their relationships between physical space and social life reflected in movement patterns and activities of its inhabitants [Hillier1984]. Space Syntax aims to analyse the spatial morphology of cities through researching the relation of space to society, [which] is mediated by spatial configuration. Spatial configuration proposes a theory in which we find pattern effects from space to people and from people to space [Hillier1998]. A methodological tool-set provided by Space Syntax facilitates the systematic study through spatial analysis and empirical observations of human behaviour such as pedestrian movement or social encounter in the urban realm [AlSayed2013]. In this context, social encounters can be seen as (un-)planned gatherings amongst strangers or people who know each other. Architectural research has defined ”shared encounters” as mostly context aware, and hence, the type of encounter stage (e.g. bus stop or museum) and its information context impacts the kind of shared encounters. Encounter stages can be defined as public spaces ”on which people negotiate boundaries of a social and cultural nature” [Fatah2009]. For example, at bus stops, social chance encounter happen when people ask for directions or start conversations about the delayed schedule. One objective of the research presented in this paper is to focus on the particular spatial properties, which physical encounter stages require in order to support shared encounters. Since the advent of ubiquitous computing [Weiser1991], and its application in urban space in the form of urban computing [Kindberg2007], the built environment incorporates architecture and ubiquitous computing technologies. In our work, we focus in particular on large electronic displays in public spaces (i.e. public displays), media facades and media architecture and their potential for mediating social interactions. Consequently, architecture and HCI are concerned with the design, deployment and evaluation of digital media technologies and their effect on social interactions in urban spaces. Seen from an architectural perspective, urban screens merged into media facades and became part of the architectural repertoire. Accordingly, media facades are visually animated architectural surfaces, such as dynamic light facades [Virilio1991] [Fatah2006] [McQuire2009]. HCI research, on the other hand, is concerned with interactions in general and increasingly with social interactions, which are mediated by computer technologies. More recently, a branch of HCI began to study social interactions and humancomputer interactions in the real world [Rogers2011]. Inevitably, this led to a discussion about space within this field. Since then HCI research has conducted extensive research in understanding technology-mediated human behaviour and social interaction in public space

[Fischer2012] [Akpan2013].

1.3 Problem statement

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1.4 Research questions

The central question I address is:

- How are technology mediated interactions changing/challenging our notion of architecture?

Subsequently this question leads to a number of related issues:

- How did human behaviour change in architecture since the digital age? (anthropometric vs. human behaviour)
- How to go about designing for interactions with large programmable electronic displays?
- How may large programmable electronic display connected to media architectural interfaces challenge our notion of architecture?

Little is know so far about the effect digital technologies have on social interactions in urban space. Therefore this research is of exploratory nature and applies a cross-disciplinary methodology.

1.5 Chapter outline summary

different output formats (dvi, pdf)

1.6 Contribution

Interactive media facades

Summarising state of the art of interactive media facades and content

Design processes

Describing the design process and identifying challenges through own projects

Interdisciplinary collaboration

Contributing to the notion of interdisciplinary collaboration between design, technology and research

Guidance

Guidance for architects and urban designers aiming to use media architecture for enriching urban spaces

Chapter 2

Background

Chapter summary

In this chapter, I provide an overview of relevant projects and research in the fields of media architecture and humancomputer interaction and focus on frameworks that describe social interactions mediated through interactive systems, with a particular focus on urban screens and media facades..

2.1 From anthropometric scale to sentiment analysis/architecture

According to Pheasant and Haslegrave (2006) *[Pheasant2006]* ”Anthropometric is a branch of the human sciences that deals with the body measurements, particularly with measurements of body size, shape, strength, mobility and flexibility and working capacity. Humans are variable (in dimensions, proportions and shape, as in all other characteristics), and user-centred design requires an understanding of this variability.”

Anthropometric data according to Jeremy Stranks Human Factors and Behavioural Safety *[Stranks2007]*

- sitting or standing height
- arm length
- arm reach in a forward, sideways, upward and downwards direction
- hand and finger size
- knee height
- strength of individual muscle groups
- range of movement possible at various limb joints
- grip strength

Behavioural data / sentiment / sensual data

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”Designing for people” in the 20th century was characterised by Cartesian methods to map the physical needs of humans. Architects and designers such as LeCorbusier (2004), Dreyfuss (1955) or Neufert (2002) surveyed human ergonomics to suggest design principles for an anthropometric scale based on Vitruvs early considerations. Today it is all about the understanding of human behaviour. The advent of the digital turned our built environment into an ecology of sensors measuring our behaviour. Human-computer interfaces such as mobile devices, urban screens or media facades augment our physical presence in digital space. But how do we actually design our physical space for people in the digital age? We propose an interactive cocoon weaved out of a translucent fabric that turns the atrium into a stage for social encounter. The aim is to foster the notion of an atrium as the social centre of a building. Our focus is on the exploration of architectural form, translucent materials and responsive lighting to facilitate social interaction. We collect peoples sentiments and materialise them into light and fibre. Based on our experience in human-computer interaction and interactive lighting we suggest a system that lets occupants interface with the light structure by using any RFID card. Simple sentiment interfaces attached to the entrance barriers and rails on each floor allow employees to express their current sentiments. These interactive dashboards were designed with knobs, dials and buttons. Each day, Arup people will be encouraged to share their sentiments via one of the dashboards that are installed on each of the six office floors. As people approach the dashboard they will be invited to choose which mood they are in to record their sentiment of the day. People will operate a dial and this will identify their sentiment, happy, sad or indifferent. Individual swipe cards such as the London Oyster card will enable participants to submit their sentiment for the day. As everyones RFID enabled swipe card is unique this will allow the system to identify behaviour albeit anonymously. A sophisticated algorithm will feed participants feelings through the dashboard and these will be digitally projected into a light field created by LEDs that forms the spine of the cocoon. Our system architecture allows for the tracking and displaying of several behaviours. These parameters are encoded into lighting patterns that suggest the collective mood of the buildings occupants. The sentiment engine (database) collects human data in the office building through the sentiment recorder. The Sentiment

Cocoon is to represent a collective visualisation of how everyone is feeling in the Arup head quarters in London on any given day. The lighting design of the Cocoon will create an enigmatic display. Natural daylight, pooling into the atrium from the skylights above will blend with the light emitted from the LEDs. This will allow for a rich interaction of varying forms of light, which will be diffused through the skin of the cocoon. The translucency of the material will create an effect whereby the suspended Sentiment Cocoon will generate a striking visual display of light that has been informed by the feelings of people working at Arup. The sentiment will be encoded in different colours and movement. Colour gradients, the velocity of the colour and movement will be represented through patterns. Over time the patterns will become recognisable and therefore people working in the Arup building No.8 will experience the overriding sentiment of the day within the office.

The Sentiment Cocoon is yet another example of the increasing proliferation of media architectural interfaces mediating human behaviour with architecture. These social applications will ultimately lead to responsive, adaptable and clever buildings that serve human wellbeing.

2.2 From public displays to urban screens and media facades

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2.2.1 DIY displays

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2.2.2 Public displays

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2.2.3 Urban screens

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2.2.4 Media facades

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2.2.5 Interactive media architecture

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2.3 Urban IxD: Technology mediated interactions in urban space

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2.3.1 From urban computing to urban IxD

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2.3.2 Tangible user interfaces (TUIs)

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2.3.3 RFID interfaces

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2.4 Interfacing with Media Architecture

Due to technological advancement, large public displays became ever more incorporated into the built environment and because of price decline its application for social and artistic purposes became popular in urban space. This led to novel technology- mediated social interactions, such as people engaging with media facades through tangible devices. Tangible user interfaces (TUIs) ”give physical form to digital information, employing physical artifacts both as representations and controls for computational media” [*Ullmer2000*](p. 916). Tangible Interactions evolved from research in TUI and rely on embodied interaction, tangible manipulation, physical representation of data and embeddedness in real space and give computational resources and data material form [*Hornecker2006*]. The intention is to embed computing into everyday life and support intuitive use. One of the first social media art projects that provided an interface allowing passers-by to create and share content on a media facade was the BlinkenLights [1] project in 2001. Participants on a street in Berlin were able to share messages typed into a mobile phone with the public through posting them on a low-resolution media facade (each pixel was an illuminated window in an office building). Over the past few years there have been numerous media art and research projects that have developed user interfaces and applications to transmit actions, in situ and in real-time, on to a media facade that is connected to an interface. For example, SMSlingshot *[Fischer2012]*, Sonic Skate Plaza *[Serret2013]*,6 Binoculars *[Guljajeva2013]*,[2] or SCSD Sao Paulo *[Behrens2013]*.[3] More recently, multiuser interactions with media facades through mobile devices revealed challenges when deploying interactive artifacts in urban space that enable passers-by to engage with media facades *[Boring2011]*. Wiethoff and Gehring *[Wiethoff2012]* introduced a design toolkit to prototype when designing interactions with media facades before the actual deployment. Since then, novel interfaces have been designed and deployed in the urban environment that let people interact with media facades *[Hoggenmueller2014]*. We aim to contribute to this existing research by exploring the relation between TUIs and large programmable displays from an HCI as well as architectural point of view.

2.5 Media Architecture and the Role of Context

McQuire *[McQuire2006]* argues that TV screens have been transformed from small-scale interior devices to large architectural surfaces that no longer broadcast to private inside spaces but to public outside spaces. Architectural surfaces turned into public media interfaces, transmitting mostly content curated by corporate organisations, rather than interactions generated by the public in situ. The monochromic ”Spectacolour Board” at the New York Times building, set up in 1976, is considered to be the first large electronic display in urban space, which broadcasts dynamic content *[McQuire2009]*. At the time, this was a technological advancement of the traditional billboard, serving to broadcast commercial content *[Huhtamo2009]*. From then

[1] xxx
[2] xxx
[3] xxx

on, the prevalence of urban screens was unstoppable in particular technological developments and price decline accelerated this trend in recent years. Whole building facades subsequently became digital walls such as the facades surrounding the New York Times Square that display dynamic content. Urban screens are either stand alone (e.g. large BBC screens initially initiated by the BBC, in Liverpool, UK), attached onto existing building facades (e.g. Piccadilly Circus, London), or the digital media technology is already weaved into the buildings surface (e.g. the Galleria department store in Seoul, Korea). Visually animated surfaces, such as dynamic light facades, are equipped with numerous light-emitting diodes (LED). They turn into large programmable pixel matrices displaying animated visual patterns. From a technical perspective, there are other types of artificial light-based media facades as well, such as projections onto facades, back projections through glazed facades, or three-dimensional media facades (i.e. voxel facades) *[Haeusler2009]*. Some see digital media facades as simple ornaments that create an ambient atmosphere *[Caspary2009]*. Others consider the potential of digital media facades for communicating content, for instance, advertising (e.g. Times Square, New York or Piccadilly Circus, London), news content (e.g. the network of Big Screens in the UK, which was initially run by the BBC),[4] media art (e.g. Lozano Hemmers work),[5] social visualization (e.g. BlinkenLights)[6] or for community purposes on a neighbourhood level (e.g. Screens in the Wild).[7] Extensive research has been carried out to explore the challenges of deploying MAI in public space. Initially, the technical challenges of deploying display technology in public space have been summarised by Streitz et al. *[Streitz2003]*. As the design and implementation of digital media facades in the built environment progresses, the purpose of such facades and the contextual characteristics of ”media architecture” are addressed. Parameters that impact the integration of media facades into the existing social fabric from a sociodemographic (environment), technical (content) and architectural (carrier) perspective have been addressed by Vande Moere and Wouters *[VandeMoere2012]*. On the urban scale, the role

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[4] xxxBBCBigscreen
[5] xxx
[6] xxx
[7] xxx

of space, social proximity and full body performative interactions in shared spaces have been addressed by Fatah gen Schieck et al. [Fatah2008], OHara et al. [Hara2008] and Peltonen et al. [Peltonen2008].

Chapter 3

A framework for Media Architectural Interfaces (MAIs)

Chapter summary

In this chapter

3.1 Designing for Interaction: Existing Interaction Frameworks

Weiser (1991) and Dourish (2004) predicted a shift in personal computing and interaction design. Interactions have moved from home and office desktops onto mobile phones, tablets or public displays into urban spaces. Since then, extensive research in HCI has explored social interactions mediated by public displays in public spaces and brought several interaction frameworks forward. Dalsgaard and Halskov (2010) have outlined the cases and challenges when designing urban media facades and suggest considering eight challenges when designing for media facades. The first two challenges focus on the need for new interfaces that are required in urban settings as well as the integration of these into the existing built environment. Based on this, a framework for designing complex media facades has been developed by Halskov and Ebsen (2013), which includes a description of what the difference is between media facades and conventional displays. Scale, shape of display, pixel shape and their configurations as well as the quality of light were defined as parameters that differ when comparing media facades with conventional displays. Most obvious is the fact that media facades are not standardized in these properties, the scale is a way bigger than with conventional displays, and compared to conventional displays media facades can have a three-dimensional surface. In the following, we focus on four existing frameworks that we consider as important milestones towards an integrated media architectural design. Each framework describes the relationship between humans and their action in the presence of programmable electronic displays and in relation to the surrounding space. These frameworks describe the following: (1) awareness space, (2) actor space, (3) action space, and (4) physical space (Fig. 1).

Figure 3.1: Background frameworks

Awareness Space

Research on awareness of public displays in relation to social interactions was first described in HCI research, when noticing a novel social phenomenon around public displays (Brignull and Rogers 2003). Three different types of activity spaces were described: (1) Peripheral awareness activities: activities that take place in the wider space around the display, where people socialize but are not necessarily aware of the presence of the public display. (2) Focal awareness activities: in this space, people are aware of the presence of the display. They are looking at the display, discuss activities that take place around the display or learn how to engage with the content. (3) Direct interaction activities: this is the space where individuals or groups actively engage with the display. The research findings suggest that people found it difficult to transit from one activity space to another. Later, Vogel and Balakrishnan (2004) published a spatial framework, which described how users fluidly move from implicit interactions in the wider surrounding towards explicit interactions when approaching the direct interaction space around a public display.

Actor Space

The actor space describes the different roles people take on when being in the vicinity of interactive installations. By now, computers have moved away from the desktop and novel interfaces appear, which spread into new spatial settings. People are changing their role; in particular, in public settings people traverse various awareness spaces, which afford specific roles. Consequently, a better understanding of what kind of roles these are, when and where people take them on, is crucial for the design and deployment of interactive systems in urban spaces. Reeves (2011) identified that the conventional user is actually changing her role when passing-by, on looking or turning into a performer in the vicinity of an interactive installation. Within this framework, the performing user plays the central role when engaging with an interface. Her acting entices other people from the audience into the experience; some of them may become performers. More recently, Behrens et al. (2013), and Fatah gen Schieck et al. (2013), have explored in detail how these roles are framed through the situated layout of urban screens.

Action Space

In the last section, we clarify the diverse roles individuals take on in connection with interactive installations; here, we describe the various phases of interactions people traverse. The Audience Funnel by Michelis and Muller (2011) depicted a framework that establishes a terminology for each transition. These phases were identified as (1) passing by, (2) viewing and reacting, (3) subtle interaction, (4) direct interaction, (5) multiple interactions and (6) follow-up action. Michelis and Muller found that people proceed from one phase to the next in order to understand the interaction. Boundaries are described as a series of thresholds that need to be crossed before one can interact with a public display.

Physical Space

The spatial localization of interactions is largely neglected in the work described above. In contrast, Fischer and Hornecker (2012) have outlined an interaction framework that focuses on the spatial properties of interactions. When looking into the various encounter stages, urbanHCI specifies different interaction spaces on which people perform different activities. This includes the (1) display spaces, (2) interaction spaces, (3) potential interaction spaces, (4) gap spaces, (5) social interaction space, (6) comfort space and (7) activation space on which participants behave differently towards an interactive media facade. Fischer and Horneckers framework was explored through a media art project called SMSlingshot. This project developed an interface that looks like a wooden slingshot, but its integrated digital technology allows the user to shoot short text messages (SMS) together with virtual paintballs on a media facade. Within these immediate spaces around an electronic display (i.e. interaction spaces), passers-by stop, watch and start playing with the media architectural interface and eventually change the look of the media faade individually; others observe in groups from a distance, discuss or engage as well; simultaneously, other pedestrians do not sense the presence of such interactions and the existence of the media facade at all. Screens in the Wild, on the other hand, addressed the question of spatial layout and its relation to technologically mediated interactions (Behrens et al. 2013; Fatah gen Schieck et al. 2013). Four interactive and networked urban screens have been deployed in four different neighbourhoods in London and Nottingham. Within this approach, the following interaction zones were recognized: (1) direct interaction space surrounding the display (direct); (2) the surrounding public space (wide); and (3) across spatial boundaries, i.e. the remotely connected space through the networked displays (networked). Sociospatial configurations mediated by urban screens were explored, and site-specific interactions were observed and compared to more generic types of interactions. Indications were found that the properties of the spatial layout play a significant role and, to a certain extent, frame the type of interactions mediated through public displays (Fig. 2).

Figure 3.2: Taxonomy

In summary, we plotted four existing spatial frameworks that describe interactions between humans and displays from (1) awareness spaces, (2) actor spaces, (3) action spaces and (4) physical spaces. Although three of the presented frameworks dealt with smaller public displays, in comparison with the large urban displays, juxtaposing these frameworks assists designers to understand the multilayered design space when designing interactive systems for large programmable displays. We contribute to this body of research by exploring specifically the relation between TUI and large programmable displays (such as media facades) in a given context. We clarify the notion of MAI and apply it on two design case studies we conducted.

3.2 Media Architectural Interfaces (MAI)

We introduce the notion of MAI. MAI capture an ecology of tangible (TUI) and non-tangible interfaces. They can be considered as interactive systems in urban space, which potentially entice people to step out of their routine and perceive urban space or act differently within it. In more detail, we consider MAI as the synthesis of situated and shared interfaces. They mediate participants engagement with large programmable electronic displays such as urban screens, media facades or media architecture. Tangible interfaces are generally located on street level, whereas the connected displays are mostly vertical surfaces attached to buildings or are the buildings themselves such as the case with media facades. Eventually, they may disrupt movement and behavioural patterns in the given spatial setting. The TUIs frame the interaction modalities (Muller et al. 2010) with the display as well as they set the level of participation as described by Fritsch and Brynskov (2011) and complemented by Caldwell and Foth (2014). Usually, these interfaces call for explicit and shared interactions following the urbanHCI framework (Fischer and Hornecker 2012). Large programmable displays amplify participants interactions through the tangible interfaces, which depend on technical properties of these displays such as type, shape, material, size and resolution of the display (Halskov and Ebsen 2013). Both interfaces (tangible and non-tangible) are dependent on the given sociospatial setting (for example pedestrianized places, busy high streets or transport hubs). As a consequence, the distance in between the tangible interface and the display can vary. Further, when changing the properties within one of the three constituent elements (i.e. the tangible situated interface, display or setting), the two other elements are directly affected. This will be discussed in more detail in Sect. 5. In the next section, we report on a case study, which describes an example of a MAI consisting of two similar tangible user interfaces connected to two very different displays within two different sociospatial settings. The aim is to test and explore the notion of MAI and to eventually guide designers when developing interactive systems for urban spaces.

Chapter 4

Methodology

Chapter summary

In this chapter I will introduce the empirical methodology for this exploratory research. A mix of existing cross-disciplinary approaches have been applied, for instance, ”research through design”, iterative urban prototyping,

4.1 Research through design approach

This PhD research is located within the fields of architectural research and human-computer interaction research in urban space (urban HCI). Both fields are concerned with human behaviour, urban space and increasingly with digital media technologies (i.e. media architecture). This PhD research explores the design, deployment and evaluation of media architectural interfaces (MAIs) in urban space. Media architectural interfaces (MAIs) consist of a mediator (i.e. situated tangible user interfaces) and a carrier (i.e. urban screen or media facade). More specifically, this PhD research will explore, how citizens may use the mediator to engage with the carrier. And further how the deployment of media architectural interfaces (MAIs) may influence the socio-spatial configuration of pedestrian flows, encounter and social interactions. In the following this PhD research suggests a methodology, which brings together empirical architectural research and interaction design research (ONeill et al., 2006; Fatah et al, 2013). It is driven by a research through design approach (i.e. iterative prototyping) using qualitative and quantitative methods.

The methodology will focus on four goals in order to address the research:

1. Design and deployment of the media architectural interface MAI (section link);

2. Analysing full-body interactions of participants interacting with the media architectural interface (section link);

3. Identifying participants behaviour when bridging the focal awareness space at the TUI and the distant awareness space at the media faade (section link);

4. Observing and analysing of pedestrian flows, encounters and social interactions before and during the deployment of the media architectural interface (section link);

To clearly describe the methodology a chronological approach subdivides it into three stages. The pre-deployment stage marks all research activities that are required prior to the actual setting up of the media architectural interface (MAI).

It mainly involves the search for an appropriate location that accepts the Mediator (i.e. tangible user interface) and a Carrier (i.e. media facade) to connect to. To inform the appropriation of the location and to have comparative data sets for the evaluation afterwards, spatial observations (see next section) have to be carried out in the field.

The during-deployment stage will mostly take place on location. The MAI is fully working and the data collection starts. As Mediator and Carrier are connected through a database, log files will store information about the interactions between user and the Mediator. Observations about the types of encounters the Attractor enables will be captured in the direct space around the Mediator and in the wider surrounding that is affected by the Carrier. In addition, audio-visual data such as full-body interactions will be captured through video recording and picture taking. In the after-deployment stage all collected data will be analysed. The data gained through spatial observation will be mapped and compared to the observation data from the pre-development stage.

4.2 Iterative urban prototyping

The prototype will be based on a technology that has been developed during a series of iterative design processes before. The shared and situated tangible interface has been originally developed as part of the authors MSc studies and since then been iteratively deployed, tested-out during various events and improved (i.e. Behrens, 2011; Behrens, 2013). The technology facilitates on the ubiquitous travel cards, such as the London Oyster Card, which is based on RFID technology. The goal is to make use of existing smart technology beyond travel purposes and allow citizens to express their mood and opinion instantly in the technology mediated urban realm.

4.3 The Interface

As outlined in the introduction, the MAI consists out of two elements: Mediator is a situated tangible user interface that generates user specific data Carrier is the object that displays the data generated by the Mediator. The carrier might be a building projection, an urban screen, or a media faade and might change depending on the location of the case study. The Mediator is built on the same technology (fig. 5) and will not change. Only the appearance (i.e. case or description) might change according to the content of the deployment (fig. 22). For this PhD research the prototype of the Mediator will be based on a technology that has already been developed during a series of iterative design processes. The system architecture behind the situated tangible interface has been originally invented as part of the authors MSc studies and since then been iteratively deployed, tested-out during various events and improved (i.e. Behrens, 2011; Behrens, 2013). The system is based on ubiquitous travel cards, such as the London Oyster Card, which are based on radio-frequency identification (RFID) technology. The idea is to build on the fact that almost everyone is carrying around such an identifiable tag and make use of the existing smart technology beyond travel or access purposes and allow citizens to express their mood and opinion instantly using this technology in the urban realm. Using an RFID tag will allow to gather data (fig. 6) such as preference of interactions (1), identification of interaction (2), date (3), and time (4) of interactions.The TUI is connected to a database, which logs all data. The visualization for the carrier will pick up the data from the database. Interactions with the feedback device will be plotted quantitatively onto timeline diagrams (fig. 7), which show the ID number of the participants transport card, the time when the interaction took place and the preference of the interaction (i.e. like or dislike). The outcomes of the surveys will be visualized and qualitative observations and interviews will be summarized in written form.

4.4 Data collection, observations and analysis

Before actually deploying a prototype interface, spatial observations need to quantify and qualify peoples behaviour and movement in relation to the specific layout of their built environment. The objectives are firstly to identify suitable locations for the deployment of the prototype and secondly to capture the socio-spatial configurations before the deployment in order to be able to compare them with the configurations before and during the design intervention. Spatial observations will be conducted as developed by Space Syntax and summarized by Kinda Al Sayed et al (2013). Therefore researchers will need to be in the field during all times of a weekday and a weekend day.

Chapter 5

Cases

Chapter summary

This chapter will present the conducted case studies in support of the research questions. I will introduce one pilot study, which originally emerged during my MSc studies. Followed by five in depth studies. All studies are based on the same digital technology to mediate human interaction, but differ significantly in In describing these case studies, I explore the deployment of each MAI and highlight the implications for designing interactions. The focus is on mediated interactions in the vicinity of the deployed MAI. Both case studies differ in the architectural scale and the nature of the urban space (i.e. pedestrianised courtyard vs. congested high street).

5.1 Swipe I like

5.1.1 The Petry Museum

5.1.2 Discussion

5.2 VEIV London

5.2.1 The Building Projection Party

This study *[Behrens2013]* (Behrens 2013) is a follow-up on the early implementation we conducted using a TUI of the digital I like button (Fig. 3), situated in the physical space within a museum context *[Behrens2011] [Behrens2011]* (Behrens 2011a, b). The findings suggested that visitors are keen to leave their feedback and share it with others (in this case through a simple swipe card interface connecting to Twitter and Facebook). Analysis of the submitted data discovered movement and encounter patterns of visitors interacting with the installed devices and the observations of interactions revealed various forms of human behaviour such as strangers discussing the purpose of the new interfaces. In other words, the space around the tangible device turned into an encounter stage that did not exist at this place before. However, it became clear that a real-time visualisation or representation of the gathered data shown to the audience as an immediate feedback of their actions was desired by many participants but missing in this initial implementation. Building on these initial findings, the purpose of the VEIV London study was to: first, explore whether a feedback device that works in a condensed indoor public space can also be deployed in an outdoor public setting full of urban distractions, and second, add a dynamic display to the device to fulfil the need of providing the user with an immediate visual feedback. Consequently, we ask what kind of social interactions and dynamic relations of human behaviours take place in an urban setting when mediated by this interactive installation. The study took place during the UCL Virtual Environments, Imaging and Visualisation doctoral centre (VEIV) festival, 2013, where we set up the first prototype of the LED display at the UCL main campus. To explore interactivity, we connected the light installation to the binary feedback device based on

Radio Frequency IDentification (RFID) technology, which was used in the indoor public space of the museum *[Behrens2011]* (Behrens 2011b). During the festival, participants were able to leave their feedback in a playful way through swiping their travel cards (Oyster) or UCL access cards over the thumbs-up or thumbs-down icons on the card reader. Basically, the simple but effective question was whether visitors like or dont like the VEIV Centre. When swiping across the thumbs-up icon, the light installation turned the VEIV logo into a warm orange, whilst the thumbs-down icon turned the logo into a cool blue (Fig. 4). The LED display consists of three low-resolution displays following the principle of 16 digit number displays, which allow the projection of numbers and letters. In total, 48 RGB 24V LED light strips are connected to micro-controllers, which are addressable through the DMX protocol. A decoder transfers the DMX signals through USB wire to a laptop. The visualisations are programmed with processing. The installation was running between 8 and 10 pm on a summer day. During the first hour, the daylight reduced the light distribution of the LED light, whereas with the approaching darkness the LEDs were colouring the surrounding buildings in either orange or blue ambient light. Throughout the event, we took pictures, notes and informally talked to people joining the event. Overall, participants enjoyed using their Oyster Cards or UCL access cards to change the colour of the low-resolution display. The fact that they were actually rating the event was less important than the playfulness of changing the colours. We observed people sitting on the lawn suddenly walking up to change the colour from the apparently uncomfortable blue to the warm orange. They obviously felt more comfortable with the cosy orange light than with the cold blue light. A kind of campfire atmosphere was created where people were sitting around a source of pleasant light that illuminates the faces of others as well as putting the surrounding facades of the classic campus building into an orange-red shade. The lawn in front of the installation was the preferred seating area and the TUI (i.e. I like device) created a stage for social encounters. However, after sunset, people moved away from the immediate space around the display as the LEDs became too bright. Interestingly, people neither sat nor stood in between the tangible interface and the

LED display nor behind the LED display. The DIY and low-resolution media display worked out very well considering the relatively low effort that was put into the design and making of the low-resolution screen and the visual impact of illuminating a courtyard during a large public event was huge. The fact that the lightweight frames are easily movable makes this project easily adaptable to other locations.

5.3 SCSD Riga

How do the citizens of Riga actually feel about their city? What do they think about urban topics that concern the development, public transport, environment, safety and culture of their city? As part of the Participatory City, initiated by the Connecting Cities Network, Staro Riga Festival invited us to show our work.

The project called Smart Citizen Sentiment Dashboard (SCSD) is an interactive and participatory installation that lets citizens engage with and comment on urgent urban challenges concerning the city of Riga. The SCSD project aims to translate citizen feedback into a visual language, which is displayed on a large LED display. The media facade and its surrounding turn into a stage for social encounter where citizens meet and urban challenges can be discussed.

5.3.1 Staro Riga Festival

During the Staro Riga Festival the installation was set up on a busy pedestrian crossing at the intersection of Marijas Iela and Satekles Iela, which is close to the Riga main train station. The visualization was displayed on a large mobile screen facing towards Satekles Iela, and the sentiment dashboard was set up in front. The installation ran daily in between 6pm and 11pm starting Friday, 14 November 2014 and finished at the National Independence Day on Tuesday, 18 November. During the five days of deployment, in which the installation was running for five hours each evening, the interactive system tracked approximately 1600 interactions.

5.3.1.1 The Dashboard

The motivation was to develop, design and deploy a situated and tangible system that mediates collaborative interactions in public spaces whilst focusing on accessibility and affordance. In other words, the interface should be understandable and easy to use for people. The employed technology makes use of existing Radio frequency identification (RFID) as known from smart card technology such as the e-talon in Riga. We build on the widely spread use of these unique ID tags for payless travel purposes, as a large proportion of citizens of Riga carries an e-talon in their pocket. Consequently the use of these cards is a recurring embodied interaction in the smart city. At the same time every interaction is uniquely identifiable and therefore traceable. Our aim was to allow people to use their ID tags beyond technical purposes and express their mood and opinion about specific issues in the technology mediated urban realm. Hence the Smart Citizen Sentiment Dashboard (SCSD) enables participants to express their mood about urgent urban challenges in the city of Riga. The challenges were defined as follows: 1) ATTłSTłBA (development), 2) TRANSPORTS (transport), 3) VIDE (environment), 4) DROłBA (safety) and 5) KULTłRA (culture). By switching a knob on the device participants are able to choose one of the aforementioned categories. By swiping their RFID token (i.e. e-talon) across one of the two emoticons (happy or sad) their mood was transmitted onto the LED display. The SCSD affords three folded interactions: 1) switching: 5 categories can be selected through a rotary switch; 2) swiping: after choosing the category, the electronic ID card needs to be swiped over one of the three mood states (happy, indifferent, sad); 3) pushing: finally a simple push-button (Red Button) allows users to view the overall feedback of all collected moods.

5.3.1.2 The Visualisation

We chose a visualisation technique that combines the seriousness of the topic with the more accessible style of popular info-graphics. The visualisation consists of an abstract sunburst representation, of which each burst corresponds to the sentiment of an individual participant towards the currently selected urban challenge. Each urban challenge is encoded by a different colour and an icon representation. Upon switching the rotary knob, the sunburst visualisation corresponding to the specific urban challenge, and coloured accordingly appears on the facade.

The sentiment value for each participant (happy, un-happy) is graphically encoded through the length of the corresponding burst: the longest burst represents a positive sentiment towards the urban challenge at hand, while the shortest corresponds to a negative statement. Our choice for this circular visualisation technique was also motivated by its scalability, which allows for an arbitrary number of people to participate and be visually represented. We considered this flexibility a desirable feature in the context of urban environments, often characterised by highly variable and open-ended, and unpredictable flux of people and interactions.

Animations

The integration of dynamic visual cues can make visualisations richer, more vivid and therefore easier to understand. Accordingly, our visualisation shows a dynamically animated circle over the sunbursts in order to convey the average participants sentiment for the given urban challenge. Each new burst from a participant visually appears with a smooth animation and bouncing effect, to highlight the recording of fresh data. A new entry is displayed in a white color to unambiguously distinct it from the rest of the graphical representation. Shortly after it is smoothly taken over by the color of its respective urban challenge.

The Red Button

In order to provide citizens with an overview of previously submitted sentiments, and a more interactive approach to exploring the installation, we integrated a Red Button at the bottom of the interface. When pushing this button, a dynamic visualisation of the average feedback for all available urban challenges is represented on the facade. As mentioned above, each urban challenge is represented by its corresponding colour, and occupies a different part of the circular shape proportionally to the relative participation rate of the according challenge. We aimed to create a simple, playful, yet meaningful approach to enable citizens and participants alike to make a deeper sense of the installation, and the underlying participation results: people can gain insight about which urban challenge is most attractive to vote for, and what is the average sentiment about it of fellow citizens. This, beyond being an overview, the heart visualisation symbolises the overall sentiment of the city towards its urban challenges.

5.3.2 Rigas Sentiments

The installation was running for five days, in total for 25 hours. During this time the database logged about 1600 interactions. These interactions cannot automatically be counted as single votes by individuals as many participants were exploring the installation in a playful manner through swiping their e-talon more often. In a next step with an elaborate data cleaning process this behaviour can be removed from the data set. However, we can already identify a clear tendency that shows that participants overall voted positive, as 75 percent of the interactions were happy. If we look more closely into the different urban challenges we can reveal more telling insights of how the citizens of Riga think about their city. ATTłSTłBA (development) was the category, which attracted with 356 interactions the least attention of participants. Still 76 percent (270 counts) of the recorded data was positive. As development maybe interpreted in many ways participants could have felt irritated and therefore may have decided not to vote in this category. TRANSPORTS (transport) and DROłBA (safety) were the most controversial topics, which is by the way in line with other cities where the installation was running before. Transport attracted 379 interactions and safety 434 interactions of which both topics were 65 percent happy and 35 percent un-happy. As there were more interactions tracked for the category of safety one may argue that this is due to the higher importance of this topic to participants. VIDE (environment) attracted 447 interactions of which 78 percent were positive and 22 percent negative. KULTłRA (culture) has been the topic most participants wanted to express their sentiments about. The system logged 518 interactions of which 441 (85 percent) were positive and only 77 (15 percent) negative. Culture is therefore not only the most frequently used urban topic but also the topic participants are the happiest about. One may argue that this result might be due to the fact that participants were influenced by the many cultural events that were going on at this time during the Staro Riga Festival.

5.3.2.1 Observations

Overall it is to say that the logged interactions by the system were on average 75 percent positive as well as none of the categories reached a majority of un-happy interactions. This is a result we did not find in any previous deployment and therefore lets us assume that Riga is a city where people seem to be quite content with the addressed urban challenges or tend to see things in a more positive way.

Our observations revealed three different participation patterns:

The serious behaviour

A participant submits exactly one sentiment for each of the explored categories. This pattern would reflect how we expected the interaction mechanism to work i.e. a person would explore the categories by rotating the knob and would submit one sentiment for a specific preference.

The repetitive behaviour

This was the most frequently observed participation pattern. The participant has submitted the same sentiment (same preference for a certain category) several times within the considered time range. The occurrence of this pattern can be explained with our frequent observation of participants holding their card over the RFID reader (for a certain preference) for several seconds. Thus the system registers several submissions (although our system had restricted votes not to be registered within 5 seconds after each given participation). This behaviour might be due to a usability flaw of our installation the participating person did not realize the effect of her participation in the visualization, hence tried several times. Another explanation might be the manifestation of a particular sentiment towards one urban challenge: by holding the card over the reader, the user might have wanted to reassure herself that her opinion would be registered by the system.

The playful behaviour

There were many occurrences of this behaviour during the deployment of the installation. The participant has submitted several different preferences for the same category within the considered period of time. This might indicate that s/he did not really want to express an opinion, but rather explored how the installation and the visualization work. While we cannot account for representative polling results, the findings indicate the installation fulfilled its intentions as an urban feedback platform, where people engage meaningfully with locally relevant topics. In the future it would be exciting to deploy several citizen sentiment dashboards permanently across the city as well as working closer with city authorities and local communities. This might open a fruitful dialog in between citizens and stakeholders of Riga.

5.3.3 Discussion

5.4 SCSD Sao Paulo

5.4.1 Viva Cidade Festival

The Smart Citizen Sentiment Dashboard (SCSD) is an interactive participatory installation that lets citizens engage with, and comment on, urban challenges in their cities. Through a tangible interface connected to a media facade, passersby and participants on-site can submit their sentiments and simultaneously see the effect of their actions projected onto the facade. The tangible urban interaction device allows for an intuitive and accessible, yet identifiable and public way of expressing ones view. The project aims to create an open, aesthetic dialogue about urban challenges and invites citizen to engage, by playfully allowing them to express their opinion and share and compare their views in the physical built environment. Our motivation was to design, develop and deploy a situated system that mediates collaborative interactions in public spaces, whilst focusing on accessibility and affordance. In other words, the interface should be understandable and easy to use for people. Based on the feedback of the previous pilot study, described in the previous section, we deployed and tested-out the TUI in various occasions and improved the system iteratively. Similar to the VEIV London study, the employed technology makes use of existing RFID technology as known from smart card technology. We build on the widely spread use of these unique ID tags for payless travel purposes or building access, as a large proportion of city dwellers carries a RFID tag in their pocket (i.e. the Bilhette Unico is the transport card in Sao Paulo). Consequently, the use of these cards is a recurring embodied interaction in the technologically augmented city. At the same time, every interaction is uniquely identifiable and therefore traceable. Our aim was to allow people to use their ID tags beyond technical purposes and express their mood and opinion about specific issues in the technology-mediated urban realm. Hence, the Smart Citizen Sentiment Dashboard (SCSD) (Fig. 5, left) enables participants to express their mood about urgent urban challenges in the city of Sao Paulo (Behrens et al. 2014). Up front, we were running four design ethnographic workshops amongst various social groups in Sao Paulo with the aim to learn about citizens urban challenges. As a result of the collaboration, five categories were established: (1) environment, (2) mobility, (3) security, (4) public space and (5) housing. By switching a knob on the device, participants are able to choose one of the aforementioned categories. By swiping their RFID token (i.e. Bilhette Unico) across one of the three emotions (happy, indifferent and sad), their mood was transmitted on to the media facade (i.e. display) (Fig. 3). The mood expressed by the user (i.e. happy, indifferent or sad) is then projected onto a huge LED media facade (i.e. display), which has been retrofitted in the existing honeycomb facade of the pyramidal FIESP building. The media facade is divided into three parts, which are situated on three different sides of the facade. The biggest and main display faces to the opposite side of the street, whereas the two smaller screens are directed to display to both directions of Avenida Paulista. The threefold low-resolution LED facade is formed of a network of approximately 26,000 LED clusters (pixels) embedded in 3700-m2 metal structure that covers the pyramidal FIESP building. The grid is approximately 13 13 cm. Each pixel consists of a module of four LEDs: 2 R, 1 G, 1 B the luminous intensity is 4.5 cd/module. For the display, we chose a visualisation technique that combines the seriousness of the topic with the more accessible style of popular info-graphics. The visualisation comprises of an abstract sunburst representation, of which each burst corresponds to the sentiment of an individual participant towards the currently selected urban challenge. Each urban challenge is encoded by a different colour and an icon representation. Upon switching the rotary knob (Fig. 6), the sunburst visualisation corresponding to the specific urban challenge and coloured accordingly appears on the facade. The sentiment value for each participant (happy, indifferent, sad) is graphically encoded through the length of the corresponding burst: the longest burst represents a positive sentiment towards the urban challenge at hand, whilst the shortest corresponds to a negative statement. Our choice for this circular visualisation technique was also motivated by its scalability, which allows for an arbitrary number of people to participate and be visually represented. We considered this flexibility a desirable feature in the context of urban environments, often characterised by highly variable and open-ended, and unpredictable flux of people and interactions. The integration of dynamic visual cues can make visualisations richer, more vivid and therefore easier to understand. Accordingly, our visualisation shows a dynamically animated circle over the sunbursts in order to convey the average participants sentiment for the given urban challenge. Each new burst from a participant visually appears with a smooth animation and bouncing effect, to highlight the recording of fresh data. A new entry is displayed in a white colour to unambiguously distinct it from the rest of the graphical representation. Shortly after, it is smoothly taken over by the colour of its respective urban challenge. In order to provide citizens with an overview of previously submitted sentiments, and with a more interactive approach to exploring the installation, we integrated a heart button at the bottom of the interface (Fig. 7). When pushing this button, a dynamic visualisation of the average feedback for all available urban challenges is represented on the facade. As mentioned above, each urban challenge is represented by its corresponding colour and occupies a different part of the circular shape proportionally to the relative participation rate of the according challenge. We aimed to create a simple, playful, yet meaningful approach to enable citizens and participants alike to make a deeper sense of the installation, and the underlying participation results: people can gain insight about which urban challenge is most attractive to vote for, and what is the average sentiment about it of fellow citizens. This, beyond being an overview, the heart visualisation symbolises the overall sentiment of the city towards its urban challenges.

5.4.2 Findings and discussion

Our findings suggest that the implementation of a tangible interface not only supports engagement indoor, such as in a museum context, but also outdoor during a festive event and a media art festival. Yet, the actual TUI in an outdoor setting was not immediately attracting participants. Instead, our observations suggest that the strong visual presence of the display (i.e. low-resolution display or media facade) appealed peoples attention first. In the first study, VEIV London, the interactive system consisted of a simple binary RFID swipe card interface. In the second study, conducted in Sao Paulo, the shared user interface was again based on RFID technology but with additional features such as a rotary knob and a push button. Initially, we decided to use RFID technology instead of simple touch buttons due to the potential to identify the user. We were able to track individual user behaviour such as returning users or misapplication, which simple buttons would not allow. Despite these useful features, we observed that the need for an individual swipe card generated a barrier that was hindering some people to interact. The reasons for this may be manifold: in London, the use of the transport card (i.e. Oyster Card) has a wider distribution amongst all citizens. Public transport is generally considered to be a convenient way of commuting and people feel secure using London buses or undergrounds. Consequently, the usage of the Oyster Card appears to be more embodied than in Sao Paulo, where private transportation is very common, mostly due to personal security. Thus, Londoners more likely understand how to engage with the interface and particularly liked the idea to use a smart card to give feedback about services. However, we observed that the fact that not all people carrying a RFID card in their pockets triggered unexpected social encounters during both studies. Bystanders, curious to get involved, asked actors to borrow their cards, or families sharing one card amongst each other. In addition, bystanders started debating about the sense of having such interfaces in urban space or simply wanted to know how the technology works. During the SCSD Sao Paulo study, we looked closely at actors directly interacting with the TUI. The most common behaviour actors performed started with looking at the TUI, swiping their card or turning the rotary knob. After expressing their feelings towards one of the categories at the swipe card interface, we saw that participants would then frequently look up to the media facade to see what impact their acting had on the visualisation. The fact that the visualisation was slightly delayed (i.e. less than a second) was an advantage for the actor experience as it left time for the body orientation towards the large media facade. Close bystanders were behaving almost synchronic in order to understand the interaction modality (Fig. 8). At the same time, we made observations in the wider surrounding of the MAI during the SCSD Sao Paulo deployment. We recognised MAI-related interactions around the facade in the close interaction space as well as in the wider ambient space. Although these observations were not rigorously conducted, we did notice a few recurring behaviours. In particular, we frequently saw people taking pictures of the media facade with their mobile phones or taking pictures of each other in front of the facade. These informal observations would suggest that people simply liked the visual presence of the media facades visualisation and the heart icon it used. Yet, the initial design aim was to develop an interactive system, which would spark passers-by engagement with the informational content and eventually may trigger new social encounters and discussions about the matter. In the case of VEIV London, participants were asked to express their opinion about the UCL doctoral centre (i.e. like or dont like), whilst during the SCSD Sao Paulo event contestants could share their sentiments about urgent urban challenges in their city (i.e. environment, mobility, security, public space or housing). Accordingly, this raises the question regarding the informational character of the installation as intended and the actual ambient perception of the visualisation by many people in particular outside the direct interaction space in the close vicinity of the TUI. Our findings here suggest that designers need to take the ambient perception of MAI set ups into account when designing interactive systems in urban environments (Fig. 9). More specifically, we would like to relate our findings to the initially examined interaction frameworks in Sect. 3, which dealt with the (1) awareness space, (2) actor space, (3) action space and (4) physical space in the context of public displays or a media facade. In the following, we will discuss these frameworks in relation to the two design studies as outlined in the last section. We argue for the consideration of these multilayered interaction spaces when designing interactive systems in urban spaces. Awareness space: In both studies (VEIV London and SCSD Sao Paulo), the direct interaction activities took place in the immediate vicinity of the TUI, whereas the focal and peripheral awareness spaces differed in their dimensions. This is firstly due to the dissimilar size of the displays. The display used for the VEIV London study was only 2 by 6 m (i.e. 12 m2) compared to the large media faade for the SCSD Sao Paulo study with 3700 m2. At the same time, the difference in distance between the user interface and the display was significant: 5 m VEIV London compared to 33 m SCSD Sao Paulo. This seemed to have an impact on peoples spatial awareness with regard to dynamic displays in the city. Actor space: Compared to the dynamic stream of pedestrians in the SCSD Sao Paulo study, the flow of people in the VEIV London study was rather calm, whilst the event was highly attended. The audience hardly changed during the party, but their actions altered; for instance, spectators turned into actors when walking up to the TUI to change the colour of the display and returned to their friends. Others simply enjoyed the presence of the colourful display or watched other guests interacting with it. In contrast, the dwelling time of the audience during the Sao Paulo event was much lower due to the high pass-through frequency of pedestrians on their way to the underground station. Action space: The flow of peoples actions during the VEIV London event was different to SCSD Sao Paulo. Other than Michelis and Muller (2011) stated, the phases through which people had to go before they could actually interact with the MAI were not stringent in the VEIV London set up. People did not necessarily cross in the described order from (1) passing by to (2) viewing and reacting to (3) subtle interactions to (4) direct interactions to (5) multiple interactions and to (6) follow-up actions. Instead, we observed groups gathering on the lawn walking up to the TUI to collectively explore the interactive system. In contrast to this, we identified human behaviour as explained by Michelis and Muller (2011) during the SCSD Sao Paulo study. Physical space: The spatial layout in the VEIV London case consisted of a pedestrianised rectangular courtyard enclosed by the historical university buildings, compared to the vibrant two-directional avenue in Sao Paulo, which was lined by high-rise office towers. In the VEIV London set up, there was hardly any gap space in between the TUI and the display (i.e. ca. 5 m), compared to the congested main road in Sao Paulo, which divided the tangible interface from the media facade (i.e.

ca. 33 m). In addition, the comfort spaces, potential interaction spaces and social interaction spaces varied greatly in both studies. The enclosed courtyard and the positioning of the display within it released more of these spaces than the congested pavement in Sao Paulo. In summary, it appears that the affordance of each of the described spaces has a strong impact on the presented studies and therefore need to be taken into account when designing for such interactive systems in the built environment. With this in mind, we return to our initial question: How to actually go about designing for an interaction with MAI? To help answering this question, we now introduce a taxonomy for the categorisation of MAI based on the triangular relationship between TUI, display and setting. Within Fig. 10, we have plotted the relevant information of both design studies against each other to gain a better understanding of the relation between the individual properties. In more detail, the properties of each constituent element will be described below: Interface: The characteristics for the participation level have been described by Fritsch and Brynskov (2011) as (1) static, (2) dynamic, (3) reactive, (4) interactive, (5) participatory and (6) communicative and recently have been extended by Caldwell and Foth (2014), who added the terms (7) performative and (8) controllable. The characteristics of the interaction modalities originate from dimensions summarised by Muller et al. (2010) and use the following interaction modalities: (1) presence, (2) body position, (3) body posture, (4) facial expression, (5) gaze, (6) speech, (7) gestures, (8) remote control, (9) keys and (10) touch. This may also impact the distance between the interface and the display. Being aware of these properties and their characteristics will allow designers clarifying the nature of interaction they want to design for. Display: These properties are mostly related to the technical details of large programmable displays as described by Halskov and Ebsen (2013). They consist of (1) type, (2) material, (3) shape, (4) size and (5) resolution but also of (6) the type of content. Each of these characteristics can impact the multilayered spatial frameworks described above (i.e. awareness, action, actor, physical). Context: Understanding the socio-spatial settings as described in Sect. 2.1 are core properties when locating a MAI. As explained in this paper, here is a huge difference when designing in the context of a pedestrianised university court (i.e. VEIV London) or a busy high street (i.e. SCSD Sao Paulo). Although most of the characteristics aligned in our taxonomy describe the properties of the constituent elements (i.e. display, interface, context) from a technical point of view, they influence the multilayered spatial frameworks (i.e. awareness, actor, action, physical) and consequently assist when designing MAI for interactions in urban space. Through understanding the effect of the single properties of each constituent element on the whole interactive system, designers may eventually be able to be fully aware of their design decisions.

5.4.2.1 Conclusion

In this paper, we ask the question how to go about designing for an interaction with such a large programmable electronic display and introduced the notion of MAI founded on existing spatial interaction frameworks established in HCI research in recent years. We further described two design studies, which we designed, deployed and observed in urban space. The first study was carried out at a gathering in a university courtyard (i.e. VEIV London), whilst the second was conducted in a complex urban setting in the city of Sao Paulo (i.e. SCSD Sao Paulo). Further, we described the setting in which the interactive system was arranged and presented our observations concerning mediated social interactions in the surrounding space. Based on our findings, we discussed the relation of our observations to four existing spatial frameworks and suggested a taxonomy, which categorises the properties and characteristics related to our notion of MAI. In this work, we laid the focus on social interactions mediated through our MAI. For future development, we aim to explore other MAI, study their properties between human behaviour, the user interface and the display in a given spatial layout and compare them with our taxonomy.

5.5 SCSD Linz

5.5.1 Ars Electronica Festival

5.6 Sentiment Cocoon

5.6.1 No.8@Arup Competition

The competition, under which the Sentiment Cocoon evolved, called No.8@arup , is a programme that provides space to host installations and sculptures in Arups Central London office. The idea is a simple one, to provide an opportunity and encourage emerging architectural practices to showcase their creativity. No.8@arup provides a fertile thinking ground to collaborate in a fast paced programme with support from Arup engineers. Arup is passionate about how the built environments will be shaped. Hence the creation of installations and sculptures plays a role in stimulating thinking around the transformation of our environment in the 21st Century.

The No.8@arup Installation is now in its third year. This year, entrants were asked to respond to the theme Designing for People, and consider how the No.8@arup installation should reflect the need for occupants to be placed at the heart of a design brief (see appendix). Arup aspires to create efficient and comfortable environments, where people are productive and also inspired, motivated, healthy and happy. Previous installations have included the 'Balls' (2014), which allowed visitors to interact with a moving sculpture and the Splinter (2013), an 18m tall timber tower.

5.6.2 Initial design idea

We propose an interactive cocoon weaved out of a translucent fabric that turns the atrium into a stage for social encounter. The aim is to foster the notion of an atrium as the social centre of a building. Our focus is on the exploration of architectural form, translucent materials and responsive lighting to facilitate social interaction. We collect peoples sentiments and materialise them into light and fibre. Based on our experience in human-computer interaction and interactive lighting we suggest a system that lets occupants interface with the light structure by using any RFID card. Simple sentiment interfaces attached to the entrance barriers and rails on each floor allow employees to express their current sentiments. These interactive dashboards were designed with knobs, dials and buttons. Each day, Arup people will be encouraged to share their sentiments via one of the dashboards that are installed on each of the six office floors. As people approach the dashboard they will be invited to choose which mood they are in to record their sentiment of the day. People will operate a dial and this will identify their sentiment, happy, sad or indifferent. Individual swipe cards such as the London Oyster card will enable participants to submit their sentiment for the day. As everyones RFID enabled swipe card is unique this will allow the system to identify behaviour albeit anonymously. A sophisticated algorithm will feed participants feelings through the dashboard and these will be digitally projected into a light field created by LEDs that forms the spine of the cocoon. Our system architecture allows for the tracking and displaying of several behaviours. These parameters are encoded into lighting patterns that suggest the collective mood of the buildings occupants. The sentiment engine (database) collects human data in the office building through the sentiment recorder. The Sentiment Cocoon is to represent a collective visualisation of how everyone is feeling in the Arup head quarters in London on any given day. The lighting design of the Cocoon will create an enigmatic display. Natural daylight, pooling into the atrium from the skylights above will blend with the light emitted from the LEDs. This will allow for a rich interaction of varying forms of light, which will be diffused through the skin of the cocoon. The translucency of the material will create an effect whereby the suspended Sentiment Cocoon will generate a striking visual display of light that has been informed by the feelings of people working at Arup. The sentiment will be encoded in different colours and movement. Colour gradients, the velocity of the colour and movement will be represented through patterns. Over time the patterns will become recognisable and therefore people working in the Arup building No.8 will experience the overriding sentiment of the day within the office.

The Sentiment Cocoon is yet another example of the increasing proliferation of media architectural interfaces mediating human behaviour with architecture. These social applications will ultimately lead to responsive, adaptable and clever buildings that serve human well-being.

5.6.3 The realisation phase

After we won the competition the hard work began. Within ten weeks we actually had to deliver a physical version of our initial design idea. Part of this challenge was the extremely short period of time that was left until the opening as well as the amount of research and development that was still needed before actually being able to build a physical form.

The following timeline shows the structure of meetings Arup requested in order to deliver certain milestones at certain dates.

Timeline of realisation 10 weeks: Friday 27th February: Kick-off meeting Monday 9th March: Design meeting Monday 13th April: Design review meeting Friday 8th May Sunday 17th May: Construction phase Deliverables: Design drawings of physical structure Interaction design method Lighting design Method statement Budget estimates Risk assessment (health and safety) Fire assessment

5.6.4 The Design Process

Form finding

The idea for the Arup atrium was to design a continuous and organic cocoon like lightweight structure that would winch through the open space and connect all eight floors of the rectangular atrium. For the initial form finding process we therefore developed a parametric programme that enabled us to explore different shapes and structures of the Cocoon. One structural objective was to determine the amount of splines on the outer surface needed to provide an optimized grid-sized surface for the transparent skin to stay tight. From physical prototyping we knew that the rhombus shaped grids size should not extend 50cm in its widest distance. Based on the programming platform openframeworks we were able to change several parameters through a graphical user interface (GUI), such as the amount of splines, the gradient of the splines or the direction in which the splines winch up. Even though parametric modelling has been conducted, extensive prototyping was needed to develop a cybernetic system that appeared to be interactive, lightweight and translucent.

Structural design

Soon after the kick-off meeting and in collaboration with an Arup structural engineer we searched for possible structures that would represent the initial design concept. As our intent was to explore architectural form, translucent materials and responsive lighting to facilitate social interaction, we studied a series of construction principles that would represent the lightweight character of the proposed Cocoon:

Pre-fabricated metal spline structure Pre-fabricated plywood spline structure Metal tube loop structure Plywood branch to core structure Metal spoke to core structure

Metal spoke to core structure Based on the branch to core principle in the last section, engineers at Arup suggested to use threaded rods instead of timber, which require fewer diameter to deal with the same amount of loads. Eventually this structural option turned out to be the most feasible to start with.

The first three structural principles follow the idea that the outer structure (i.e. the splines) are self-sufficient, meaning that all loads, such as the weight of the structure itself as well as the applied translucent fabric, will be carried through the surface structure. We were in favour of this idea, but considering planning, manufacturing and assembling efforts, eventually we decided to split the structure into an outer and inner configuration. Later it even turned out to be a good decision as during the prototyping phase we explored additional loads caused through the processing of the translucent outer skin.

The scale of the Cocoon, initially proposed, was to have a 30m tall structure with the widest diameter of 5m within a 6m by 9m wide and 30m tall atrium. When considering all design constraints such as suspension of the installation, fabrication of the substructure and the existing staircase between ground floor and basement we came to the conclusion that the initial proposition needed to be down scaled slightly. The final size was 20m in height and 3.5m in diameter.

Translucent Skin

Initially the translucent skin of the Cocoon was thought of a fibre structure applied onto the substructure through a spinning weaving machine. A small-scale prototype of this processing machine was already successfully in usage, however the enormous upscale of the fabrication process in connection with the available budget and the short developing time created insuperable challenges. As a consequence we had to rethink the making of the translucent skin from scratch. The new design intend here was to come up with a material that has very similar properties as the initially suggested fibres but at the same time the fabrication process needed to be significantly faster. After intense research into materials and production methods we finally came up with the at first glance rather unattractive looking cling film. Cling film, also called plastic or cling wrap, is an affordable and efficient material mostly used in logistics to wrap goods on pallets.

Consequently along our research journey several processing methods came up, as well as appropriate machines available on the market. Due to their weight and limitations in size, rather than freestanding machines, we decided to explore autonomous wrapping machines. After testing one of those machines, we eventually bought an affordable second hand pallet robot in Munich. In the next step we were able to hack the robots electronic in order to make customized processing programmes. Therefore we attached a micro-controller interface (i.e. raspberry pie) to remotely control the robots activities and to emergency stop it. Finally the pallet wrap robot was able to perform the wrapping of cling film up to two meters at any given diameter following a given outline. Furthermore the programmed weaving patterns allowed performing various patterns. As our initial design intents included the fabrication of the translucent skin on site, we were working on a processing method that would allow the weaving during working hours in the atrium space of the Arup London office. The aim was to get the fabrication out of hidden workshops into the heart of engineers and designers. Hence we planned to build a stage above ground level with the aim to bring the process of making as well as the digital fabrication through the robot on a plinth. From below onlookers would get a new perspective onto the production process. Implementing this intent required careful planning in close collaboration with the health and safety department at Arup to avoid distraction or even hazards for employees.

5.6.5 Interaction Design

The motivation for the interaction design was to develop, design and deploy a situated and tangible system that mediates collaborative interactions in public spaces whilst focusing on accessibility and affordance. In other words, the interface should be understandable and easy to use for people. The employed technology makes use of existing Radio frequency identification (RFID) as known from smart card technology such as the London Oyster card. We built on the widely spread use of these unique ID tags for payless cash and travel purposes, as a large proportion of citizens in London carries an Oyster card in their pocket most of the time. Consequently the use of these cards is a recurring embodied interaction in the smart city. At the same time every interaction is uniquely identifiable and therefore traceable. Our aim was to allow people to use their ID tags beyond technical purposes and express their mood and opinion about specific issues in the technology mediated workplace. Hence the Sentiment Dashboard enables employees to express their current mood when in the Arup London office.

The dashboard works as follows: On top of the dashboard the user is asked: How are you feeling today? Below three categories were defined as follows: 1) Happy (green), 2) Motivated (blue), 3) Workload (red). By pushing one of the buttons on the device participants are able to choose one of the aforementioned categories. In the next step they need to turn the dial to express if they are happy, indifferent or sad and eventually swiping their RFID token (i.e. Oyster card) across the bottom of the interface where it says: Register your Sentiment: Swipe your Card to submit their mood to the Sentiment Cocoon. In summary, the sentiment dashboard affords three folded interactions: 1) pushing: one out of three categories can be chosen; 2) dialling: by turning a rotary switch the user can gradually adjust their mood; 3) swiping: finally the electronic ID card needs to be swiped over the allocated field. The interaction modus was set to allow participants to only express their mood once an hour. This measure has been introduced to avoid certain users swiping over and over again to manipulate the results. In total six dashboards were distributed across six floors of the office building. All dashboards were installed at the balustrade facing towards the atrium. In the heart of the interactive dashboard there is a microcontroller (i.e. Arduino Yun), which can be directly connected via an Ethernet cable to the in-house network. On top of the Arduino Yun we placed a customized sentiment shield, which we have designed and produced for the specific needs of the sentiment data collection. Each shield is equipped with three RFID reader, three slots for potentiometer input and three slots for push button input.

5.6.6 Lighting Design

For the lighting design the idea was twofold, to visualise the data captured by the six sentiment dashboards and to also create a visceral response to the interaction with the dashboard. The intent has been to use the lighting within the Cocoon as a visual indicator that represents and physically situates the recorded sentiments within the Cocoon and thus in the real space of the Arup atrium. As well, the lighting was intended to mirror the actions, and the physical presence of people interacting with the sentiment dashboard that is connected to the Cocoon sculpture. When a user swipes their RFID card and sends (records) their sentiment a white flash of light appears directly in front within the Cocoon. The white flash of light is intended to mirror the users presence and to give them the feeling that they have transformed their sentiment and presence into a pulse of light. The intent of the visceral lighting response was to encourage and to provide a moment of instant gratification, which in turn would encourage further interaction. It was also important the lighting visualisation not be too detailed, that users could immediately intuit the meaning of the lighting.

The LEDs are four continuous lines totalling 4800 pixels that generate complex patterns and gradients of colour. Running the entire height of the Sentiment Cocoon, 20 metres, the LEDs will create an enigmatic display. Natural daylight, pooling into the atrium from the skylights above will blend with the light emitted from the LEDs. This will allow for a rich interaction of varying forms of light, which will be diffused through the skin of the cocoon. The translucency of the material will create an effect whereby the suspended Sentiment Cocoon will generate a striking visual display of light that has been informed by the feelings of people working at Arup. The sentiment will be encoded in different colours and movement. Colour gradients, the velocity of the colour and movement will be represented through patterns. Over time the patterns will become recognisable and therefore people working in No.8 will experience the overriding sentiment of the day within the office. The lighting visualisation was implemented using an LED lighting system, which consisted of a power and control system along with four 20m runs of LED ribbon, which can be controlled down to the level of each individual pixel. A bespoke app, known as the light server was created to control the lighting within the Cocoon, running within the app is an algorithm designed to record, catalogue and transform the individual interactions (recorded sentiments) into animated light pulses. Interactions are recorded via Arduino Yun micro controllers situated within each dashboard that send data recorded via interactions to the app. Another aspect of the implementation was devising how to blend the emitted light with the physical materials used in the Cocoon, specifically the plastic wrap skin and light diffusion materials, the goal was to create a blending of light and materials that were indistinguishable from each other.

5.6.6.1 The Construction Phase

The Final Cocoon Structure

The Sentiment Cocoon is an in total 20m tall and in between 1.4m and 3.5m wide lightweight structure suspended from the atrium ceiling. Alongside an inner core with a diameter of 0.15m there are 21 rings that consist of ten spokes, each layered on top of each other in a distance of 1m. The inner core is made off 20 segments each 1m high. One segment consists of two plywood disks, which host the horizontal spokes and two vertical threaded rods. In between the two plywood disks there is a 0.96m long white PVC tube (thickness 1.5mm). The two threaded rods (10mm) compress both disks against the PVC tube. All segments are interconnected and therefore require onsite construction. The horizontal rings consist of ten threaded rods (thickness 10mm), which are screwed into the plywood disks. During the prototyping phase the applied forces onto the larger rings (i.e. radius ¿ 1m) required to support the threaded rods with additional metal tubes. All the way from top to bottom the 210 spokes are tied together with 2mm metal ropes, in a rhombic pattern. At the position where the metal ropes meet each spoke they are clamped together with a round-head screw. Snap hooks on both ends of the ropes connect them back to the inner core. The whole construction was designed to be suspended from the atriums ceiling. Hence special construction efforts were needed. During the initial design stage it was planned to build a truss structure on top of the 5th floor. After first cost estimates building facilities and Arup engineers decided to make use of the building maintenance unit (BMU) on the 6th floor. Usually the BMU is pulled out to clean the glazed parts of the atrium. After structural considerations it was possible to attach the cable winch to the BMU. Being able to use the BMU enabled us to navigate the Cocoon in all directions (x-, y-, z- axis).

Another challenge that needed careful considerations during the design construction process from the very beginning on was the restriction of access for production materials. The only available entrances into the building were limited to the dimensions of 2.2m in height and 1.4m in width. As a matter of fact it was not possible to prefabricate the Cocoon and deliver it in one piece. Even the delivery of single segments was not feasible. Therefore all parts had to be delivered individually and assembled on site. Assembling on site compared to prefabrication on site requires a much simpler method as the processing conditions differ enormously (e.g. skilled worker versus motivated volunteers). Eventually the whole substructure (i.e. the inner core, the spokes and the metal ropes) was assembled only with hand tools.

Setting up the Cocoon

The on site construction started Friday May 8th in the evening with the setting up of the scaffolding platform founded on the basement floor and finished with the upper edge on 1.4m above ground level. To ensure safe working the platform needed to be secured with a balustrade and people had to wear full personal protective equipment

(PPE) whilst on platform. In addition everyone involved needed a induction to Health and Safety as well as fire safety standards held by Arups H and S officer. Before the scaffolding platform could be completed, the wrapping robot had to be lifted through a whole in the wooden blanks with the help of the BMU. Thus the rigging company had to attach the winch to the movable truss of the BMU. In the next step the robot could be lifted onto the platform. After this the platform floor was closed and additionally the raw scaffolding floor needed to be covered by additional MDF boards to provide the pallet wrapping robot with a smooth surface. Another task during the pre-setup included the construction of a wooden ring with a diameter of 3.7m in the centre of the platform. The outline of this ring gave the wrapping robot the direction to follow. The centre of the ring carried a metal mounting fixture to hold the different segments of the Cocoon whilst assembled. The pre-setup was accomplished by Saturday and the construction of the Cocoon itself started. First of all the winch was lowered onto platform level in order to equip the hook with the first segment of the inner core. At the same time all power supplies and data wires for the LED stripes had to be mounted on a separate winch and connected with the top of the first segment. The aim was to lift both the power supply pack and the Cocoon at the same time. Therefore all electrical installations had to fully function before lifting, as maintenance work afterwards would have been difficult. The next steps included the mounting of the plywood disks with the threaded rods and the PVC tube in between the disks. The four LED strips were fixed to the white PVC tubes of the inner core. Two segments consisted of three rings and two PVC tubes and formed one unit that the pallet-wrapping robot was then able to wrap. All rings had to be assembled on the platform. Only on Monday we were able to wrap the first segment and hoist it. From then on we tried to speed up the process in order to achieve our goal to finish all ten segments by the end of the week on Friday evening. On Saturday the dismantling of the temporary support structure began. First the robot had to be lifted off the platform. As the winch was in use for the Cocoon riggers had to bring in a second winch and set up a truss frame to lower the robot from the platform back on to basement level. After this the scaffolding company dismantled the platform. All works finished in time before Monday morning the office opened as usual. During the following two weeks we had to prepare the dashboards, set up the network and finish the interactive part of the installation.

Dismantling the Cocoon

The disassembling of the Cocoon started on Friday 28th September and finished on Sunday 30th September. This time there was no scaffolding needed on the ground floor level. Due to the winch fixed to the BMU the riggers were able to navigate the Cocoon into one corner of the atrium. This way the structure did not conflict with the existing staircase when lowering the Cocoon. However, the floor on the basement needed to be covered and barriers were set up to prevent unauthorised entering of the construction site. The Cocoon was carefully lowered onto working height before volunteers cut off the cling film and the metal ropes. In a next step the diffusers were dismantled and the subjacent LED strips were pulled off. Only then we screwed off the threaded rods and the plywood connectors. A second team of volunteers unscrewed the nuts and separated the threaded rods from the metal tubes. Basically three types of materials needed to be recycled: plastic (i.e. cling film, diffuser film and PVC tubes), wood (i.e. plywood connector) and metal (i.e. threaded rods, metal ropes and tubes). As a consequence all materials could be separated and recycled unmixed. The dismantling of each of the twenty segments was finished by Saturday afternoon. On Sunday the riggers took the winch off the BMU and got the cleaning unit back onto the BMU.

5.6.7 Findings

The installation was running 24/7 throughout 13 weeks in total starting Monday 25th of May 2015 and finishing on Friday 28th September 2015. During this time the database logged about 1880 single interactions, which were recorded through six sentiment dashboards. Many employees at Arup on their way to their desk, during lunch time or in the late afternoon on their way back home either engaged directly with their Oyster cards (direct interaction) or simply enjoyed the colourful and dynamic visualisation on the Cocoon (ambient interaction). According to the collected data most interactions took place after the official opening of the Cocoon (June 2nd 2015), after the Show and Tell event (June 16th 2015), during the opening of another exhibition in the Arup reception space (June 22nd 2015) and whilst the Arup summer party was in full swing (July 14th 2015).

We conducted a preliminary data analysis of the 1880 valid ID card interactions captured by the dashboards and logged on our database.

The aims were two folded: Understanding how participants use the dashboard. Identifying sentiment patterns of group and individual behaviour.

For each unique card ID that has been used, we looked at the logged data sets and extracted the specifics of the submitted sentiments (which floor, which category, and which preference to this category).

From our observations and in accordance to the collected sentiment data three different major participation patterns were observed when individuals or groups approached the sentiment dashboards:

Serious behaviour: o This was the least frequently identified participation pattern. The participant (card ID) has submitted exactly one sentiment for each of the explored categories. And each submission recorded a different preference value (i.e. in between 0-1024). This pattern would reflect how we expected the interaction mechanism to work - i.e. a person would explore the categories by pushing one of the three buttons and would submit one sentiment for a specific preference. Clumsy behaviour: o This was the most frequently extracted participation pattern. The participant (card ID) has submitted the same sentiment (preference) for each of the three categories. Or the same value of the sentiment was submitted as by the previous user. The occurrence of this pattern can be explained with our frequent observation of participants holding their card over the RFID reader only without having pushed any of the category buttons. This behaviour might be due to a usability flaw of our installation - the participating person did not realise the effect of her participation in the visualisation, hence tried several times. Playful behaviour: o The participant (card ID) has submitted several different preferences for the same category within the considered period of time. This might indicate that s/he did not really want to express an opinion, but rather explored how the installation and the visualisation work.

After eliminating the repetitive submissions, we extracted the distribution of submissions across the three categories. The category workload was the most popular (35 percent) of all submissions, followed by motivation (33 percent) and happiness (32 percent). While we cannot account for representative polling results, the findings indicate the installation fulfilled its intentions as a public feedback platform, where people engage meaningfully with their sentiments. Besides the data captured through the TUI device we observed interactions around the Cocoon in the close interaction space as well as in the wider ambient space. Although these observations were not rigorously conducted, we did notice a few recurring behaviours. In particular, we frequently saw people taking pictures of the installation with their mobile phones or taking pictures of each other in front of the Cocoon. In addition we observed Arup employees introducing the Cocoon to their clients when they are visiting the building. These informal observations would suggest that people liked the Cocoon and the visualisation it used.

5.6.8 Discussion

In the previous sections we have introduced our research interest in interactive media architecture, gave insight into the design and building process of our case study the Sentiment Cocoon and provided a first glance on the freshly gathered data. In this section the discussion about commercialising academic research requires the consideration of diverse aspects one usually is not immediately concerned in academic research.

Initial design

The nature of any initial design proposal is that it will need much iteration and some alterations when it comes to the construction design phase and will need to be adjusted to the constraints and limitations in the real-world context. For instance in the case of the Cocoon we had to downscale the height and diameter of the

Cocoons outer shape. Otherwise fabrication on site with the help of the pallet-wrapping robot would not have been possible. On another note, our ambitions of creating a 3D printing machine that weaves the Cocoons skin through fibres in one piece had to be re-engineered considering the limited budget and the extremely short tie for research and development. The final outcome was a pallet-wrapping robot that would fabricate the Cocoons outer skin with cling-film in segments. However, we do not think that these alterations downgraded our initial design; instead, we demonstrated that we were able to adapt our methods for the good of our design vision as well for the real world implementation.

Construction

To come up with the final design construction for the Cocoon much iteration was explored on paper however only physical prototyping eventually led to the final design. Looking at the construction of the Cocoon and its scale, we underestimated the high standards towards health and safety when it came to the actual implementation on site. At the same time the budget that would be required for external contractors to set up the construction site (i.e. scaffolding and rigging) blow our initial estimates. Considering that most of the work contractors were assigned for was merely allowed to be executed by qualified and certified staff there was hardly any possibilities to optimise these estimates. It is to say that due to Arups enthusiastic attitude towards our project the budget was raised by almost one third. As a result we were able to cover the additional costs by our contractors. Furthermore we underestimated cost and effort to dismantle the structure again. The fact that everything was assembled on site made it easier to dismantle all parts. Arup requires high standards for sustainability and therefore recycling needed to be done properly. In addition the amount of paper work that was compulsory in order to get permission for building the Cocoon inside an office space (i.e. fire assessment, risk assessment) could only be dealt with due to the help supported by Arup. In summary it is to say that we clearly underestimated the hidden costs in our initial cost estimate.

Interaction Design

From the technological perspective the Sentiment Cocoon set up consisting of six networked sentiment dashboards, data collection and the connected light visualisation worked perfectly. We have not had a single outage so far, neither from the hardware (i.e. dashboards or LED installation) nor the software. The reason for this is that we put enormous efforts into the development of the networked sentiment dashboards and the visual representation of the collected data by employing two experienced developers. At the same time we were able to report on our previous experiences with the deployment of feedback dashboards for the developers to start from. This is a great improvement in the development and a further step towards commercialising the idea of building a platform that connects an ecology of sentiment interfaces. However seen from longitudinal aspects, we have noted that interactions have dropped down considerably over the last couple of weeks. The reason for this could be that many users now seem to understand how the Cocoon works and may have become bored with it. This would mean that the only attraction would have been the novelty effect. On the other hand one may argue that interactions will need to level off. The data sets suggest that this process started after week five of the deployment. In the following weeks peaks could be identified when certain events happened, such as the Arup summer party on Tuesday July 14th. In particular the transition from the novelty effect to the levelling off phase is a highly relevant observation that clearly needs further exploration.

Lighting Design

From the point of view of fulfilling the original design intent towards the lighting design the outcome was successful in terms of technological implementation as well as from the user experience perspective. The technological implementation was carefully planned from the very beginning and managed sensibly during the construction phase. Only one time a serious issue appeared when the LED strips started to flicker. We discovered the lighting within the cocoon would flicker rapidly whenever there would be a lot of brightness and movement in the lighting patterns. From previous experience of running similar installations with short data/power cables we knew immediately this was due to the length of the cable runs from the control and power supply to the LED lights but were not sure of the exact cause. We found the answer quickly online in the knowledge base associated with the control card we are using. It turned out that the pluggable resistor network on the control card was the cause. The resistor packs on the control card were changed to eliminate the flicker issue as proposed by the online solution

In tackling the challenge of making the lighting work we learnt much more technically about the circuitry and operation of LED control systems and the DMX protocol. In making the system work properly we also learnt about TCP/IP protocols and UDP packet structure and its relationship to high frame rate capability in the animating of LED lights. The online knowledge base, in this case what is most interesting is that the control card we are using runs the DMX/Artnet protocols standard to the lighting industry and normally costs upward of 3000. However, there are hobbyists using the same protocols and have created their own hardware. What is available online is a card worth 600 and by consequence a knowledge base around it that proved to be very valuable on this project.

The design intent of the light visualisation has been accomplished, but more complex behaviours could not be implemented due to time and budget reasons. Over time the users seem to have come to know the Cocoon visualisation and are in a position to have more curiosity awakened by the behaviour of the Cocoon evolving over time. This again might be a reason for the drop of interactions after week five. We also learnt that to achieve both good interaction and visualisation one needs to be weary of feature burden where the interactions and visualisations are too complex for users to understand or relate to. Observations in relations to this were made regularly. Many users did not understand the operation procedure when approaching the interaction device. For instance we experienced people who swiped their RFID card before actually turning the dial or pushing a category button. At the same time many people understood that their actions on the dashboard will trigger a change in the lighting behaviour of the Cocoon, but could not explain what it mean.

In summary it is to say that even the fact that our strong design intent always was to focus on simplicity, when it comes to interaction modes and visual representation of those interactions, we still need to improve the clarity the dashboard and lighting design.

Research and Development - Prototyping

Due to time and budget constraints research and development (R and D) presented many difficult challenges, there was seldom enough time for prototyping the interaction of the materials and the lighting, this could have been much better. As well, there was little time and money to facilitate the proper testing of the power system for the lighting. We have clearly underestimated the amount of resources needed for the prototyping stage. In essence, extensive prototyping in advance can save both time and money, arguably it may even save more money than it costs to prototype.

Public relations and academic dissemination

Crucial to any commercial and research project no matter how successful it is, is to talk about it and spread the word. This needs to be planned well in advance and with the same care as other design work packages within in a project. From the beginning on Arup provided a film making team that accompanied us from day one of the building process on site and left when the Cocoons scaffolding has been removed. In addition we asked a filmmaker known to us to take additional footage during the setting up and to take shots when people interact with the Cocoon. Throughout all stages of this project we took pictures with mobile phones and cameras. However we had to learn that we did not budget enough for the documentation and dissemination process also, a clear strategy was missing we were relying on Arup as they promised a PR agency. Their outreach was limited and reached only one print magazine and a few less popular design blogs. Only now we are trying to research relevant magazines, blogs and other platforms through an additional PR person with an updated story and better audio-visual coverage.

Collaboration, team and social dynamics

Generally speaking the collaboration between a small creative practice and a large resourceful and knowledgeable corporate global company should ideally be of mutual benefit towards prototyping our future city. One may argue that young practices bring in fresh ideas into creative processes, which ideally flourish through the secondment by experienced and established companies. However it comes with some challenges both sides need to be aware of in order not to discourage the others. We were constantly appreciating the expertise and wide experience of Arup engineers and the open mindedness of Arup with regards to exploring new directions in design and architecture. Alongside this we had to accept that the corporate space of a global company his highly controlled in the way that communication leaving the bespoke space needs to be signed off by company officials. This can be cumbersome from time to time as young practitioners are constantly in the need of sharing their activities in form of snapshot images or video footage with their digital networks in order to increase their professional exposure.

From the beginning of this project the core team consisted of three members; an architect, a lighting designer and a product designer. After we won the competition and the scope of work was clear there was the biggest moment of uncertainty in this project. We had promised a huge design vision for which we did not know how to deliver at this point. This entrepreneurial risk seemed to be too high for one of the core members. As a consequence and after intense attempts to keep him on board the product designer, who was responsible for the digital fabrication, left the team. This caused a vacuum that needed to be closed rapidly. After intensive search we were not able to find a full replacement and decided to split the tasks amongst the remaining two project partners in order to distribute the risks of another failure. Having learnt from this we found it extremely hard to bring a team together that would stick together no matter what challenges may suddenly appear. We found it easy to get people enthusiastic about our project and of course to work with Arup, but finding people with the right skills and commitment was almost impossible within the given time and budget. We learnt that we needed to come up with intangible incentives such as individual creative freedom, access to a professional network and social amenities to convince enthusiasts to come on board. At the same time besides the efforts to find the right kind of collaborators, the core team constantly had to keep the initial design intent in mind to avoid the leaching out through too many concessions towards individual creative freedom.

CManaging expectations the client relationship

As a matter of fact the different parties involved in this project wanted to achieve the same goals (i.e. completion of the Sentiment Cocoon) their motivations however were different. For Arup it seemed to be the priority to showcase the Cocoon as a structure as well as a vision for better workplaces to their clients in order to demonstrate Arups ability to innovation and to support new designers through this competition. For us as the designers and researchers it was preliminary important to materialise and implement our vision and the containing research knowledge. And of course to increase our professional network, by showing our skills. At the same time, managing expectations was a tricky venture throughout the project. For instance when initially proposing a 3D printer during the competition people actually expected what they considered a 3D printer. When we came up with a pallet-wrapping robot, they were rather disappointed of this creature that looked more like a vacuum cleaner. However, considering the fact that the robot quickly got a name (i.e. Einstein) seemed to be a sign of some kind of affection. In addition, calling the new surface a cling film structure made the whole process of wrapping Cocoon sounded a bit trivial. Another issue rose when we were calling the pallet-wrapping machine a robot. The health and safety department was particularly concerned about workplace safety. An autonomous machine in an office space would have been an uncontrollably risk. Only when we demonstrated that this machine is not acting like an industrial robot arm being able to cause severe damage we were able to convince the person in charge to sign off this fabrication process. In a nutshell, the challenge for a successful client relationship is a careful management of expectations.

5.6.8.1 Conclusion

With the Sentiment Cocoon we have achieved both an interesting aesthetically pleasing installation that can encourage interaction. Through its implementation in an atrium surrounded by workplaces, the sentiment data collected by the dashboards created a value. It gained relevance towards enhancing the wellbeing of employees. In other words we successfully embedded academic knowledge into a commercial use case. In addition we have created a discussion about the mapping of emotions relative to a specific location (i.e. workplace) as well as to the happenings in that location. We strongly feel we have moved toward an interesting phase in the use of aesthetic architectural works to trigger and enliven contemplation of social conditions and issues directly related to specific locations. Eventually we can assume that there is a demand for situated sentiment analysis in a workplace. From an architectural point of view we have described the design process from the very beginning of the competition up to the opening of the interactive structure. The aim here was to share the enormous efforts - mostly invisible we undertook to successfully complete such a venture. We have discussed the challenges and lessons learnt. Finally this may help other academic researchers from the emerging fields of interactive media architecture to explore the opportunities of commercialising their work. Speaking for ourselves, due to the exciting outcome and huge success of the Sentiment Cocoon, we are currently exploring options to further push our academic research towards applied practice.

Chapter 6

Discussion

Chapter summary

In this chapter I will introduce my research, which will lead to the main research question and the subsequent question that will assist to answer the main research question. Further an outline of the thesis will be conducted. This chapter then concludes with the overall contribution the reader can expect from reading this thesis.

6.1 Taxonomy for categorizing interactive media architecture

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6.2 Towards sentiment architecture

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Chapter 7

Conclusion

Chapter summary

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7.1 Future work

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Appendix A

An Appendix About Stuff

(stuff)

Appendix B

Another Appendix About Things

(things)

Appendix C

Colophon

This is a description of the tools you used to make your thesis. It helps people make future documents, reminds you, and looks good.

(example) This document was set in the Times Roman typeface using LaTeX and BibTeX, composed with a text editor.

$01_{Preamble}, 03_{Background}$