

A FRAMEWORK TOWARDS DESIGNING RESPONSIVE PUBLIC INFORMATION SYSTEMS

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Abstract. "Evolving effective responsive systems, and creating a credible interface between the work and the user, requires an awareness of many different types of user, contexts and functions as well as the phenomenological aspects of social and environmental conditions." (Bullivant, 2006). Responsive design and interactive architecture operates at the intersection of Architecture, Arts, Technology, Media Arts, HCI and Interaction Design in a physical context suggesting ways in which the existing physical environments can be augmented and extended adding a greater level of depth, meaning and engagement with the world around us. Through a series of case studies, this paper explores a number of principles which may be applied to the design of responsive environments of which public information systems form part. Divided into three main sections, the paper first explains how responsive environments have addressed the application of public information systems, secondly, through a series of case studies, precedents are highlighted which lead to development of principles for developing designs for responsive environments. The third section discusses and elaborates on these principles which have been developed based upon our own interpretations and grouping of precedents and approaches towards interaction design. This paper contributes towards the field of responsive environments and interactive architecture through an analysis of case studies to infer a framework from which responsive environments may be created and developed.

1. Public Information Systems – Application Domain

Public Information Systems are modes of communicating information content and facilitating interactions and transactions with members of the public. In an architectural context they can be considered to encompass any

form of information exchange or transaction in the public realm, from the scale of posters, newsstands and advertising through to ATMs, information kiosks and large scale urban display screens. Simply, public information systems are seen to comprise of a mode of posting of information in the public realm for dissemination or interaction with.

Public information systems are significant as they can offer modes of interaction and engagement which extends the physical paradigm of the urban environment when they cross into the boundary of responsive environments. Urban display screens offer the potential for dynamic information display or artistic intervention (Brill, 2006) whilst information kiosks offer the potential to foster information dissemination and advertising, interactive information content and the facilitation of transactions in the public realm (Morris, et al., 1995). It is also suggested that public information systems could be used to foster public participation and social empowerment (Steele, 1998), engaging with aspects of e-democracy and increasing user engagement with their wider environment.

Current challenges faced from development of these systems stem from a lack of understanding of the interactions and relationships between the users, information and exchange channels available and the modes of interaction and engagement between user, public information system and the wider physical and digital context of implementation. These contexts could develop based upon location in an urban environment, engagement with particular user types based on contextual changes and links fostered through connectivity with a wider digital infrastructure. The level of interaction between user and content is currently very poor, with recent studies in Newcastle highlighting inadequacies between user awareness, interaction and interfacing between the public and information content.

Responsive environments offer the potential for engaging with users at a meaningful level through the built environment, facilitating interactions between people, their environment and wider networks in an intuitive manner. Issues such as lack of user engagement can be addressed through the development of urban space designed to be pro-actively engage with users and intelligent modes of interfacing can lead to ways to deliver and for the active exchange and constructive modes of information and cultural exchange. Recent work has explored public interfaces in public spaces, modes of communications between users and environments from aesthetic to deeper levels of dialogue (Eng, et al., 2003) through to modes of public control over their own physical environment (Lavén, et al., 2006). The majority of these projects stem from Media Arts and are employed in an artistic context, however from an analysis of these applications a series of principles forming an initial framework for this applied art, relating to the

development, design and implementation for a holistic physical architectural context.

2. Interactive and Responsive Architecture - Case Studies

These case studies highlight a wide spectrum of projects emerging from Media Arts, Architecture and their intersection with HCI and computing. The projects have been selected as they represent the forefront of responsive design applied to physical environments allowing for study of work operating at the intersection of physical computing, HCI principles and architectural design. These studies are collated in tables briefly summarising each project the intended types of interactions seeking to be encourages and the ways in which these are actually implemented and realised. The following cases are summarised and they are all expanded upon in section 3: Target Interactive Breezeway, Enteractive, D-Tower, KineCity Projects, Medial Stage and Costume Design Project, ADA Intelligent Space, Colour By Numbers, Mobile Phone Disco, NoRA, Social Serendipity, Urban Tapestries and Web2.0 concepts.

TABLE 1. Target Interactive Breezeway and Enteractive - Electroland

Image	Description	Intended Interactions	Implemented Interactions
 <p data-bbox="371 1503 584 1576"><i>Images from http://electroland.net accessed 16/07/07</i></p>	<p data-bbox="639 1167 858 1384">User movement through a space in the Rockefeller Centre is converted to patterns which follow users and change according to user movement patterns. .</p>	<p data-bbox="890 1167 1046 1384">Interactions between user motion and the dialogue between this and the environment are sought.</p>	<p data-bbox="1078 1167 1256 1547">Interactions are facilitated through motion tracking and arrays of LEDs. The programmable nature of the system allows for different relationships between user and environment to be explored.</p>

TABLE 2. Interactive project - Electroland

Image	Description	Intended Interactions	Implemented Interactions
 <p><i>Images from http://electroland.net accessed 16/07/07</i></p>	<p>Based in a lobby of a building the relationship between user and wider context is explored through a game involving patterned floor panels which is reflected in the changing patterns of the external façade.</p>	<p>Interactions between user and the immediate physical and wider architectural context are sought and a game is established between the users and the building.</p>	<p>Interactions are facilitated through pressure sensors and arrays of illuminated panels on both the inside and outside of the building. User interactions are gained through users standing on the panels.</p>

TABLE 3. D-Tower – NOX & Q.S. Serafijn

Image	Description	Intended Interactions	Implemented Interactions
 <p><i>Image from http://commons.wikimedia.org/wiki/Image:DtowerNOX.png accessed 17/07/07</i></p>	<p>A sculptural intervention which responds to local emotional states and feelings causing the tower to change colour. Connections with an online system and forums allow a wider network of interactions to occur.</p>	<p>Interactions linking personal emotion with the wider context and community are explored. Connections between personal feelings and broadcast public in the public realm are developed.</p>	<p>An online survey and website accessible to the local population creates a link between users and the lighting of the tower also enabling physical events to take place mediated through the online system.</p>

TABLE 4. Comment Wall, World Trade Centre Podium Lighting & Public & Expert - *Kinecity*

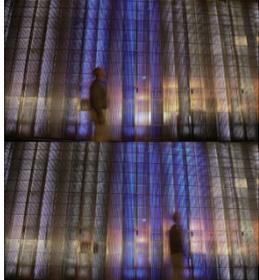
Image	Description	Intended Interactions	Implemented Interactions
 <p>Images from http://kinecity.com/ accessed 17/07/07</p>	<p>“World Trade Centre Lighting Podium” responds to public presence to change lighting around No 7 WTC.</p>	<p>“WTC Lighting Podium” aims to link user movement with the lighting in a wider context. .</p>	<p>“WTC Lighting Podium” uses motion tracking of user movement, mapping this to a changing lighting system.</p>

TABLE 5. Medial Stage and Costume Design Project – Art+COM

Image	Description	Intended Interactions	Implemented Interactions
 <p>Image from http://www.artcom.def accessed 17/07/07</p>	<p>A responsive theatrical project for “The Jew of Malta” which uses dynamically responsive theatre stage and costumes.</p>	<p>Interactions between users and their stage environment are linked to support the opera’s narrative.</p>	<p>Advanced user tracking systems map movements of the actors to a projected stage and costume environment.</p>

TABLE 6. ADA Intelligent Space (Eng, et al., 2003)

Image	Description	Intended Interactions	Implemented Interactions
 <p>Image from http://ada.ini.ethz.ch/presentation/images/Stefan_Kubli/13.html Accessed 17/07/07</p>	<p>An autonomous space capable of communicating with users through light and sound for the Swiss Expo 2002.</p>	<p>bi-directional dialogue within which both parties are able to actively engage.</p>	<p>Pressure, motion and audio sensors sense users and with lights are used as inputs and outputs to users. An AI system maps users’ profiles.</p>

TABLE 7. Colour By Numbers (Lavén, et al., 2006)

Image	Description	Intended Interactions	Implemented Interactions
 <p>Image from http://www.colourbynumbers.org/EN/infoPress.html accessed 17/07/07</p>	A user controlled interactive installation enabling users to control the lighting patterns of the Telefonplan building in Stockholm	Easy access user control over large scale lighting to, explore the relationship between the individual and the public realm	Mobile phones and an online website were used to enable users to control the large scale lighting system.

TABLE 8. Cell Phone Disco – Megla & Informationlab

Image	Description	Intended Interactions	Implemented Interactions
 <p>Image from http://cellphonedisco.informationlab.org/CellPhoneDisco.pdf accessed 17/07/07</p>	An exploration into extending the notion of flashing LED mobile phone accessories to the scale of a room enabling non-standard modes of interfacing with mobile devices.	Interactions between user mobile devices and the visual environment were sought.	Sensors of differing sensitivities mapped phone activity to changing LED patterns on the walls. Low sensitivity cells enabled painting using the mobile.

TABLE 9. NoRA (Jensen, et al., 2006)

Image	Description	Intended Interactions	Implemented Interactions
 <p>Image from (Jensen, et al., 2006)</p>	A temporary pavilion designed for the Venice Biennale intended to explore architecture as a series of flows rather than a fixed static product.	Interactions were sought from the external environment affecting the architectural design in real-time.	Satellite sensors mapped external influences to changes in lighting and generative soundscape within the pavilion.

TABLE 10. Social Serendipity (Eagle, et al., 2005)

Image	Description	Intended Interactions	Implemented Interactions
 <p><i>Image (Eagle, et al., 2005)</i></p>	<p>A project to take social software in the form of a dating site and to transfer the social connectivity across the digital divide.</p>	<p>Social interactions were sought connecting individuals who made aware of each other through a digital network</p>	<p>Mobile phones connected to an online social network enabled user's devices to recognise each other and check and notify any potential profile matches.</p>

TABLE 11. Urban Tapestries

Image	Description	Intended Interactions	Implemented Interactions
 <p><i>Image from http://urbantapestries.net/ Accessed 17/07/07</i></p>	<p>A project to enable users to access and produce relevant geo-located information around an urban context.</p>	<p>Socially constructive engagement in the creation of shared information content of use for urban tapestry users.</p>	<p>Mobile phone based software enables users to edit, upload and download maps of their local area and connect to interest groups.</p>

TABLE 11. Web2.0

Image	Description	Intended Interactions	Implemented Interactions
 <p><i>Image from http://www.wikipedia.org</i></p>	<p>Online web systems focussing upon bi-directional content delivery such as Wikipedia, Facebook and Myspace.</p>	<p>Socially constructive interactions based upon community based content creation contribution and editing.</p>	<p>Through online web based systems a two way relationship encompassing many to many authoring is established.</p>

3. – Principles for developing designs for responsive environments

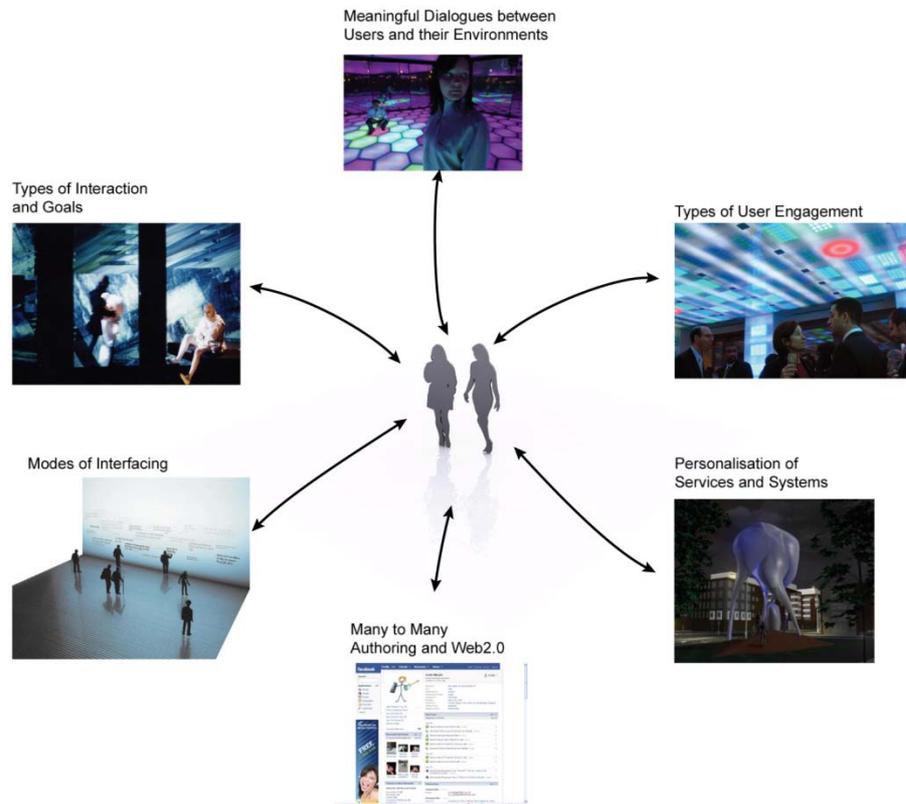


Figure 1. Overview of Principles for Developing Responsive Environments

With a wide gamut of technologies and precedents for engaging with an interactive agenda, it may seem hard to focus on particular appropriate modes of implementation, especially considering rates of technological development. Therefore the need to critically question what something should do rather than how it is made up is intrinsically important to developing meaning and validity in an interactive system, be it at the scale of a mobile phone, computer interface or in a larger urban (or hybrid urban) context.

“When the objects of artifice pervade our lives, cultural narrative and memory depend on widening our appreciation of design. The true test of a medium is its capacity to support cultural expression. Beyond usability and identity, we seek appreciation. Unless the kinds of deliberation generalized here can be built up and around the interactive technology productions that

increasingly occupy our efforts, those efforts are likely to result in cultural noise.” (McCullough, 2005)

Interaction design offers a starting point for establishing a framework for designing for responsive environments, with a basis in HCI and also increasingly in psychological principles (McCullough, 2005) the process is considered an applied art rather than a hard science with solutions contextual, specific to particular problems and situations. A number of methodologies as part of this process have been established, although no hard and fast rules apply all of the time and exceptions to more established approaches always emerge (Saffer, 2007).

We have developed our own interpretations and sets of groupings based upon the case studies as precedents and the relationships between the modes of implementation and methods of engaging with interaction design, questioning what is trying to be achieved by users and the ways in which these can be best met and how users may be engaged. The following sub sections expand upon these concepts and the ways in which these principles relate to the projects are explained:

- Types of Interaction and Goals
- Meaningful Dialogues between Users and their Environments
- Types of User Engagement
- Modes of Interfacing
- Personalisation of Services and Systems
- Many to Many Authoring and Web2.0

3.1 - TYPES OF INTERACTION

From questioning design goals and in proposing new modes of interaction and communication, an awareness of initial design goals will dictate potential scenarios in order to best meet these. Through questioning interactions may occur within spaces, scenarios and interaction maps may be developed in order to develop a coherent design. For example, a starting point when analysing an urban context may be:

On the Town:

- Eating, drinking, talking (places for socialising)
- Gathering (places to meet)
- Cruising (places for seeing and being seen)
- Belonging (places for insiders)

(McCullough, 2005)

From here, goals and modes of interactions can be explored which are intended to support these types of engagements and activities making the implementation of a responsive environment have a meaning and appropriateness for a specific context. The type of interactions possible were key in Electroland’s “Target Interactive Breezeway” where

engagement with a wide number of users, often in a state of distraction passing through the responsive space led to the question as to the depth of interaction possible in that scenario and how to facilitate this. The questioning of the types of interactions are technologically independent to the purpose such as can be seen with ART+COM's responsive opera. The interactions and responsive stage set stemmed from the need to create a stage environment supporting the events onstage. The technical manner in which this was achieved is secondary to the design goal, a dynamically changing operatic experience.

3.2 - MEANINGFUL DIALOGUES BETWEEN USERS AND THEIR ENVIRONMENTS

"...to explore comprehensively the poetry of interaction we believe we need to consider what truly intelligent spaces might be like: we might not like them, we might not fully understand them, we might even decide we don't want them. However the most stimulating and potentially productive situation would be a system in which people build up their environments through 'conversations' with the environment, where the history of interactions builds new possibilities for shared goals and shared outcomes." (Haque, 2006)

The way in which we interact with our environment and the dialogues that are established between both parties are important in developing meaningful interactive applications, particularly as computing pervades our urban setting. Within the framework for environmental interactions exists the potential for bi-directional interactivity between user and their environment, closing the cybernetic loop between user action and environmental response. In the Paskian sense, a dialogue between user and space is a continuous relationship between user affecting environment and environment affecting user. The work of cyberneticist Gordon Pask is receiving increased attention in application to the ways in which people respond and engage with their environments (Haque, 2006). This dialogue between user and environment is explored with "ADA" which establishes relationships through profiling to create a bi-directional relationship. KineCity's "Public and Expert" project extends dialogues to those between people mediated through the built fabric and digital infrastructures between different users. Where users actively engage with each other mediated through their environment, the nature of the interactions and the meaning imbued to them are critical. The design of responsive system offers the potential to close the loop between user and environment in a real-time manner with a meaningful dialogue.

3.3 - TYPES OF USER ENGAGEMENT

The types of user engagement are the specific ways in which interactions may occur in an environment, either physically or digitally mediated. In the case of a digitally mediated layer integrated with the environment, the question arises of whether this interaction is a passive system requiring users to choose to engage with it or whether it is an active system, grabbing user attention and working with this. A hybrid may also be appropriate where direct engagement is appropriate at some times, whilst acting in a passive manner in other contexts. “Colour by Numbers” uses a passive mode of interaction, requiring active engagement from the user in order to become involved with the system to change lighting patterns. Consequently this mode of interaction can to exclude uninformed or uninterested users from engaging.

Operating actively, “Social Serendipity” engages users directly, through mobile devices and “ADA” engages through active communication with light and sound. Through actively engaging with users systems may stretch out to make the first move in establishing an interactive and responsive dialogue between users and their environments. This is analogous to “push” data where information is actively sent out as supposed to users requesting this first (pulling), commonly used in a web based context (Wikipedia, 2007). “ADA” follows this principle by actively profiling users based upon what it deems to be interesting and therefore will act to engage more meaningfully, pushing towards, those particular users.

A hybrid of active engagement (pushing) and passive engagement (pulling) can be seen in Electroland’s “Target Interactive Breezeway”. Users will pass through the space and choose whether to engage with the installation or not. This means that whilst interactions are at a user’s discretion (passive), the space actively through creating patterns and lighting effects based upon user behaviour, attempts to start a dialogue between user and environment.

3.4 - MODES OF INTERFACING

Where an interaction is occurring between two systems, an interface exists at the boundary between the two, mapping one set of actions onto something else. Transferred to a physical (urban) environment, traditional modes of interfacing can be questioned and more intuitive forms may be possible through larger scale physical computing. KineCity’s “Comment Wall” highlights the possibilities when engaging with an exchange and navigation of user generated information across the digital divide into a physical space. Traditionally, this may have been simply a console, screen and keyboard, but through using a gesture based recognition system an easily understandable

interface is established where users can write their own comments on the digital wall. In addition, the need to navigate this content was directly mapped to physical movements in space, correlating with the assumption that if you were closer to the wall you were wanting to read the closest (most recent) information posted. In this case the implementation of physical computing meant a direct mapping of user actions in the physical world to logical actions in a digitally mediated one. Similarly “ADA” uses light, sound and patterning to communicate with people in an intuitive manner. Users did not need a manual to understand the language of engagement with the space as these were easy to understand at a very basic level.

In addition to intuitive physical computing, interfacing between users and digitally mediated content in a responsive environment can be facilitated by mobile devices such as mobile phone and PDA’s having the added advantage that they can integrate geo-locative information from wireless connections with a wider information network. In a straightforward implementation of such an interface this can operate like “Social Serendipity” where mobile devices connected to a wider infrastructure can recognise one another and deliver relevant content to users based on their geographic positions. Similarly geo-locative authoring of content allows spaces to be tagged with information which users can then directly access either online or via mobile device acting as information terminals. “D-Tower” and “Colour By Numbers” suggest forms of interfacing where wider networks can be linked to physical infrastructure, spanning the digital divide. Informationlab’s “Mobile Phone Disco” is an exploration into non-standard interfacing suggesting ways that information from these may be transferable to physical infrastructures in a more intuitive manner than simply using the phone as a direct terminal. KineCity’s “Public and Expert” proposal went as far as to suggest a design for a table where objects themselves could become input for establishing a dialogue with a wider digital system, enabling nearly any object to interface with it. The key element from the previous case studies is the notion of breaking down interface barriers in order to foster a natural interaction and subsequent response between user and environment through an understanding of modes of mapping and interfacing actions together in an easy to engage with way.

3.5 - PERSONALISATION OF SERVICES & SYSTEMS

Personalisation of services and information provided through responsive urban environments is a particularly strong way in which content can be made personally engaging and meaningful. This enables users to become better connected to what they engage with and establish a personal relationship with this.

“Places are defined less by unique locations, landscape and communities than by the focussing of experiences and intention onto particular settings.” Relph in (McCullough, 2005)

A shortfall in “Target Interactive Breezeway” was the manner in which users were able to interact in a personal way with the responsive environment, due to the volume numbers of people involved and average user usage time. Personal content could have possibly been explored had users been engaging with the space over a longer period of time, this and the user’s relative state of distraction means meaningful implementation of such a system could be hard to achieve. “Facebook”’s use of personal information (www.facebook.com) enables users to be updated as to changes to their friend’s personal profiles, providing important and meaningful information content. Whilst this is an online service, there is no reason why this level of sophistication could not be integrated into the development of a responsive environment. Questions of the public and private nature of associated information from personal profiles would be an important part of how this is engaged with in a public place. “Social Serendipity” crosses the bridge between online social network and physical environment through directly connecting a personal profile to a user’s space in the physical world enabling people to navigate and discover hidden personalised information content in the physical realm which is related to the individual’s personal profile. ART+COM’s virtual opera suggests a novel approach to personal information content. Whilst this is a performance system, personal information about the dancers is needed so that virtual costumes can track actors around stage to co-ordinate the response between actor and virtual environment. Whilst nature of this personalisation may be a step removed, it highlights manners in which these ideas can be taken in novel and intuitive directions. In the case of “ADA Intelligent Space”, the responsive environment was able to develop its own user profiling in order to better interact and establish a meaningful dialogue between user and environment.

3.6 - MANY TO MANY AUTHORIZING AND WEB 2.0

The potential to support public authoring and ownership in an urban environment extended through responsive means akin to a web 2.0 methodology suggests modes of information exchange which can engage users at a social level which in some cases can engender a sense of community, ownership and belonging. The move from static information broadcast to a wider audience, one-to-many, is being displaced by the richer notion of many users able to produce, respond to and engage with the content from many others. Online communities have developed using these principles and similar ones such as communal knowledge building systems such as wikis have developed strong communities and interest groups.

In the context of responsive environments, the implementation of these notions is partially explored. To someone experiencing NOX's "D-Tower" in its immediacy, one perceives the object as a one way communicative tool, displaying a different colour from day to day, however there is no way a user can affect the immediate context. The physical artefact of the responsive system is for displaying information content not in the most intuitive of manners (do the users know instinctively what the colours of the tower refer to?). KineCity's "Comment Wall" on the contrary is very clear about the information content displayed and acts both as an authoring and display medium. "Comment Wall" becomes a bi-directional exchange tool which can foster a greater level of social involvement and interaction in a physical space than traditional information broadcast and publishing. Authoring within the public realm explored through the "Urban Tapestries" project has enabled users to share and contribute information about their experiences in the public realm. It is in shared content creation that web 2.0 principles offer a strong precedent for developing meaning and ownership over urban spaces which may serve to add value to a specific place and develop a sense of community around such a system, be it physically or virtually located.

"Community is not just a marketer's mailing list. Rather these are complex, subjective perceptions in which the nature or mediated interactions plays a vital role. When experience flows we get place. Flow is of course an essential goal of interaction design and fixity is the essential goal of architecture. Now the two join." (McCullough, 2005)

4. - Conclusion & Further Research

As can be seen from recent case studies, responsive environments suggest new modes of interacting and interfacing between users and their environments offering the potential for richer and more intuitive dialogues to be between users, each other and our wider environments. In the field of public information systems, these cases highlight interfaces and modes of engaging with digital media meaningfully and engagingly. When developed in line with the goals of facilitating public information exchange and discourse in the built environment the application of responsive environments to this context seems well suited to contribute towards contexts encouraging active user participation, social empowerment and personalised information content.

Further questions arise based upon the suggested principles; what and how can these be fostered successfully within an urban context? How can notions of web2.0 and socially constructive applications be applied in a physical urban context and how does this change those models of interactions? The issues of the most appropriate methods of engaging with

users in an already busy urban environment and how these relationships may be developed, used and maintained in a meaningful manner question the modes of interactions in this context also emerges from this.

This paper contributes to the field of responsive design through our own establishment and presentation of a number of principles based upon precedents contributing towards a methodology for integrating meaningful responsive environments within the social and architectural context of the public realm. The further development and analysis of implementation of these principles within a responsive environment may offer the next steps in understanding the relationships between users, each other and their environments in the digitally extended physical realm.

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