AUGMENTING TIME AND SPACE IN DESIGN INQUIRIES

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Abstract. Our research revolves around developing applications of augmented reality technologies to support changing temporal contexts in architectural design. In order to ground this research in contemporary professional culture, we first undertook a structured data gathering exercise, analysis of which will inform development of new AR technologies and tools to support temporal visualisation of architectural designs. This paper reports on the first phase of this project in which we undertook extended conversations and documentation of 22 design offices that represent practices of varying sizes and competencies. The intention of this data collection exercise was to map out spectrum of design issues and representations that specifically revolve around changing temporal or spatial contexts in design. This paper reports collection and preliminary analysis of data intended for developing specifications of future AR applications.

Keywords. augmented reality; design representations; spatio-temporal design; contextual design.

1. Introduction

Our research aims to investigate (1) responses to temporal contexts in architectural design projects by professional practices, (2) develop new digital technologies and tools to support temporal visualisation of architectural designs, and (3) evaluate qualitative impacts that may arise out of adoption of such technologies by design practices.

This paper reports on the first phase of this project in which we undertook extended conversations and documentation of 22 design offices that represent practices of varying sizes and competencies. The intention of this data collection exercise was to map out spectrum of design issues and representations that

specifically revolve around changing temporal or spatial contexts in design. The paper briefly describes the overall context of research project, then provides detailed account of the process of how conversations with and documentation of design practices were conducted, illustrates the kinds of data that were collected and analysed, and provides an overview of how this information will be useful for specification and design of augmented reality tools in the subsequent phase of our research.

2. From Ultimate Display to Tangible AR

'The Ultimate Display' by Sutherland (1965) set out ambitious challenges for development of mixed reality technologies, some of which are already realized whereas others remain to be fulfilled. Over the last few decades, efforts aimed at developing *ultimate display* have resulted in a number interesting prototypes and projects in various domains including architecture. Representative applications of mixed reality technologies directed at architecture and urban design include Feiner et al. (1997), Noble and Keating (2000), Sketchand+ by Seichter (2003), Arthur (Broll et al., 2004), Benchworks (Seichter, 2004), Moloney (2006), and others. Based on the surveys of AR applications in design (e.g., Simpson, 2001; Schnabel et al., 2007), it is also obvious that research in AR applications has become untethered from fixed displays to mobile settings (Piekarski, 2003) and begun to embrace use of multiple interaction devices including tangible objects and other contextual information.

3. Design in Context

To visualise ideas that may not be fully formed or realised, designers have historically used a range of representations for this purpose, from sketches, planar or perspectival projections to scale models and other representations in architectural design. The representational issues faced by designers are, at one level, very similar to issues that arise in AR research. These representations connect real and imaginary worlds of design. If we were to map Milgram's *reality-virtuality continuum* (Milgram and Colquhoun, 1999) on design development, the process from design to construction may appear to traverse from *virtuality* end of the continuum to the other end of material *reality*.

The following discussion briefly reviews selected examples from architecture to illustrate how designers have traditionally dealt with issues of light, working in situ, and serial vision.

3.1 LIGHT

Although light has always been one of the key compositional and experiential elements in architectural design, it was only in the late 17th and 18th century that light was finally understood as a phenomenon within a scientific frame of reference. Perhaps as a reflection of this emergent scientific attitude of the time that we find use of architectural models that were made to understand distribution of light. One exemplary proponent of use of such modes was the British architect Nicholas Hawksmoor. The model for his country house, Easton Neston (1694-1702), enabled study of how light would propagate in interior volumes of the residence. However, it was not until the early 20th century when photography finally made possible recording of light that designers could finally reflect on light as a temporal element in design development.

3.2 FULL SCALE MOCK-UPS

Full size mock-ups in architectural design have been used as props while designing and during construction. When used as part of designing, the full-size mock-ups can hardly be surpassed using any other representations.

Figure 1. Via della Conciliazione, Rome (1938), adjustable full-size mock up.

The development of Via della Conciliazione in Rome (Kirk, 2006) was initiated under the Fascist rule in 1936 and completed in 1950. It was an urban redevelopment project that reconstituted the thoroughfare leading to the St. Peter's basilica in Rome. Given the politically charged and sensitive nature of space, it was crucial that proportions of existing and new structures be calibrated and framed with utmost care. As an aid to design and communication of design intent to the client, in this case Mussolini, various full size models of wood and

canvas were erected in situ. Some were mounted on wheels with viewing boxes at correct heights, and painted with cut-outs for openings. Piancentini, one of the designers of the Via, intended these mock ups to perform similar to a theatre's changing set, a way of designing that also came to be labelled as 'mobile interruption'. As this example shows, augmentation of vision using full-size props in situ has a long history in architecture. Here the real and imagined spaces come together, a case of augmented reality at full scale and design as an adjustable "interruption" at full scale.

3.3. MOVING CAMERA, MOVING TIME

The various representations used by designers over the years have tended to reflect and freeze a moment in time. This is part of the legacy inherited by designers for whom architecture implied 'frozen music', or 'stability' and 'firmness' as virtues to be aspired to in design. The traditional media such as paper further fostered representation of a singular idea. Not unsurprisingly, representation of time and movement do not come to the fore in architectural literature until very recently.

Figure 2. Gordon Cullen: Townscape studies.

In contrast to architecture as 'object' fixed in space and time, and especially as a reaction to problems that erupted around faceless and homogenous social housing of the 60's, sketches of Gordon Cullen (1961) captured a *serial vision*

in motion and celebrated the specific over the general. This 'peripatetic' view of space was not entirely novel, Baudelaire in the late 19th century had already introduced the idea of a *flaneur*, a person who partakes of the city and observes all but ambles on without any specific direction. However, it is with Cullen's sketches that both time and space were finally captured in sequential frames that echoed techniques of filmic sequences of motion pictures using moving cameras and moving visions.

Figure 3. From physical site models to video walkthroughs.

At about the same time, technologisation of serial vision in design inquiries was further developed in the projects of people such as Donald Appleyard and Peter Bosselman who popularised endoscopic analysis of scale models in urban design and planning projects. As Bosselmann notes (1993), the approach revolved around " … *a computer-controlled camera and robotics system similar to those used by cinematographers in Hollywood's special effects industry. We have used stage-set-type model displays made from photographs to realistically simulate eye-level views in motion. Theatrical lighting illuminates the scenes*".

Even before AR research and development gathered momentum, the importance of dynamic context, i.e. changing site and temporal phenomena and their significance for design development were recognized. The selected examples of representations useful precedents for AR research in the form of practices already embedded in professional design cultures.

4. Views from the field

To understand how contemporary practices deal with designing in context (regardless of whether they use digital media) and how it may inform

development of future AR applications, we undertook a focused data gathering exercise.

4.1. ISSUES OF INTEREST

To encourage a structured conversation about dynamic context in design with practices, we articulated the following six themes and leading questions for each to guide conversation about design in general and no explicit reference to augmented reality technologies was made. The methodological approach was to schedule a personal conversation with professional practices, solicit responses to the following issues and obtain examples of projects that illustrate their responses (in the form of sketches, photographs, writings in press, in print or digital form).

Context: How does the practice define context with relation to architectural design? How does the body of work produced in the practice respond to this notion of context? Is there a preferred range of representation techniques used to investigate context?

Time: How do the projects in the practice respond to notion of time? Are responses manifest through specific design elements and/or vocabulary? Is there a preferred range of representation techniques for investigating time?

Critical Junctures: Are there specific stages or junctures in design when design responses to context and time are undertaken in the practice? Why? What precedes and follows these stages in design?

Exceptions: Are there specific projects that required alternate techniques of representations in reference to temporal context in design? Why?

Recurrent themes / typologies: Are there recurring themes or particular attitudes towards architecture that are consistently explored in the work? Are there recurring representational techniques used in the practice? Are they more significant in certain design projects and less so in others? Why?

Constraints and Opportunities: Is the interest in temporal context in design driven by specific requirements of a project, or underlying design philosophy of the office, or other factors? From the practice perspective, are the opportunities to explore issues of temporal context constrained at present due to the nature of information, tools, or representations? Are there alternate representations or tools that might be desirable?

4.2. DATA COLLECTION

To capture views from a broad sample of design practices, we used a matrix of practice types (strong idea, strong delivery and strong service; Coxe et al. 1987) vs size (small <10 employees, medium 10-30 employees, large 30+ employees). An initial list of 32 practices was distributed over this matrix and invited to take part in the data collection phase. Of these, 22 practices responded positively and provided input in the following ways:

- Semi-structured conversation on techniques for analysing and conceptualising 'Temporal Context' in design projects. The conversations were recorded and generally lasted for an hour.
- Additionally, practices were requested to provide examples of projects in which consideration of 'Temporal Context' informed design development in the form of sketches, photographs, drawings or writings, in press, in print or digital form. These materials complement the semi-structured conversation.

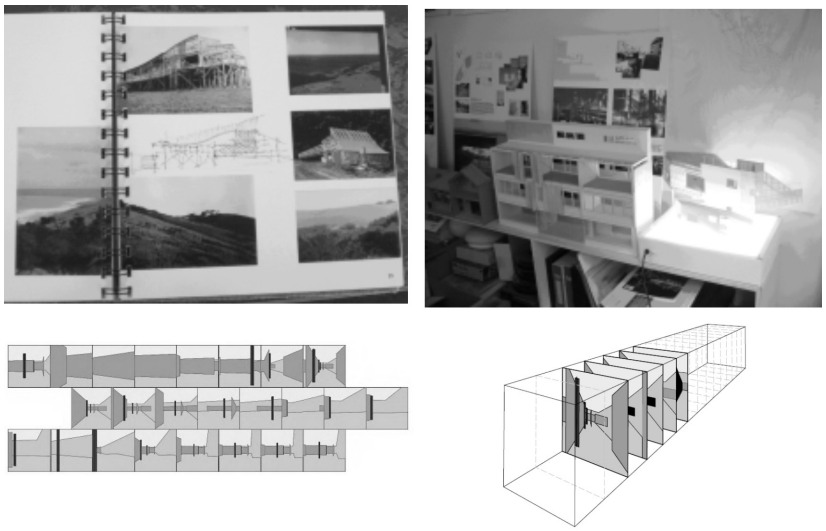

Figure 4. Selected examples of representations collected

4.3. SNIPPETS FROM PRACTICE

The recorded conversations were subsequently transcribed and are currently being analysed and collated with project materials and representations. The following selected quotes are representative of how designers reflect on their design process and what they imagine technology can or should offer.

One of the practitioners employs a scrapbook of sketches, drawings, photographs, etc. which acts as a way to carry site information and design ideas in a portable format. The drawings and sketches become overlaid over time, and "… *site sections we use these a lot, and then view lines etc, stuff that needs to respond to the need to comply with Rescode (i.e. local planning regulations) setback which is a sectional line, so the response is often in section."* These comments highlight the need to selectively project view cones into design space. Further, he also suggest a need for representations at various levels of abstractions: *"When it comes to the representation it is either at really broad scale, or it is a very close physical context that we model and investigate."*

Talking about designing in a dense residential fabric, one designer yearned for an accessible repository of site data so that "… *over time, you ended up with a repository of a suburb, then you could put your building in it and people could see the implications of the proposal on their backyard. Just as a town planning tool, being able to see that it does not overshadow much, and therefore does not pose a huge concern, could be a good thing."*

Another designer talked about need to visualize how building fabric ages over time at variable rates: *"perhaps, there is a way of bringing time into the way town planning is assessed or performance of buildings are assessed. For example, thinking about the need to grow density, you could look at a couple of models about how that might happen …"*.

An interesting issue about representational fidelity and its utility in design was raised by another architect: *"… we try and record the site data as accurately as possible. Which is fine if you are working in a dense inner city context, because the boundaries of what you are dealing with are confined. A different scenario is, with a house which we are doing [… on …] a steep site, with trees everywhere and we tried to replicate the context of the place in the computer, but how do you get all that natural form in there? One of the problems was we got the contours wrong, we were designing to this crazy slope which was actually only half of what was in the model. I got really used to looking at a site with a lush lawn and only couple of sticks, only a few trees, but then after going back to the site I realised that the site was an entirely different place from the 3D. I had got so used to looking at the site in 3D. So, I had to go to the site a few more times to get the real context in my head, and to really push the computer to get a bit more life into it, just to convince ourselves that we were actually designing something for the site and not for this 3D representation."*

Further, he envisaged a different scenario for designing on site and in studio: "*Instead of us going to the site and photographing, measuring, checking sight lines and bringing back the data, building a model of it and checking this against our memory, if there was something like a high resolution Google earth it could be a kind of middle ground ... What will happen more and more is that*

we will just go out to site and probably have these fancy 3D things that we can drop in the middle of a site, and they will just scan the physical conditions and build you virtual model of it for you."

Only a preliminary scan of collected data has been carried out so far but even at this stage early stage in analysis of data, it is obvious that designers foreshadow functionalities that would be desirable in future AR applications. Besides finding ways to shift time and space experiences, we also recognize the need to map and register abstract representations (for example, bottom row of Figure 4) together with data from the real world. A comprehensive analysis of data is underway to correlate key comments of practitioners with specific design representations, which then becomes a basis for specification of prototype AR application development. A preliminary summary of what we hope to incorporate in prototype specification and functionalities follows.

The future AR applications need to support ways to switch between *spatial descriptions* (e.g. geometric information about architectural elements) and *processes* that unfold around/within them (e.g. movement of shadows, wind, etc.) on site. There is also a need to selectively swap in and out *alternate representations*, e.g. seeing structural information instead of geometric description of parts in context. A more challenging goal for AR applications is to support use of dynamic information (e.g. shadow or wind movements on site) as a driver for *supporting interactive design moves* (e.g. moulding volumetric configurations). In other words, future AR research agenda may need to align more with interactive modeling operations instead of being limited only to rendering predefined scene geometries.

5. Augmenting Design Inquiries

Designers routinely exercise judgments about variable context, whether about site or time, and draw upon or invent representations that allow these judgments to be made. As reflected in selected quotes in the preceding section, key issues that emerge from our conversations with practices revolve around ways to investigate and explore design issues on site, often from the eyes of a moving body as a frame of reference, and along real (e.g. seasonal) and historical scale of temporal changes. Also there is a sense of seeing, recognizing, designing, standing back, reflecting, all in one continuous loop as part of designing. Although these are very early and broad observations drawn from current data, they already indicate the direction in which next generation of AR applications will need to develop. In order to support such fluid inquiries and augmentation of design process, AR applications need to integrate and support functionalities that reflect discipline-specific modes of working.

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References

Bosselmann, P. and Gilson, K.: 1993. Visualizing urban form: Endoscopy as a tool in architecture, *Proceedings of the 1st European Architectural Endoscopy Association Conference*, ISBN 951-722-069-3, Tampere, Finland, 25–28 August, 9–30.

Broll, W. Lindt, I. Ohlenburg, J. Wittkämper, M. Yuan, C. Novotny, T. and Fatah gen Schiecky, A. Mottramy, C. and Strothmann, A.: 2004, ARTHUR: a collaborative augmented environment for architectural design and urban planning, *Journal of Virtual Reality and Broadcasting*, **1**(1), 1–10.

Coxe. W. Hartung, N. Hochberg, H. Lewis, B.J. Maister, D. Mattox, R.F. and Piven, P.A.: 1987, *Success strategies for Design Professionals: Superpositioning for Architecture and Engineering Firms*, McGraw-Hill, New York.

Cullen, G.: 1961, *Townscape,* Architectural Press, London.

Feiner, S. MacIntyre, B. Hollerer, T. and Webster, A.:1997, A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment, *Proceedings of the 1st IEEE international Symposium on Wearable Computers,* October 13–14, ISWC, IEEE Computer Society, Washington, DC, 74.

Noble, D. Kensek, K. and Keating, G.: 2000, Stereoscopic imaging in architectural design: A communications experiment, *SIGraDi'2000: Construindo (n)o espacio digital (constructing the digital Space)* [4th SIGRADI Conference Proceedings / ISBN 85-88027-02-X] Rio de Janeiro, Brazil, 25–28 September 2000, 216–216.

Kirk, T.: 2006, Framing St. Peter's: Urban Planning in Fascist Rome, *Art Bulletin* **88**(4), 756–776.

Milgram. P. and Colquhoun, H.: 1999, A taxonomy of real and virtual world display integration, *in* Y Ohta, H Tamura (eds.), *Mixed Reality-Merging Real and Virtual Worlds*, Springer, New York, 5–30.

Moloney, J.: 2006, Augmented reality visualisation of the built environment to support design decision making, *Proceedings of the conference on Information Visualization*, IEEE, London, 687–692.

Piekarski, W. Thomas, B.: 2003, Interactive augmented reality techniques for construction at a distance of 3D geometry, *Immersive Projection Technology / Eurographics Virtual Environments*, Zurich. Switzerland, May 2003.

Schnabel, M. A. Wang, X. Seichter, H., and Kvan, T.: 2007, From virtuality to reality and back, *Proceedings of the 12th International Association of Societies of Design Research (IASDR),* Hong Kong, 12–15.

Seichter, H.: 2003, Augmented reality aided design, *International Journal of Architectural Computing,* **1**(4).

Seichter, H.: 2004, BenchWorks augmented reality urban design, *in* H. S. Lee, J. W. Choi (eds.), *CAADRIA 2004,* Seoul, Korea, 937–946.

Simpson, D. M.: 2001, Virtual reality and urban simulation in planning: A literature review and topical bibliography, *Journal of Planning Literature* **15**, 359–376.

Sutherland, I. E.: 1998, A head-mounted three dimensional display, *Seminal Graphics: Poineering Efforts that Shaped the Field*, ACM Press, New York, 295–302.