A Conceptual Framework for the Formulation of Stakeholder Requirements

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Abstract. We need to face challenging needs for the planning of sustainable future cities. New methods in urban simulation enhance significantly the early urban design phase. However, these promising methods will only be sustainable if they consider stakeholder participation from the very beginning. Therefore we propose a conceptual framework for the formulation of stakeholder requirements, which enables the iterative modification of an urban model inside participatory workshops. A special emphasis concentrates on environmental, social and economical factors. The requirements posed by the stakeholders are instantly transferred into urban design patterns. Each single pattern stands for a solution for a specific problem that is integrated and visualized in a procedural model. Our goal is to create a participatory process that takes advantages by the use of comprehensive urban design patterns. The results are integrated within an interactive procedural model that communicate the most important guidelines for the planning of sustainable future cities.

Keywords. Decision-making process; stakeholder participation; shape grammars; urban patterns; urban planning.

Introduction

“Master planning has been subject to major critique, and in some parts of the world it has been replaced by processes and plans that are more participatory, flexible, strategic and action oriented” (UN-Habitat, 2009). As many modern cities have shown, their urban structure has not been very successful coping with rapid environmental, social and economical changes. Here is where the issue of sustainable urbanization becomes crucial. The goal of such a planning process should be to raise the urban quality. The new city has to be enabled to adapt and to integrate urban, environmental, social and economical impacts more efficiently and more openly for its inhabitants.

Sustainable urban planning of cities involves many other aspects besides urban structure. According to UN-Habitat (2009), such planning approaches have to be strategic rather than comprehensive. They should be flexible rather than end-state oriented and fixed, unlike present master planning. Another important element of a sustainable urban planning is the concentration on action definition and implementation control by linking budgets, projects along with citywide and, or regional infrastructure. These
planning initiatives are stakeholder or community driven instead of only expert driven, though they are occasionally linked to political terms of the office.

One of the strongest characteristics of sustainable urban planning is the participation of stakeholders with their different forms, meanings and purposes (White, 1996; Cornwall, 2008). The quality of a plan can be greatly enhanced and set up towards effectiveness through the contribution of insights, intelligence and perspectives that are usually not considered within the formal plan making process. Stakeholders are an incredible helpful stock when it comes to the evaluation of the effectiveness of a plan, and to weight successive plans by evaluating a plan’s performance. In this context it is important to encourage the use of collaborative and participatory approaches for urban plan making and evaluation. Now the interesting question in terms of research is: How can those participatory processes be linked with new methods for the simulation of sustainable future cities?

Related work

This paper focuses on the participatory modeling of urban environments using procedural techniques. Currently, the first attempts for procedural modeling of architecture and cities have been published. Shape grammars have been implemented in the past for the analysis of several examples in architecture, such as the Palladian Villas (Stiny and Mitchell, 1978), Frank Lloyd Wright’s prairie houses (Koning and Eizenberg, 1981), and Alvaro Siza’s houses at Malagueira (Duarte, 2001). The technical characteristics are directly derived from an attributed shape grammar called CGA Shape, which is suited for applications in computer graphics. It was introduced by Müller et al. (2006) and is now commercially available as CityEngine (Procedural Inc., 2010). It had been extended by Ulmer et al. (2007) and Halatsch et al. (2008b) with urban planning rule sets and landscape patterns. Integrating shape grammars into the urban planning process offers unprecedented opportunities to understand and encode urban patterns (Alexander et al., 1977), generate and visually assess various urban design variations, and can thus achieve more sustainable urban designs (Halatsch et al., 2008a). Beirão et al. (2008) introduced a shape grammar based support tool for urban design. It is a composition of an urban pattern formulation model, a design generation model, and an evaluation model.

However, these methods – in terms of urban planning – are still in their infancy. No solutions are available for the complexity of urban environments and their participatory design cycles (e.g. for the definition of master plans). Even more important, there is a lack of integrating interactive 3D urban models with urban design cycles (Jacobi et al., 2009). Resulting from the facts mentioned above there is a need for an overall simplification of this modeling process and integration of participatory methods into the modeling process (Wissen et al., 2008).

Stakeholder participation is a must-criteria for the decision-making process in sustainable urban planning (UN-Habitat, 2009). Participation of stakeholders requires different forms of interactions (Arnstein, 1969; Pretty, 1995; White, 1996; Cornwall, 2008). Comprehensive participatory urban development should be based on a broad, common understanding of aesthetical, emotional, ecological, and economical qualities of the urban pattern.

One conceptual problem of participatory urban development is the separation into different scales, e.g. regional or local scale. Jacobson and Storey (2004) link Nepal’s population program with ideas of Habermas to implement participatory practices. Similar to the “communicative action” of Habermas (1985), the stakeholder participation has to be open, undistorted, and non-manipulative on matters of public importance. The conventional top-down distribution of information by institutional actors may result in a systematic manipulation of information, which Habermas calls “concealed strategic action”.

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Overview

In this article we show on an exemplary base the application of our approach (a) to gather stakeholder requirements and (b) to incorporate the resulting information in form of urban design patterns into (c) a procedural multi-dimensional procedural model of the eco-city “Swiss Village Abu Dhabi” (SVA) inside Masdar City (SVA, 2009).

We use the participatory method ‘architectural programming’ for the gathering of the specific requirements of the different stakeholders. Through this technique information about a design project is gathered in form of figurative expressions and standardized interview processes. It had been initially introduced in the late seventies by Peña (1977). Robinson and Weeks (1983) integrated architectural programming inside design phases and Henn (1994) is using this method as a quality control instrument for daily use in architectural offices. We started with a stakeholder-monitoring phase in early planning briefings that have been structured following sustainability impacts properties described by Bossel (1999) and Xing et al. (2009).

Stakeholder feedbacks and resulting requirements are formulated into urban patterns according to “A Pattern Language” by Alexander et al. (1977) and transformed into urban design rules. For the evaluation and visualization a procedural model was implemented which represents a collection of urban patterns for the proposed solution.

Formulating stakeholder requirements into urban patterns for the procedural modeling of sustainable future cities

The process is described as follows: First, the steering criteria are defined for the requirement definition process. Second, the requirement definition process is collaboratively realized where urban patterns are defined. Following a procedural model is set up, which is driven by urban patterns. Based on that model a participatory design review is performed that may effect the initial definition in the form of an iterative change cycle.

Integration of sustainability impacts in the earlier design phase

It is important to integrate environmental, social and economical requirements into the procedural model. Due to the participatory process sustainable urban patterns will be determined by the stakeholders.

Bossel (1999) had initially presented the definition of a system for sustainable development. Xing et al. (2009) pose methods for assessing urban sustainability impacts, which are important for the modeling of the environmental, social and economic costs and benefits especially when a life cycle model of an urban environment has to be created. Both presented approaches are used to set up the initial interview structure for the architectural programming briefing.

Participatory method: ‘architectural programming’

During the requirement definition process an architectural programming matrix is composed. Each requirement is expressed through a fact pattern – for the analysis – or through a design concept pattern for a proposed reaction on the existing conditions that had been discovered during the briefing and identified as a threat. The briefing team moderates the process and pre-defines urban planning requirements (e.g. geographic orientation, definition of land and space use). The resulting matrix is then evaluated by the stakeholders and visible to all participants, which gives room for individual discussions. An iterative enhancement of the alternative urban patterns can take place as well. By the stakeholders’ weighting of the functions the architectural programming matrix is interactively modified. The results are then incorporated into a pre-defined procedural urban model.

Procedural modeling incorporating design rules

Alexander et al. (1977) described the paradigm of
establishing design patterns that can be applied to urban design. Each pattern describes a particular environmental problem and a general solution to that problem. The inherited relation between patterns can be expressed and implemented with the help of shape grammars (Stiny and Mitchell, 1980). These patterns can be used to set up 3D city models, which is subject to communicate decisions to the stakeholders.

**Case study Swiss Village Abu Dhabi, Masdar City**

**Structure of the predefined architectural programming matrix**

The main idea of the architectural programming matrix is strongly originated in the isolation of the most challenging planning problems during the very early design phase. The global goal for the SVA is to create a CO2 neutral urban settlement under extreme climate conditions that is additionally able to operate as a technology hub and technology implementation test bed for itself. Therefore a preliminary preparation of the monitoring process has been necessary. Since several foci on planning problems existed the monitoring process was divided into two workshops. The topical structures of the pre-prepared architectural programming matrixes have the following structure (Table 1).

**Architectural programming workshop**

The idea behind an architectural programming workshop (Figure 1) is to let stakeholders detect a holistic view on the planning scenario and to incorporate personal and technical views from each field of knowledge. Moderators used the structure presented in section 5.1 to steer the monitoring process. The gathered opinions had been collaboratively rated and weighted in their particular importance by the stakeholders. Furthermore, these opinions have been translated into figurative expressions – so called programming cards. Each cardboard describes one particular aspect represented by a simplified sketch or diagram, which is accompanied by textual and numerical attributes. The results are (a) single cards representing a detection of a planning problem (fact) or a definition of a potential solution (concept) and (b) a structured card matrix – architectural programming matrix – that represents the overall planning task definitions in a weighted and jointly agreed representation.

**Resulting architectural programming matrix**

The architectural programming matrixes (Figure 2) are used to create a holistic and weighted overview on the collaborative planning aspect definition.

<table>
<thead>
<tr>
<th>Work-shop</th>
<th>Impact</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1</td>
<td>Transportation and distribution&lt;br&gt;Supply system&lt;br&gt;energy, water, food, goods, services&lt;br&gt;Waste disposal&lt;br&gt;Natural environment</td>
<td>42 students of architecture, 20 students of environmental science, 2 assistants, 2 moderators, 1 expert of SVA</td>
</tr>
<tr>
<td>B.1</td>
<td>Masdar guidelines&lt;br&gt;passive design strategies (shadings, water consumption, air ventilation), fire safety, volume fabrics, street network, green environment</td>
<td>18 students of architecture, 2 assistants, 1 moderator, 1 expert of SVA</td>
</tr>
<tr>
<td>B.2</td>
<td>Clean tech guidelines&lt;br&gt;cluster effect, interdisciplinary / energy, from innovation to market, clean tech</td>
<td>18 students of architecture, 1 expert in the field of clean tech</td>
</tr>
<tr>
<td>B.3</td>
<td>Building guidelines&lt;br&gt;adaptivity/flexibility of buildings, address access, floor height/plan depth, structure, infrastructure</td>
<td>18 students of architecture, 1 expert in architecture</td>
</tr>
</tbody>
</table>

*Table 1 Pre-defined structure of the architectural programming matrixes*
for all stakeholders. A single matrix itself is divided into two arrays: a sub-array that contains only fact programming cards and a sub-array that contains concept-programming cards. The cards are layout in columns that respect the topological structure that initially defined in 5.1. The order of each card inside a distinct array is conjointly agreed by the workshop participants and is subject to modification during the workshop. It is possible that previously accepted cards may be later deleted from the matrix. Additionally, the matrix is also a progress indicator during the workshop for the participatory decision making process.

**Defining design rules concerning sustainability impacts**
The architectural programming matrix is finally used to define sustainable design rules. In our particular case of the SVA design rules have been derived to achieve from the matrix performance criteria and measures for energy efficient settlements as well as for urban qualities such as pedestrian climate...

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*Figure 1:* Architectural programming workshop with 60 students from architecture and environmental sciences.

*Figure 2:* Architectural programming matrix, which was composed straightly in the workshop.
comfort. The results are translated into visual models (Figure 3) as well as into concrete task definition in the form of a binding planning decree. As a guideline the system approach by Bossel (1999) has been used to validate the selected sustainability criteria.

**Defining urban patterns**

Each sustainability criterion has been translated into a measure. Whereas a measure may reflect a regional definition of required values – such as targeted air ventilation or heat distribution. Alternatively, a measure may result in a parametric definition of a geometric configuration that provides a particular performance – such as the shading of a façade – and ecological, economical and social impact. In the case of the example provide shading for a façade, a possible solution may be to introduce shading elements on the façade or – which might be more ecological efficient – to establish an ecological shading service that is provided by selection of regional and economical efficient plants. These definitions – at one hand based on statistics; at the other hand...
Implementing urban patterns into a procedural model

A procedural urban model offers several advantages if compared to 3D analog models or digital urban model representations. The initial costs for mid-scale models are quite similar (up to 20’000 inhabitants). For large-scale models procedural modeling techniques offer an unprecedented level of detail management and very fast modeling. Second to that, a procedural model can be iteratively changed (Figure 6) – independently from how large the areas of editing are. With traditional models a change request will result in immense labor force. The procedural model can be set up that for each need a necessary level of detail is provided. Design measures can be communicated to participants already during the workshop. Jointly identified problems can be changed immediately and iterated. Furthermore, a freezed model geometry can be evaluated in simulation software packages (Figure 7), e.g., to detect urban heat islands, or given to a model maker for a public communication. Despite the geometric appearance of a procedural model it can be used to report the fulfillment of key attributes and even to evaluate more intellectual goals such as architectural aesthetics.

In our context the procedural model is set up with the idea of urban patterns. Whereas each urban pattern describes a particular sustainability criteria, which was previously defined during the workshops. This data is used to create several urban scenarios. The participants see a direct visualization of their planning interventions along with associated numbers such as GFAs and resulting CO2 emission.

Conclusion and future work

The present work describes a conceptual framework for the formulation of stakeholder requirements into urban patterns for the procedural modeling of sustainable future cities. In more detail the work presents a collaborative platform, which allows the iterative modification of an urban model inside participatory workshops and through this the development of sustainable urban patterns while incorporating the concerns of the stakeholders. The discovery of best-fit scenarios that are expressed in the form of urban design patterns. They only will empower the design process if the multi-disciplinary views of stakeholders are included. They determine key variables that amplify the identity of the city and guarantee the sustainability of the dynamic urban system.
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