Towards an Urban Design Evaluation Framework

Integrating Spatial Analysis Techniques in the Parametric Urban Design Process

Jorge Gil [1], Jose Pinto Duarte [2]
[1] Space Syntax, UK
[2] Faculty of Architecture, Technical University Lisbon
http://www.spacesyntax.com
[1] j.gil@spacesyntax.com, [2] jduarte@fa.utl.pt

Abstract. *The 'City Induction' research project aims to develop an urban design framework at the scale of site planning consisting of three modules: formulation, generation and evaluation. This paper presents the start of the on-going research on the evaluation module with the aim of identifying and discussing the assumptions behind its development.*
The evaluation module will be driven by sustainable urban development principles, which determine the design analysis criteria and benchmarks, and it will be structured around selected urban analysis and design methodologies. We discuss the challenges of bringing these two domains together, and propose to incorporate techniques of interaction and video game design towards a more meaningful and inspirational design experience.
Keywords: *Parametric urban design; sustainable development; public space evaluation; design support tools; interaction design.*

Introduction

The research described in this paper is part of a larger research project called 'City Induction,' which aims to develop a framework for urban design at the scale of site planning. The development of the framework foresees the creation of three modules: formulation, generation and evaluation. At the outset, each of these modules departs from an existing established theory, respectively Alexander's pattern language, (1977) Stiny's shape grammars (1980), and Hillier's space syntax (1984). The ultimate goal is an interactive computer system to support the designer in various stages of the urban design process. This paper is concerned with the evaluation module and it describes the initial stages of the ongoing research, which was targeted at identifying benchmarks and discussing the assumptions behind its development.

In the next section, we present the current sustainable urban development context and the development vision within which the formulation of urban programmes takes place in terms of policy, goals, strategies and tools. In the subsequent section, we

look at urban design methodologies and analytical tools that are appropriate for a strategic and performative urban design approach, both in practice and in education. We then proceed to discuss how the two activities of urban spatial analysis and parametric urban design can be brought closer in a tight loop to be evaluated in tune with the initial development vision. From this point on we will be investigating and developing an evaluation system to be used by designers as an urban design support tool. We conclude with how we envisage the system in terms of interactive information visualisation.

Sustainable urban development

In the current scenario of urban development we witness two extreme phenomena: the population boom in mega cities and the decline of shrinking cities. These two trends cause dramatic tensions of growth and contraction to existing urban fabric, and together with climate change and scarcity of natural resources, set the political agenda on sustainable urban development and urban regeneration. Furthermore, the topic of new towns built from zero is very much on top of the table, not only in the fast growing Asian countries like China or the Arabic peninsula, but also in countries like The Netherlands, with the creation of the International New Town Institute, and the United Kingdom, with the goal of the Eco-Towns programme to build ten new eco-towns by 2020 (TCPA 2007).

Urban design evaluation

When we consider a sustainable urban development approach, rather than a purely investment-oriented one, the stress is on establishing a dialogue among the stakeholders to keep the process as transparent as possible, and with mechanisms to ensure that a strategic development vision is defined, an adequate urban programme is laid out, and a matching outcome is then reached that can be both quantitatively and qualitatively evaluated (The Prince's Foundation 2007).

Current practice suggests the application of evaluation techniques like SWOT (Strengths, Weaknesses, Opportunities, and Threats) (Halla 2007) and PEST (Political, Economic, Social, and Technological) to help define the urban development strategy and set assessment criteria and performance targets. In the UK there are public space quality evaluation methodologies like PERS (Pedestrian Environment Review System) by TRL Software (http://www.trlsoftware.co.uk/: May 2008) or 'Design Quality Analyser' by CABE (http://www.whichplaceswork.org.uk/: May 2008), and in Germany there is an European Urban Index under development by Mediastadt (http://www.urban-index.net/cms/: May 2008). Other evaluation activities like 'Spaceshaper' by CABE (http://www.cabe.org.uk/default.aspx?contentitemid=1675: May 2008) and 'Placecheck' by Rob Cowan for the Urban Design Alliance (http://www.placecheck.info/: May 2008) involve stakeholder workshops. All are used to identify positive and negative aspects and rate existing urban spaces or even whole cities. Alternatively, they can be applied to the outcome of the development process, showing what went wrong and what has been successful.

Nevertheless, none of the above evaluation mechanisms can guarantee the link between development vision and successful outcome as they do not intervene during the design and implementation process. A possible solution to overcome such a flaw is to establish design guidelines like 'By Design' (DETR and CABE 2000) or the 'Urban Design Compendium' (http://www.urbandesigncompendium.com/: May 2008) on which those evaluation methods are based. These guides suggest an adequate design process and establish a list of parameters which need to be considered when defining the urban programme. These guidelines can be a helpful reference but cannot be directly applied to the urban design process.

The Formulation module

The 'City Induction' project proposes an urban design framework that attempts to span between the

Figure 1
The central role of the development vision in the design process and the interdependency of the three stages of formulation, design and analysis.

two goal posts: development vision and successful design outcome.

The formulation module defines an ontology of urban patterns that is shared by all modules to ensure a consistent and iterative evaluation during the design process. In addressing a specific urban context, the user will select a valid set of patterns that fulfils a sustainable development vision and determines the program for the urban intervention. This program sets the performance criteria and target values to be used by the evaluation module. The user then uses the generation module to produce alternative design solutions. The evaluation module provides constant feedback to ensure that the solution being generated matches the program

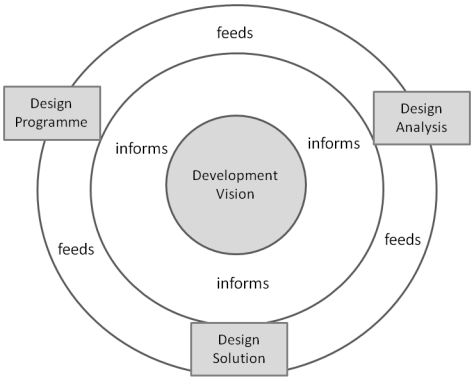
Strategic and Performative Urban Design

The urban design process is a complex endeavour that poses specific challenges to the designer due to the levels of information that need to be assimilated, the necessary involvement of various stakeholders with different perspectives and often conflicting interests, and the time it takes to develop and implement an urban plan.

As such, there is a growing interest among urban planners and architects, and a demand or expectation, from other stakeholders, to incorporate analytical data in the design process in an attempt to guarantee the quality of the outcome at different levels, namely: environmental, structural, infra-structural, visual, social, economic or cultural.

The result is an urban design process with a clear strategy and performance evaluation. The proposed computational framework addresses this form of urban design and consists of the following ingredients (Figure 1):

- Design programme - requirements, values, urban patterns, subjects
- Design solutions - form, space, relations, objects
- Data and design analysis – properties, profiles, impacts, phenomena



At this stage, we aim to investigate how the two fields of analysis and design can co-operate. There is a natural tension between the design and the analytic domains; designers tend to perceive analysis as unnecessary, and analysts tend to face design as the source of trouble. This tension should be minimised to create a more dynamic urban design process. We need to identify design processes that accept more rigorous analytical models, and analytical processes that support flexible design models with the capacity for quick response to change.

Design Analysis in practice

For the purpose of this project, the evaluation module will be looking at spatial analytical methodologies that cover socio-economic, environmental, and mobility aspects of urban plans. Special focus will be given to urban layout and public space because these are the first elements to be determined and the most difficult to adapt a posteriori, having great influence on the future development of the city (Hillier 1996).

We will initially be looking at software like the iVALUL urban layout evaluation tools (Chiaradia et al 2008) and the Ecotect application by Andrew Marsh, which are used in urban design practice, but also approaches like that of the Senseable City Lab at the MIT (Morello and Ratti 2007), environmental analysis

of urban areas (Nikolopoulou 2004), and other urban analysis techniques applied both in professional practice and academic research.

The goal will be to find answers to questions such as which analytical techniques are more meaningful for a designer? What level of expertise is required to understand and manipulate them? Which ones must stay in the hands of experts? To what level can they afford to be simplified to fit the demands of the design process?

Parametric urban design methodologies

It has been shown that such an evidence-based design approach, where an urban designer works closely with a wide range of experts to support his design decisions, can generate more sustainable solutions. But simultaneously, it becomes apparent that the analytical process must intervene earlier in the urban design process and be more tightly integrated in the creative loop.

For that reason, methodologies for flexible or parametric urban design using urban grammars (Beirao and Duarte 2005) or design patterns (Woodbury, Killian, and Aish 2007) seem to be appropriate design methodologies, as they can incorporate the output of analysis into design to enable a semi-automated process. In particular, Generative Components using design patterns has been successfully linked to Ecotect for interactive design analysis. However, as long as the focus is on the performance of the design, even a traditional pen and paper methodology can incorporate evaluation criteria.

What are the characteristics and requirements of a semi-automated urban design methodology? This is something that we need to answer to move to the next stage: the integration of design and analysis for evaluation.

The integrated urban design evaluation framework

The main aim of this framework is to integrate selected analysis methodologies with simplified models into design tools that are suitable for working with urban design methodologies. But what are the difficulties that need to be addressed? So far, we have identified the following:

A common language

An important step in creating this integrated system is the definition of a unified urban planning ontology suitable for both analysis and design, which will facilitate the sharing of knowledge between models and tools. This should eliminate the existing monologues based on each side's rhetoric and jargon, which create barriers to mutual understanding among practitioners and software alike.

CAD Tools ≠ Urban Design tools

There are many tools for architectural design and drafting, e.g. AutoCAD, Microstation, Rhino or Sketchup, or new tools to support the parametric design process, e.g. BIM in general or Generative Components, but none exist that specifically supports parametric urban design processes in the generation of alternative solutions. The components, parameters, and scale of urban design are very different.

In particular, the intangible nature of public space and urban layout must be explicitly incorporated into urban design tools to facilitate the interaction between designed and non-built space.

Analysis Tools ≠ Urban Design tools

GIS platforms can perform display and analysis of large scale urban developments and be essential aids to the management of the data required for the urban design process. However, GIS tools designed specifically for urban analysis (Gil 2007) are not simple or flexible enough to integrate directly into the design process. Namely, their graphic and visual output is limited in comparison to their quantitative output, and they require expert knowledge, statistical analysis and information visualisation skills to derive useful information from their output.

Existing Tools

The field of integration between CAD and GIS needs to be investigated, from the simple capability of manipulating geo-referenced data within traditional CAD, e.g. AutoCAD Map 3D and Civil 3D, to tools that incorporate levels of analysis and provide interfaces similar to those of CAD systems.

CityCAD (http://www.holisticcity.co.uk/: May 2008) is a new tool under development that addresses this difference, but it can only be used after strategic decisions (main routes, areas, and layout) have been made and drawn via a traditional pen and paper process, although it produces summary values for external analysis and evaluation. Hence, it's a tool that partially addresses the design and the analysis components.

CityZoom (http://www.cityzoom.net/: May 2008) is a decision support system for urban planning that uses rule-based design methodologies incorporated with design layout analysis and a GIS platform in the back end (Grazziotin and Turkienicz 2004). The stress is, nevertheless, on decision and analysis rather than on the intuitiveness and flexibility of design tools.

Design Models ≠ Analytical models

Besides functionality and interface differences between design and analysis tools, an important distinction is in the elements that they manipulate.

Design models can be complex with detailed geometry, rich descriptive representation conventions, and based on generic geometric elements that are independent and non-hierarchical. Most of the time these models are flexible to changes by the designer.

Analytical models are usually simple in terms of geometry, abstract in what they represent, with a set of domain specific elements and sticking to very specific formats. Most of the time they are based on interrelated information and generated by complex processes that make them inflexible to change without having to start all over again.

Parametric design models share characteristics with analytical models, so this evaluation framework is naturally suited to parametric design methodologies. It needs to specify a new set of components and parameters specific to urban design and accommodate the large number of components required for urban simulation (Wu 2002).

Analysis ≠ Evaluation

Finally, designers need to understand that analytical results are simply numbers that only acquire a value when placed within the whole evaluation framework together with a solution and a program. The same analytical results can have positive or negative interpretations depending on their context. This evaluation framework has to present the value rather than just a series of numbers or maps with a scale.

Evaluation requires an interpretation of the analytical results as it tests them against regulations, development targets, and quality and sustainability benchmarks. This needs both a quantitative and a qualitative output. The first to feed generative design methodologies and to produce technical reports, the second to provide visual feedback for traditional design methodologies and to support presentations of the design.

Visualisation and interaction models

The last stage of our research will address the relation between the designer and the evaluation framework's output. The evaluation system should be equipped with a graphical user interface to provide dynamic visualisations of complex urban phenomena to sustain meaningful stimulation of the creative process. How does evaluation provide feedback? How does the designer intervene in the process and respond to this feedback? These are some of the questions that need to be addressed at this stage.

Design is traditionally a top down process, controlled from a single source and based on individual authorship. To accommodate the complexities of urban design and achieve more sustainable solutions, we need to allow external influences to emerge in a

bottom up fashion into the design process. But the designer still needs to play a central role and be able to accommodate these external forces through an intellectual understanding of the subject matter and direct manipulation of the object matter, towards indirect generation of successful and sustainable urban environments (Figure 2).

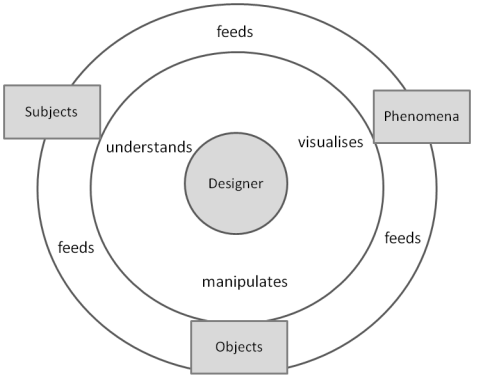


Figure 2
Diagram representing the interactions between the designer and the three stages of the design process

Previous work demonstrated the importance of such 'tools for thinking' in the context of urban planning (deVries et al 2005, Becket et al 2005, Penn et al 1995, Attfiled et al 2005). With this in mind, relevant visualisation techniques and interaction models will be investigated in the fields of interaction design, data visualisation, and video game design.

Meaningful and operational abstractions

Urban design analysis results can be quite complex with large amounts of data that is difficult to interpret, in the first place, and translate into design decisions, in the second place. Evaluation results provide summary diagrams of specific analytic parameters that usually take the form of charts, tables and maps.

The diagrams, despite being simplified abstractions of real phenomena, must be meaningful to the urban designer so that s/he immediately knows how to incorporate this information into the design process, rather than leaving it as an interesting side note to demonstrate that the specific aspect was looked into.

In this sense, the diagrams are operational, i.e. immediately usable in the design process without expert intervention for further technical manipulation or statistical analysis.

Understanding through interaction

To achieve the above requirements there is a need to facilitate understanding of the phenomena being evaluated. Complex phenomena with feedback loops and interdependencies are best understood by playing them, seeing the phenomena unfold and respond to user intervention. This aspect of play and learning is important in urban design education but also in practice.

What can popular simulation and strategy video games contribute to the interaction model of strategic and performative urban design?

Popular games like the SimCity series have a focus on entertainment, but they also encode urban models that become understood through play thereby enabling the user to win. Recently, these games have moved from essentially economic management to urban quality-oriented targets, as in the cases of SimCity Societies and City Life.

What models of embedded learning do serious games provide in particular? Urban Science: an epistemic Game (http://epistemicgames.org/eg/?cat=14: May 2008) is a role playing game for civic thinking targeted at school children that has successfully helped to convey the problem-solving nature of urban planning and the importance considering the various stakeholders.

Conclusion

In a scenario where urban development is facing a need to become more sustainable there is a move to involve every stakeholder of the development process in its evaluation. But for implementing a particular development vision, the fields of spatial analysis

using GIS and urban design using CAD do not have an adequate framework to support strategic and performative urban design.

This is the nature of the challenge: the development of an urban design evaluation framework that integrates the technicalities of spatial urban analysis, the complexities of urban simulation, and the specificities of urban design to provide the designer with the creative means to explore quality urban design solutions.

In addressing the issues raised by this integration through the selection of appropriate visualisation and interaction models from the fields of interaction design and video games, we aim to develop an integrated evaluation system. Evaluation wraps the semi-automated loop between formulation, design and analysis, thereby providing feedback to the designer on the quality of the design solutions in relation to the original goals set by the sustainable development vision.

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References

Alexander, C., Ishikawa, S. and Silvestrin, M.: 1977, A Pattern Language: Towns, Buildings, Construction, Oxford University Press, New York.

Attfield, S., Blandford, A., Mottram, C., Penn, A. and Fatah Gen, A.: 2005, Exploring the effects of introducing real-time simulation on collaborative urban design in augmented reality, in International Workshop on Understanding Designers '05, 17-18 October 2005, University of Provence, Aix-en-Provence, France.

Beckett, K. and Shaffer, D. W.: 2005, Augmented by reality: The Pedagogical Praxis of Urban Planning as a pathway to ecological thinking, in Journal of Educational Computing Research, 33(1), pp. 31-52.

Beirão, J. N. and Duarte, J. P.: 2005, Urban grammars: Towards flexible urban design, in J. P. Duarte, G. Ducla-Soares and A. Z. Sampaio (eds.), Digital Design: The Quest for New Paradigms, Proceedings of eCAADe, Lisbon, pp. 491-500.

Chiaradia, A., Schwander, C., Gil, J., Friedrich, E. and Gosset, A.: 2008, Mapping the intangible value of urban layout (i-VALUL): Developing a tool kit for the socio-economic valuation of urban areas, for designers and decision makers, in H. Timmermans and B. de Vries (eds.) 9th International Conference on Design & Decision Support Systems in Architecture and Urban Planning, Eindhoven University of Technology.

Department of the Environment, Transport and the Regions (DETR), Commission for Architecture and the Built Environment (CABE): 2000, By Design - Urban design in the planning system: towards better practice, UK.

Gil, J., Stutz, C. and Chiaradia, A.: 2007, Confeego: Tool set for spatial configuration studies, in A. Turner (ed.), New Developments in Space Syntax Software, Istanbul Technical University, pp. 15-22.

Grazziotin, P., Turkienicz, B. and Sclovsky, L.: 2004, Cityzoom: A Tool for the visualization of the impact of urban regulations, SIGRADI 2004.

Halla, F.: 2007, A SWOT analysis of strategic urban development planning: The case of Dar es Salaam city in Tanzania, in Habitat International, (31), pp. 130-142.

Hillier, B. and Hanson, J.: 1984, The Social Logic of Space, Cambridge University Press.

Hillier, B.: 1996, Space is the machine - a configurational theory of architecture, Cambridge University Press, UK.

Nikolopoulou, M. (ed.): 2004, Designing open spaces in the urban environment: a bioclimatic approach, Centre of Renewable Energy Resources, Greece.

Penn, A., Conroy Dalton, R., Dalton, N., Dekker, L., Mottram, C. and Turner, A.: 1995, Intelligent Architecture: User Interface Design to Elicit Knowledge Models, in Applications and Innovations in Expert Systems III. SGES Publications, Oxford, pp. 335-348

Morello, E. and Ratti, C.: 2007, Raster Cities: Image Processing Techniques for Environmental Urban

Analysis, in S. Porta, K. Thwaites, O. Romice (eds.), Urban sustainability through environmental design, Taylor and Francis.

Stiny, G.: 1980, Introduction to shape and shape grammars, Environment and Planning B: Planning and Design, 7, 343-351.

The Prince's Foundation for the Built Environment: 2007, Valuing Sustainable Urbanism: A Report Measuring & Valuing New Approaches to Residentially Led Mixed Use Growth, The Prince's Foundation, London, UK.

Town and Country Planning Association (TCPA) and Lock, D.: 2007, Eco-towns: scoping report, helping to deliver a step change in the quality and availability of homes for the people of England, TCPA, UK.

deVries, B., Tabak, V. and Achten, H.: 2005, Interactive urban design using integrated planning requirements control, Automation in Construction, (14), pp. 207–213.

Woodbury, R., Killian, A. and Aish, R.: 2007, Some Patterns for Parametric Modeling, in Expanding Bodies: Art, Cities, Environment, Proceedings of the 27th Annual Conference of the Association for Computer Aided Design in Architecture, Dalhousie University School of Architecture and NSCAD University, pp. 222-229.

Wu, F.: 2002, Complexity and Urban Simulation: Towards a Computational Laboratory, in Geography Research Forum (22), pp. 22-40.