Understanding and representing the social prospects of hybrid urban spaces

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Abstract. As built environments become increasingly hybrid physical, social, and digital spaces, the intersecting issues of spatial context, sociality, and pervasive digital technologies need to be understood when designing for interactions in these hybrid spaces. Architectural and interaction designers need a mechanism that provides them with an understanding of the ‘sociality–places–bits’ nexus. Using a specific urban setting as an analytical case study, we present a methodology to capture this nexus in a form that designers of hybrid spaces can effectively apply as a tool to augment digitally sociality in a built environment.

1 Introduction
Digital information is increasingly becoming part of the contemporary built environment, from digital information screens, to scrolling directional signs embedded in the fabric of the environment, through to handheld personal mobile digital devices (e.g., mobile phones). These digital devices offer an exciting opportunity for computing to augment and enhance the way that we operate in the built environment, the activities that we participate in, and the direct relevance of the information that we receive as we communicate and socialise with others in a place. The emerging nexus between sociality, places, and bits requires, on the one hand, analytical approaches to study these developments and, on the other hand, ways to translate their findings into design propositions that can be implemented in digital systems and evaluated. While these issues and opportunities are recognised, they have now become more critical with the increasing spread of pervasive computing technology.

The emerging technology of pervasive computing is defined by Moran and Dourish (2001) as the trend towards numerous, casually accessible computing devices, frequently mobile or embedded in the environment, and connected to a ubiquitous network infrastructure. These computing devices exist in our environment with varying degrees of granularity and embeddedness. They range from handheld devices that rely on satellite information (GPS) to define their location and positional context, through to devices located in the very fabric of the walls around us, providing highly localised contextual information such as the proximity of others (using, for example, Bluetooth microchips).

The introduction of pervasive computing technology changes the relationship between sociality and place in the sense that interactions are no longer constrained by physical location. This change raises questions about the design of information systems and their relationship to architectural design in these digital places. According to McCullough (2004) the need for digital interface designers to understand how this technology becomes
an ambient and social medium brings their work more closely into alignment with the concerns of architecture. The physical context and social interactions are intimately connected with the activities of people in these spaces (Dourish, 2004). Therefore, architects and human–computer interaction (HCI) designers need to understand how people's activities, desires, and serendipitous encounters play out in contemporary hybrid urban spaces.

One way to investigate digital augmentation of traditional urban spaces is to make use of the ability of computing technology to adapt to its physical context. Context-aware computing emerged as a result of advances in the proliferation and affordability of positioning technologies. The primary goal of context-aware computing is to use knowledge of the current context of a device to provide services that are appropriate to particular people, at a specific place and time, and in respect to current activities (Dey, 2001; Moran and Dourish, 2001). As a subset of context-aware computing, location-aware technology provides “an increasingly crucial way to weave together cities, their inhabitants, and digital information” (Mitchell, 2003, page 114).

A digital device that is embedded into a physical location and aware of its context increases its usefulness by providing information that is directly relevant to people in that location. However, how to design a context-aware pervasive computing system that simultaneously draws upon and augments the physical and the social context is not yet well understood. According to McCullough (2001), “The relationship between subject and environment is the key to any additional digital layer.” This suggests a need to understand better the relationship between the physical context of a built environment and the social context created by people interacting in that place when designing digital systems (Agre, 2001).

Our approach to this problem of understanding and designing for such hybrid environments is to analyse the physical and social layers of the environment, and to model emergent relationships and complementarities between these layers. Armed with such an understanding of human interactions and space, we can then design additional digital layers to make use of the knowledge that people already have about the world and their natural abilities to operate in space.

To investigate opportunities for digitally augmenting sociality in public places, in this paper we introduce methods to analyse and model people's understanding of existing architectural and social cues in the built environment. In doing so, we address the problem faced by designers of hybrid spaces—to think about, and design for, the needs of people. We examine the ‘sociality—places—bits’ nexus from the perspective of those tasked with understanding and designing such spaces, including architects and interaction designers. Our contribution is a set of methods that assist in the examination of the physical and social layers of hybrid spaces, and a set of representations that can usefully assist designers of these spaces.

This paper discusses our methodological approach including:
(a) the means of capturing emergent understanding of an urban context, in the form of:
   • the MIRANDA (Multilayer Information Read in Architecture coNtextual Data Analysis) method, and
   • the SOPHIA (SOcial PHysical Interaction Analysis) method;
(b) representations for visualising this understanding, in the form of:
   • the MIRANDA environmental image map,
   • the MIRANDA conceptual framework, and
   • the SOPHIA conceptual framework; and
(c) applications of the above for the design of integrated hybrid spaces, including the derivation of design opportunities and the conceptual design of a pervasive context-aware information system prototype.
MIRANDA demonstrates a method for analysing and modelling the physical context of a space, where the focus is not on technology, but on understanding the way that people operate in space. It therefore provides a model of ‘inhabited’ physical context. SOPHIA demonstrates a method for analysing and modelling the social context of a space, where the focus is on understanding the situation of social interactions. It therefore provides a model of ‘situated’ social context. Based on these two methods, two conceptual frameworks are developed that designers can effectively employ for designing digital applications to augment social interactions in place.

This paper is structured as follows. Section 2 uses a scenario to situate social activity at the intersection of physical, social, and digital spaces, and identifies the challenges involved in understanding the relationships between these layers. Section 3 describes the process of understanding and representing social activity in hybrid spaces, by looking at architectural, social, and computational approaches, and discusses the need for an integrated view. Section 4 introduces the case study to illustrate development of the MIRANDA and SOPHIA frameworks. It also demonstrates application of these frameworks in the conceptual design of a pervasive-computing prototype. Section 5 is a critical review of the MIRANDA and SOPHIA methods, their implications for design, and speculation about future possibilities.

2 Intersection of social, physical, and digital spaces
2.1 Problem scenario: social activity in urban space

Jordan is passing Federation Square on her way to the train station and is reminded of her friends Mikaela and Corey, who she usually meets here for coffee. Jordan, Mikaela, and Corey are regular visitors to Federation Square. She remembers that on Tuesdays (today) they have classes in the city, and after several exchanges of text messages to establish that they are nearby, she arranges to meet them “in the usual place in fifteen minutes”. Jordan has some time before they arrive, so she decides to find out where the art gallery is because she has not been there before. She walks up the stairs where everyone sits, heading for the main plaza, because most places seem to be there. The main plaza is a sparse open space with very few people walking across the middle, so she walks around the edge. She checks entrances she passes, but it is unclear where they lead. The buildings feel monolithic, inward looking, with unclear entrances. Jordan feels unsure about how ‘public’ these buildings are, and if she has missed the gallery. From her experience with Federation Square, it is usually difficult to understand how different places are located relative to each other. Jordan always approaches her favourite places using the same path, even if it sometimes feels like the long way around.

This scenario illustrates that Jordan chooses the people she wants to meet with because they have shared past experiences in Federation Square, during which the group established a familiar place to have coffee. Although they establish a virtual social space through texting on their mobile phones, their close physical proximity and trajectories within the city make it possible for them to set up a face-to-face interaction. This scenario then goes on to show the problem that Jordan is having reading cues in the physical environment. It is hard to understand which activities are housed in which buildings, and whether one is allowed to enter them, since all the buildings look similar and one cannot see what is inside them. Entrances into most buildings head directly to stairways leading up or down, so one cannot look ahead to see where they go. It is also difficult to work out specific pathways around the space, and where one is supposed to walk.
Jordan looks for signs on buildings to indicate their purpose, instead finds building names, such as ‘Alfred Deakin Building’. She looks to the large screen at the bottom of the plaza for information. Instead, it is showing a live feed of people entering the plaza—fun! But no help. There are some vertical scrolling digital signs, but after turning her head on the side, she finds that the information is impossible to decode. Giving up on her aim of looking for the gallery, Jordan decides she wants to know if there is anything special happening here today so that when her friends arrive she can suggest an activity, but there is no information about what is on right now. There is a large signpost at the top of the plaza, the arrows are artistic but directionally unclear, and words like ‘BMW-Edge’ hold no meaning at all for her. She even sees the word ‘The Ian Potter Centre’ but doesn’t realise it’s the name of the art gallery.

The informational/digital layer in this part of the scenario provides certain information in certain places, but not always in the places and form that may be useful. There is a problem with screens attempting to be both decorative and informative, because they do not do either properly. People have different levels of experience with this place, and so there are different information needs that go beyond wayfinding. When socialising, people usually want to know more about places than just names, and they like to know what is happening around them, so they can make spontaneous decisions about activities to become involved in.

It is nearly time to meet up with Mikaela and Corey at their usual coffee shop, and, from her current location, Jordan would usually have walked around the outside of the square to get there. However, as she is standing checking her watch, a large group of people walk into a doorway she hasn’t noticed before. Curious to see where they are going, she follows them into the entrance and down the steps. When she gets to the bottom she sees that the atrium is full of people. There is a craft market on there today, and the entrance to the art gallery is right in front of her! Jordan hasn’t ventured to this end of the atrium before, but from where she is standing, she recognises the large glass and steel opening at the other end of this space, and knows that the coffee shop they are meeting in is just below this opening. Not only has she saved herself a long walk around, but she also knows the others will be interested in visiting the market after they have had coffee.

This scenario highlights the fact that Jordan wants to see what others are doing, but social information in this space is not readily available because gathering places are segmented and not visible from the main plaza. People like to go where others are gathering, and the presence of others is taken as an indicator of a good venue or activity so it is important to know what others are doing. In this space, due to unclear entrances and bad signage, following a group of people helped Jordan to expand her knowledge about the space and to discover a new path to her favourite coffee shop.

The scenario illustrates the problems and opportunities that people are presented with in designed environments. It shows the importance of physical and social cues in the built environment in providing information to people about where they can go and what they can do in hybrid urban spaces.

2.2 Physical and social spaces
The issues identified in the preceding scenario have been traditionally explored in architecture and sociology. Some of the key insights from this literature relevant to our work include the following. The architectural design of form in the built environment responds to a set of social and physical issues in respect of anticipated activities and historical expectations of certain buildings types (Agre, 2001; Mitchell, 1995; Norberg-Schulz, 1971). People operate in urban spaces by interpreting the physical and social affordances of a place to make sense of it. As people walk around an
architecturally designed space they make certain assumptions about the kinds of activities and social interactions that are supported in different places. It is the individual’s understanding of the purpose of a built environment that determines its functional success. People read cues from their physical environment, and combine this with previous experience to define their context (Erickson, 2002; McCullough, 2004).

Physical space plays a constructive as well as a receptive role in shaping social interaction in urban spaces (Hillier and Netto, 2002). The physical affordances of architectural elements of a space help to define such things as places for sitting, paths to walk along, landmarks to locate by, and entrances for transition from one place to another. These physical cues, coupled with the information layer of a space—for example, labels on buildings, directional signage, and media screens—help shape the situated interactions that happen in a place. These physical spaces are designed in anticipation of people’s activities and needs for social interaction.

Behaviour can be framed as much by the presence of others as by the physical environment (Harrison and Dourish, 1996). People understand the kind of behaviour and activities that are appropriate through established cultural patterns (Bell and Dourish, 2004). A person’s history and experience with a place also play a constructive role in how people understand a space. The scenario illustrates how the social affordances of a space influence people—for example, using flows of people and groups of people gathering to make assumptions about where to go and where activities of interest might be happening. It also shows how familiarity with a space and past social experiences help structure situated interactions in a place—that is, people tend to rely on familiar paths and patronise familiar places. Space is given significance through its link to human behaviour (Hillier, 1996).

Both physical and social spaces are well understood by the respective disciplines of architecture and sociology, but when a digital layer is added to this space, the inter-relationships and complementarities of all three layers need to be understood to design effective pervasive computing systems for contemporary urban spaces.

2.3 Digital spaces
Pervasive computing introduces opportunities for shifting space, time, and social interactions, and thereby extends the roles of architecture and urban design. The modern built environment is augmented with an information layer in the form of textual, graphical, and digital signage; maps; and labelling. These are sometimes designed concurrently with the architectural space, but, over time, additional layers of information are typically added.

The design of the city affects not only how well people find their way around, but also how they make sense of the social and symbolic complexities of that city (Lynch, 1960). However, as Mitchell (2001) points out, cities no longer need visible landmarks and edges to provide guidance, or the qualities of legibility and memorability described by Lynch. People who are digitally connected to each other and to the elements of the city no longer need signage, they use their technology to guide them to where they want to go and to tell them what is happening in the places around them. These developments challenge the traditional role of architectural and urban design. According to Mitchell (1999, page 8), “we must extend the definitions of architecture and urban design to encompass virtual places as well as physical ones ... [it is time] to reinvent urban design and development and to rethink the role of architecture.”

What can the addition of digital layers to social and physical ones contribute to our social interactions? The introduction of a pervasive context-aware computing layer of dynamic information triggered by the current location of a person can accommodate
delivery of the differing information requirements of individuals in different places. A person familiar with a space reads a lot more from his or her environment, and does not enjoy being told where to turn and what exactly occurs in each place along a path (McCullough, 2001). Computing appliances in digital spaces can be designed to be both physically and socially aware, providing information that is just in time (MacKnight, 1996), just in place (Kjeldskov, 2002), and just for us (Paay, 2004). According to McCullough (2004, page 47), “architecture has acquired a digital layer”, in that digital technologies are now able to extend the reach of architecture by using pervasive computing to augment social interaction in urban spaces.

Interaction design, like architecture, and increasingly as a part of architecture, affects how each of us inhabits the physical world (McCullough, 2004). Mobile digital devices, accompanying individuals as they move through space collecting embedded situated information, open up opportunities for people to restructure space effectively, and to initiate more fluid and serendipitous activities and interactions in any place. This will necessitate a rethinking of the design of spaces. Pervasive computing is breaking down the traditional mapping between activities and places, allowing people to participate in social interactions no longer tied to their current location, by supporting continual presence in every place (Agre, 2001). For example, cafes become corporate meeting rooms as users deal with business calls over lunch; corporate meeting rooms become social arenas while participants text loved ones unobtrusively; streets become guided walks; and plazas become information kiosks, all without any changes to the built fabric.

2.4 Identifying the challenges
The challenge for designers of context-aware digital devices is that their focus should not be on the technology but on how these digital devices may transform dependencies between place and social interactions. As Harrison and Dourish (1996, page 75) point out, “the very thing that makes place work [is] the shared understandings of appropriate use, and the social interpretation of cues in the physical environment.” Any new form of embedded interaction needs to be responsive to the needs and activities of people who occupy these places (Dourish, 2001).

This section reviewed modern urban space as being composed of three layers: physical, social, and digital. It highlighted the problem of understanding hybrid spaces using a scenario and illustrated how individuals routinely encounter these three layers in contemporary urban spaces.

3 Understanding and representing social activity in hybrid spaces
To investigate challenges identified in the preceding section, the following provides an overview of methodological approaches in the three correlated disciplines: architecture, sociology, and computing. What we need are specific techniques that can be readily operationalised in order to understand and to represent the relationships between physical environments, social interactions, and digital devices. We then present the need for an integrated view to understand how the ‘bits’ might be connected to ‘place’ and ‘sociality’.

3.1 Architectural approaches
Architecture encapsulates the deepest practical knowledge of environmental perception (McCullough, 2004). Architectural design implicitly and explicitly incorporates social theories and user needs into design methods.

The seminal studies by Lynch (1960) and Alexander et al (1977) implicitly include people in their analysis of physical environments and provide theoretical models that support a people-centred perspective on the built environment. Both provide a specific
set of categories and descriptions of the built environment that can be used in
grounded analysis of urban space as encoding schemata. Such formal taxonomies by
Lynch and Alexander are often used in HCI research when looking for inspiration
to create models to understand the relationship between physical and digital space
(eg Cheverst et al, 2005; Crabtree and Hemmings, 2001; Dieberger and Frank, 1998;
Erickson and Kellogg, 2000; Ingram et al, 1996; Kulju and Kaasinen, 2002; Paulos
and Goodman, 2004; Sparacino et al, 2000; Vinson, 1999). In this paper we use the
work of Lynch and Alexander not so much for directly adopting their ideas, but rather
as methodological scaffolds to use in modelling the physical context of urban spaces.

Lynch (1960) developed a method for visual analysis of cities through descriptions
of key aspects of the space held by people as they navigate and orient themselves
within city precincts. The method proved successful at assisting in the analysis of types
of elements of a city. In this method an architecturally trained observer undertook a field
reconnaissance to map the presence of various elements of the physical environment,
classified as one of five elements: districts, landmarks, nodes, edges, and paths. A similar
method was adapted in our case study to identify key environmental features and to
develop the MIRANDA environmental image map (described in the next section).

Alexander et al (1977), empirically investigated the interplay between architectural
space and its inhabitants. This produced a collection of 253 hierarchically ordered
patterns that constituted the ‘pattern language’, providing a catalogue of elements of
the built environment that reflected design responses to social relationships. A similar
approach was used in our case study to identify a preliminary vocabulary of patterns of
interactions and design elements. The outcome of this approach was the MIRANDA
conceptual framework.

3.2 Sociological approaches
In sociology significant ethnographic studies have investigated how to understand the
behaviour of people in public places. An example of such investigations is the study of
public squares by Whyte (1980), undertaken in New York, to discover what makes
some places popular and others not. He used time-lapse photography, and ethno-
graphic observation to discover the embodied nature of people’s experience of physical
space. His studies revealed the importance of allowing people to use a space flexibly
and contributed to an understanding of sociality. The ethnomethodological approach
from sociology is interested in the activities of creating, understanding, and maintain-
ing the order of social life, where the results of studies are descriptions rather than
theories. These descriptions are used to help researchers to understand ‘ordinary’
everyday action (Buscher and Hughes, 1999). A theoretical approach to understanding
the behaviour of people in public places was taken by Goffman (1963) in his notes
on the social organisation of gatherings and inquiry into the interactional involvement
of people in social situations.

The sociological approach has a long tradition of methods for gaining insight into
human interaction and the social affordances of inhabited spaces. Only recently have
these studies started to consider or measure the impact of electronic environments
on these interactions. Although computational approaches are becoming intertwined
with social approaches, research in these areas has not yet taken a situated approach
to the analysis and design of hybrid environments. The ethnographic methods of
field observation and contextual interview, and the sociological research method
of grounded theory analysis have been used in this study to understand social con-
text in the case-study environment. The outcome of this approach was the SOPHIA
conceptual framework.
3.3 Computational approaches

Sociological techniques and analytical approaches have been applied in HCI and computer-supported cooperative work research for over a decade. Researchers interested in designing for virtual communities have used the work of Whyte (Buscher and Hughes, 1999; Donath, 1996; Erickson et al, 2002). Using ethnomethodology to study people's interactions in, and with, electronic environments, Buscher and Hughes identified a 'language of sociability', encapsulating interactional information to understand the interactions between people in face-to-face situations. The work of Goffman has been used to give accounts of the ways in which social cues shape behaviour, directly informing interaction design (Erickson et al, 2002).

While the earlier studies centred around 'bounded' work environments, the introduction of pervasive computing has reignited interest in understanding social interactions in public places. Many mobile users are looking for suggestions from their physical and social environments, on how to enhance the activities in which they are currently involved (Persson et al, 2002). Electronic augmentation of physical space is one way this can be achieved, but it needs to be based on an understanding of how social interaction in public places unfolds, and of its situated nature. Mediating technologies can extend the possibilities for human interaction, but need to take account of the interactionally relevant information that people take for granted in everyday face-to-face interactions. Certain contexts enable people to perform actions that are significant only at a particular moment in time, and so defining this dynamic context of use is difficult. To understand this context and to inform the design of interactive environments, ethnographic studies of the strategies that people use in moving around real-world space, and observations of people's interactions have been undertaken (Buscher and Hughes, 1999; Ciolfi, 2004; Tamminen et al, 2003).

The computational approach is moving toward understanding human interactions in space by observational methods adapted from sociology. Although these methods are beginning to shift the focus of inquiry from a task-oriented view of computing to a situated one, detailed examples of work that integrate these methods with an empirical evaluation of the contribution of physical and social space to human interactions in hybrid environments are not available. Current computational approaches provide little in terms of precedents for us to follow or build upon, and the work that exists does not bridge well to the design of systems for hybrid spaces.

3.4 Need for an integrated view

Each of these approaches, if applied in isolation, tells a separate story about human interactions and space, and so an integrated view is needed to understand intersections between physical, social, and digital layers. To this end, a case study of an existing urban environment was undertaken and is described next.

4 MIRANDA and SOPHIA frameworks

4.1 Case study of an urban space: Federation Square

Inspired by the need to provide an integrated view of the physical and social context of an urban space in a form useful to designers of hybrid spaces, two field studies were conducted at Federation Square, Melbourne, Australia (figure 1). Federation Square is an award-winning architecturally designed urban space, opened to the public in October 2002. It is intended to provide the people of Melbourne with a “unifying square, a landmark, a civic focus” (official brochure), by bringing together a creative mix of attractions and public spaces. One key design intention of the project was to incorporate digital technologies into the building fabric, creating a space 'between the virtual and the real' for people to socialise in.
Federation Square was chosen for the case study because it is a multimodal public space with a mixture of distinct architectural features and embedded digital elements. It invites a diverse population of visitors of all ages, both first-timers and people who visit regularly. It supports a variety of activities to visitors, including restaurants, cafés, bars, a museum, art and media galleries, cinemas, retail shops, and several public forums, within a single large city block.

4.2 Development of MIRANDA

4.2.1 Data collection and analytical approach

The first field study was designed to analyse physical space at Federation Square. The data collection phase included several field visits to Federation Square, during which 250 photographs were collected that formed the basis for analysis and classification of elements of the physical space. Observational and reflective field notes were also kept, and were referred to during the analysis phase, in conjunction with the photographic images.

In the analysis of this data, Lynch’s (1960) expert field reconnaissance method inspired a visual inspection technique which used the photographic material to identify the five elements of Lynch’s taxonomy (ie districts, landmarks, nodes, edges, and paths) in the photographs. These were then marked on an existing plan of the space, resulting in the MIRANDA environmental image map. Secondly, Alexander et al’s (1977) patterns were used to inspire the initial encoding schema used in the content analysis (Neuman, 2003), performed on descriptions associated with the photographs. Alexander’s patterns were used as an analytical tool for identifying architectural elements within physical space and to generate descriptions and sketches of architectural elements in Federation Square. The content of the descriptions associated with each image was then analysed.
in detail to identify and code repeating themes and concepts, and these codes were refined until a set of abstract concepts could be used to describe the prose.

The affinity diagramming method (Beyer and Holtzblatt, 1998) was used on the abstracted concepts and themes identified during content analysis to provide a high-level abstraction of the original dataset. This involved a process of continual grouping of concepts into higher level concepts, refining these groupings and renaming them until a small set of categories (representing both ‘descriptor’ words and ‘place’ words) was derived from the process. This set of emergent categories became the vocabulary of the conceptual framework, MIRANDA.

4.2.2 MIRANDA framework

MIRANDA represents the ‘inhabited’ physical context of Federation Square, from the user perspective. MIRANDA has three components:

- MIRANDA analysis—the process of data collection and analysis, presenting a general method that can be applied to any space to provide a grounded abstraction of architectural elements of that space;
- MIRANDA environmental image map—the identification of key elements of an urban space, presenting a visualisation tool that gives an image of the space representing districts and landmarks; and
- MIRANDA conceptual framework—the emergent ‘vocabulary’ and the abstract representation of that vocabulary, presenting a visualisation tool that gives access to an overview of key characteristics of the space.

The MIRANDA analysis combines architectural methods for analysing built environments and social science qualitative research methods. The method is used to analyse and to understand the inhabited physical context of a built environment. The form of representation is discretionary. The data can be visualised and represented in many ways depending on the intended application.

The MIRANDA environmental image map (figure 2) is a visualisation of a physical space identifying districts and landmarks within the case-study space. The identification of these characteristically distinct districts within Federation Square and their related landmarks inspired a unique way of thinking about locating digital appliances in this space.

The MIRANDA conceptual framework represents in graphical form the qualitative findings of the architectural study and encapsulates human understanding of elements of the space. The framework presents a vocabulary of the space, which can be used to understand the predominant physical attributes of the space as perceived by visitors.

The syntax of the MIRANDA vocabulary is a signed word pair:


text: [+,-] <descriptor>.<place>

The descriptor set of words derived from the content-analysis phase (described in the previous section) is: activity, bright, clear, connected, decorative, focal, functional, general, high, human-scale, inviting, natural, sheltering, and visible. The place set of words is: goal, edge, entrance, floor, node, path, roof, structure, surrounds, transition, and wall.

As an explanation of this syntax, the first set indicates that one of these signs, ‘+’ ‘~’, or ‘-’ applies to the phrase, where ‘+’ indicates the positive form of the phrase, ‘~’ indicates the partial or fractional form of the phrase, and ‘-’ indicates the negative form of the phrase. The sign is then followed by a word pair, the <descriptor> and <place> words, each chosen from the set of descriptor words and the set of place words defined during the analysis. Together they act as a language statement that represents the human-centred view of a physical element of the urban environment.
Figure 2. MIRANDA environmental image map.

Figure 3. MIRANDA conceptual framework: (a) positive description of architectural elements; (b) negative description of architectural elements.
being described. For example, ‘+ inviting.path’ indicates a path that is inviting to people, whereas ‘– inviting.path’ indicates a path people do not like to walk along.

These word pairs, of the MIRANDA vocabulary, were then used to replace the prose descriptions on each of the photographs. These were written as a language of one-to-many statements, which could succinctly represent the subject of the respective image. Each occurrence of a language statement on a photograph was plotted on bipartite graphs (see figure 3), for the purpose of analysing and illustrating the frequency of association of word pairs within the total dataset, indicated by the width of the connecting line on these graphs.

This representation of the data provided an additional benefit as a tool for visualising an overview of the inhabited physical context of Federation Square. By surveying this diagram it was possible to use the tallied language statements of architectural space to draw summary conclusions about the space, such as it having strong activity edges and visible surrounds, which would not be evident from viewing the original data, or merely by visiting the space. This composite view of the urban space was judiciously extracted from a historical understanding of human experience of physical space through an observational expert audit and content analysis of urban space.

The MIRANDA conceptual framework provided an understanding of inhabited physical space. This motivated the need to understand how social interactions unfold in this environment to be able to consider the interplay between the physical and social contexts of the space.

4.3 SOPHIA

4.3.1 SOPHIA analysis

The second field study was designed to understand social space at Federation Square. This phase included four field visits to Federation Square with three established social groups. Each group consisted of three young urban people, each group with a mix of males and females, who had a history of socialising at Federation Square together. Each visit lasted approximately three hours and comprised ethnographic observation and contextual interview (Beyer and Holtzblatt, 1998), while the group participated in their usual socialising activities. Participants were asked to ‘think aloud’ (Preece et al, 2002) as they moved around the space involving themselves in different interactions and activities, and were asked to respond to questions on points of clarification about interactions and decisions not explicitly verbalised.

This produced eight hours of digital video documenting the field visits, which were transcribed and then analysed using the grounded theory analysis method. The encoding schema used in this method was McCullough’s (2001) proposed typology of situated interactions of everyday situations that might occur while out ‘on the town’. These include: eating, drinking, talking (places for socialising); gathering (places to meet); cruising (places for seeing and being seen); belonging (places for insiders); shopping (places for recreational retailing); sporting (places for embodied play); attending (places for cultural productions); and commemorating (places for ritual).

In our case study only a handful of McCullough’s (2001) situations appeared relevant to being ‘on the town’. Eating, drinking, gathering, cruising, and attending were the predominant activities identified at Federation Square. An additional category of contacting was identified, which was directly attributable to people’s use of mobile phones to coordinate meeting up. In operationalising McCullough’s typology through this fieldwork, our understanding of how these interactions play out in real-world situations has been deepend, translating the typology to another level of usefulness to interaction designers.
The grounded analysis of the data provided a set of 124 unique themes. These themes provided a rich story about understanding user experience of situated interactions while socialising in an urban environment. Affinity diagramming was then used to draw successively higher levels of abstraction from the data, by grouping and sorting the themes and concepts, until a small set of high-level concepts was extracted. This process resulted in the conceptual framework, SOPHIA.

4.3.2 SOPHIA framework

SOPHIA represents the ‘situated’ social context of Federation Square, encapsulating a structured understanding of the context of everyday social interaction in the situation of an urban environment. SOPHIA has two components:

- SOPHIA method—the process of data collection and analysis, presenting a general method that can be applied to any space to provide a grounded abstraction of social interactions of that space; and

- SOPHIA conceptual framework—providing a rich understanding of sociality in urban environments in the form of a structured qualitative story about how people experience physical space and how they interact with each other while socialising in these spaces.

The SOPHIA method combines social science qualitative research methods of data gathering and analysis with interaction design methods for data analysis and interpretation to produce a rich story about a situation of use. It provides an understanding of situated social context for built environments. As with MIRANDA, the form this representation takes is discretionary. The data can be visualised and represented in many ways, depending on the intended application; for example, these same data could be used to create a rich picture of social interaction in public places, or a set of user scenarios (Rosson and Carroll, 2002) for use in the interaction design process.

The SOPHIA conceptual framework represents the qualitative findings of the social study at Federation Square giving insight into how people perceive the sociality of urban space. The framework identifies three main categories of social interaction in the physical setting of an urban environment: knowledge, situation, and motivation. These three key categories are further divided into eight subcategories, and each of these subcategories are further divided into a set of concepts that represent a summary of the themes extracted from the grounded analysis. This representation of the SOPHIA conceptual framework (figure 4) is directly related to the final affinity diagram produced by the SOPHIA method, but structured into a table format for readability. Each of the four columns in this table represents a level of hierarchy, and therefore a level of abstraction in the affinity diagram, with the highest level concepts in the left-most column.

The SOPHIA conceptual framework tells a story of the social context of situated interactions as observed in urban space. Each row of the diagram, when followed from left to right, gives an insight into aspects of the social context in which people operate in urban space. For example, knowledge is an important part of how we operate while socialising in an urban environment. We use our ‘knowledge-in-the-world’ (Norman, 1990) to interpret the physical affordances and social affordances of a place. From this understanding we are able to judge which places we can enter, places that are for gathering, and the common use of landmarks as reference points. Socially, we use the presence and actions of others to read cues about what we can do, and where we can and might want to go. Similarly, situation and motivation are also important aspects of sociality in urban space, and the SOPHIA conceptual framework details their related concepts.
<table>
<thead>
<tr>
<th>Knowledge</th>
<th>physical affordances</th>
<th>social affordances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>places to enter</td>
<td>landmarks as focal points</td>
</tr>
<tr>
<td></td>
<td>places for gathering</td>
<td>foreign points</td>
</tr>
<tr>
<td></td>
<td>landmarks as focal points</td>
<td>cues for what to do</td>
</tr>
<tr>
<td></td>
<td>cues for where to go</td>
<td>personal preferences</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>physical familiarity</th>
<th>social experience</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>familiar paths</td>
<td>past experience</td>
</tr>
<tr>
<td></td>
<td>familiar places</td>
<td>shared experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>recommendations from others</td>
</tr>
<tr>
<td></td>
<td></td>
<td>personal preferences</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Situation</th>
<th>people</th>
<th>setting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>us and them</td>
<td>setting matters</td>
</tr>
<tr>
<td></td>
<td>interaction by maintaining group</td>
<td>others (social)</td>
</tr>
<tr>
<td></td>
<td>interaction by proximity</td>
<td>environment (physical)</td>
</tr>
<tr>
<td></td>
<td>interaction by watching</td>
<td>convenience to current location</td>
</tr>
<tr>
<td></td>
<td>discomfort of waiting</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Situation</th>
<th>surroundings</th>
<th>indexing to surroundings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>index to shared knowledge</td>
<td>index to visible elements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>index to events</td>
</tr>
<tr>
<td></td>
<td></td>
<td>index to physical objects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motivation</th>
<th>reflection</th>
<th>gathering information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sizing up the situation</td>
<td>different levels of information</td>
</tr>
<tr>
<td></td>
<td>getting an overview</td>
<td>media screens as decoration</td>
</tr>
<tr>
<td></td>
<td>pausing before committing</td>
<td>what's new</td>
</tr>
<tr>
<td></td>
<td>making sense of a place</td>
<td>uncertainty (lack of information)</td>
</tr>
<tr>
<td></td>
<td>making sense of what's happening</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motivation</th>
<th>extension</th>
<th>directed movement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>exploring</td>
<td>transition through spaces</td>
</tr>
<tr>
<td></td>
<td>exploration for the sake of it</td>
<td>dynamics of a place</td>
</tr>
<tr>
<td></td>
<td>wandering and browsing</td>
<td>wayfinding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motivation</th>
<th>negotiation</th>
<th>making decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>discussing suggestions</td>
<td>someone takes the lead</td>
</tr>
</tbody>
</table>

**Figure 4.** SOPHIA conceptual framework.
4.4 Findings and contribution

MIRANDA and SOPHIA make available representations of a specific space that can then be used to understand the key physical and social characteristics of that built environment, and to describe the user’s surroundings in a way that is grounded in human observation of that place, and that is formed with reference to collected knowledge about human understanding of architectural form and social interaction. The MIRANDA and SOPHIA methods are unique, insofar as they provide systematic techniques for creating a grounded representation of inhabited physical context and situated social context, which do not exist in the literature surveyed.

MIRANDA and SOPHIA provide a way to bridge the gap between understanding current context and designing new artefacts to fit that context. To assess the usefulness of ideas emerging from MIRANDA and SOPHIA, a conceptual design of a prototype mobile information system was developed. This prototype system, (see figure 5), incorporates seven overall design opportunities, which exploit the unique characteristics of the urban case-study place, drawn from the understanding and identified features of the built environment provided by the MIRANDA and SOPHIA conceptual frameworks.

Applying the MIRANDA and SOPHIA methods to Federation Square facilitated the creation of the conceptual frameworks of physical and social context. Using these frameworks, interaction designers were able to make a transition from analysis to design by deriving design opportunities as follows:

A design opportunity identified from the MIRANDA environmental image map:

- location by district—the system can respond to the user’s location in terms of one of the defined districts, rather than with exact locational coordinates.

Design opportunities identified from the MIRANDA conceptual framework:

- augmented photorealistic depictions—each district can be represented in the system by an interactive photorealistic depiction of the physical surroundings of the user, augmented with textual or symbolic information needed to understand the place better; and

Figure 5. Prototype design informed by MIRANDA and SOPHIA: (a) rich descriptions for wayfinding; (b) representation of people and activities.
rich descriptions for wayfinding—locations and instructions for navigation could be expressed through rich descriptions derived from the distinctive characteristics of the place, rather than through locational coordinates.

Design opportunities identified from the SOPHIA conceptual framework:

- use of history—the system can keep a record of the user’s history of visits to a place, and the visits of accompanying friends, to deliver socially appropriate information about things to do and places to go;
- extension through movement—the system can support wayfinding with the use of a system of relying on people’s familiar paths and indexing to their familiar places to get them to their destinations;
- representation of people and activities—the activity and location of others in a place can be represented to the user so that he or she can make activity choices based on this information; and
- meeting and waiting—the process of ad hoc meeting up with friends can be streamlined through the use of familiar places, identified groups of friends and their proximity, and with information about how long a person will need to wait.

These ideas later became design specifications through processes of design sketching (Buxton, 2005) and paper prototyping (Snyder, 2003), out of which a final design emerged. The visual form of both frameworks helped designers to identify prevalent issues, and therefore the models were found to describe the space in a form that was useful in interaction design.

Designer understanding of the physical and social context of the user emerged in the interaction design of those parts of the system that implicitly rely on the user’s knowledge of his or her physical or social context to understand the information content on the screen. For example, knowing about physical aspects of the square, such as it having visible surrounds, means that wayfinding instructions can be given to the user in the way that people generally communicate about their physical environment [see figure 5(a)]. This means that, rather than being told to ‘go forward 150 m then turn left’, users can be instructed to ‘head towards the railway station’. In another example the representation of people and activities screen [see figure 5(b)] uses the ability of technology to locate and represent the position and activity of others in places surrounding the user, allowing people to draw their own conclusions about where they want to go based on their social need to size up a situation (for a detailed design and technical description of this prototype, see Paay and Kjeldskov, 2005).

4.5 Usage scenario: digital augmentation of urban space

Jordan meets up with Mikaela and Corey in Federation Square. Their usual coffee shop is closed for renovation, so they need to choose another. Jordan takes out her PDA and looks at her ‘favourites list’ of places to go for coffee. The device senses that Jordan is currently with Mikaela and Corey, and since they have been to the Arintji coffee shop together in the past when the weather is nice, and the system knows that their favourite coffee shop is closed and it is sunny today, it lists Arintji on the top of the favourites list. Looking at the name Arintji, Jordan is unsure which coffee shop it is, because she does not know the formal names of her familiar places. She selects the wayfinding option next to the place name in her system and is taken to the wayfinding part of the system. Since the system recognises this as a place that Jordan is familiar with, and also notes it is next to the museum that Jordan often visits, it gives a simple description and a photograph of the coffee shop. The description reads “The Arintji coffee shop is next to the Champions museum, near the river.” Mikaela, looking at the photo displayed, says “I know where that is—I recognise the umbrellas—it is the coffee shop with the nice tables in the sun—if we walk back around the outside of the Square it is easy to find.” Jordan also feels she is
now sure of the location because she can picture in her mind the location of the museum and the river.

Before heading in that direction they want to check that it is open and lively, as they like being in places where others are enjoying themselves. Jordan switches to the representation of people and places on her PDA and can see from the large purple dot where she has guessed Arintji is located that many people are having coffee there at this time. They can also see that it is actually quite close to their current location, which is also indicated on the map. Corey interjects that there must be something “cool” happening at Arintji. Jordan clicks on the purple dot for confirmation that it is indeed the location and representation for Arintji, and is given information about the coffee shop. From this information they can see that Arintji is a participant in the Melbourne Bean Festival, and is offering tasting of ‘coffees of the world’ today, with live jazz music. All three are chattering excitedly about the prospect of this event as they walk along their usual path to the venue, around the outside of the square. When they arrive, Jordan looks at her PDA. It is already displaying the complete menu of the different coffees available at Arintji today, and they contemplate their choices as they head for their usual table, where they are happily surprised to see their friend Jorja drinking coffee.

The system informed by MIRANDA and SOPHIA provides information to the users in respect to their current socialising group, patterns of their past and shared experiences with places at Federation Square, their current location in a district, and the current weather conditions. In situations in which the user is unsure of the location of a place and how to get there, it shows what the destination looks like and gives descriptions in meaningful words about how to find it, again in respect to knowledge that the system has about the user’s history, and the understanding that people have about their current location and the physical environment around them. This gives users the flexibility to use their own familiar paths around the space. Detailed wayfinding instructions are provided only in cases in which the system knows that the user is unfamiliar with that locale.

The system provides information about the current context of surrounding places that is beyond the users visual range, thereby augmenting their ability to make assumptions and decisions based on the location and activities of others in places around them. In this way, users are able to get a sense of what is happening, while maintaining the flexibility to draw their own conclusions about how they use that information. The context-aware system also provides access to differing depths of information required by the user at the times that it is needed. A general overview of the space provides links to detailed information about places in proximity, and detailed information such as menus is immediately available when the users are actually in a place.

The system based on MIRANDA and SOPHIA provides contextually relevant information that integrates the physical, social, and digital layers of hybrid spaces because a grounded understanding of how users perceive their physical and social environments was made available to the interaction designers in a form that proved useful and usable in the design process.

5 Social prospects of hybrid spaces
In this paper we began by introducing the issue of hybrid environments that combine physical, social, and digital spaces. We identified a methodological gap in how to move from an analytical understanding to designing digital systems that draw upon the knowledge of the spatial context of a built environment and the social interactions of people in that place. We also indicated the importance of an integrated approach to
understanding the interrelationships and complementarities between physical, social, and digital layers of built environments.

Pervasive computing requires information technology to go to the places and activities of daily life (Agre, 2001). It is therefore imperative that we understand the interactions of users both with their physical and with their social environments more fully in order to be able to facilitate and augment sociality in urban spaces using technology. Our approach in tackling this issue was to create methods to analyse how architectural and social layers of the environment contribute to human understanding of that space. Our contribution is the two methods, MIRANDA and SOPHIA, which capture the emergent understandings of inhabited physical and situated social context; we have also provided conceptual frameworks of the findings and their respective visualisations; and we have demonstrated their implications for the design of integrated hybrid spaces through a conceptual context-aware prototype design. This paper provides an understanding of the places and activities of daily life needed to design more effective digital systems that are seamlessly integrated into a built environment.

This is preliminary and exploratory work in this area; it is therefore scoped to include limited aspects of the visual environment. The existing conceptual frameworks can be refined and added to with additional studies. Both models can be adapted to include data from different environments and with different user groups. Similarly, the methods can be used to analyse the elements of spaces of different scales; from a whole city block, such as is used in this study, to a whole city or a small corner café. The methodology presented in this paper provides a set of methods that can be used as the starting point for identifying the essence of any physical and social environment as perceived by the users of that space.

The idea of the need for a holistic approach to understanding physical and social context came to light through a process of drawing together the approaches from different disciplines for understanding and representing contexts. A future research direction could take the methods and experience gained through the discovery of the processes documented in this paper, and use them to refine, validate, and generalise the frameworks to create a universal ontology of hybrid spaces.

Designing for future pervasive computing in the built environment is challenging. Inhabited physical spaces are complex and dynamic. Social interactions have an intricate relationship with the physical context in which they are situated. By adding a digital layer of information to our inhabited built environment we mediate new types of social interaction happening there. In supporting situated interactions in urban environments, the concerns of architecture and human–computer interaction design collide. Assimilation of knowledge from both disciplines is the key to designing these hybrid environments.

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