Decision Support in Architectural Strategic Planning

Towards a Volumetric Modeling of Solution Strategies in Investment Planning

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The goal of this paper is to present the conceptual scheme of a research project focused on digital support of strategic planning in the architectural context. Firstly, the paper describes briefly the architectural design process in its strategic planning phase, focusing on problems that investors and planners need to handle. Next, commercial applications and current relevant academic projects are presented, showing different approaches to the use of digital technologies in strategic planning decision support. Subsequently, a thesis is introduced that if access to reliable data is ensured and modern digital technologies like case-based reasoning and evolutionary algorithms are used, it will be possible to generate, optimize and evaluate development solutions in early phases of architectural design process, providing a reliable decision support tool for architects and investors.

Keywords: Strategic planning; optimization; decision support; cost estimation.

Introduction

In Switzerland, the tasks and responsibilities of the architect during the planning process are clearly defined and described in the “Service Model”, one of the regulations of the Swiss Society of Engineers and Architects (SIA 2001). The goals of the first phase called “Strategic Planning” are to define needs, goals and general conditions of architectural solution, and to determine strategy for this solution. This paper will focus on how these tasks could be supported by modern digital technologies. Because the project is carried out in Switzerland, initially the development will remain Swiss-specific (data sources, typical building characteristics etc.), but the conclusions and tools could be later used in a more general context, too.

Strategic planning in architecture – current process and its risks

“A few of the major components for which costs and quality can be differentiated include physical design, functionality in interior layout, density of the site and its adequacy of access and egress from transportation, amenities (…), landscaping, parking and circulation on the site, common areas, elevators, quality
of heat, ventilation and air-conditioning (HVAC), and exterior finish (…). Because of uncertainty about how the quantity and quality of services provided as a part of the development should be combined or “packaged” to meet demand, each of these elements presents a potential source of project risk (Brueggerman 2005).

There are a few architecture related reasons why decision-making in strategic planning is difficult and inherently risky. First and foremost, the inaccuracy of costs estimates could cause problems for the investor. In Switzerland, strategic planning is usually expected to be estimated with the accuracy of +/- 20%.

Such rough estimates are not a reliable base for decision-making.

Another problem during strategic planning is the organization of the planning process itself. Architects prepare solution strategies including proposals relating to the form and program for a given site. The estimate of costs and profitability of various scenarios is then handled by investment experts, because architects usually do not have access to appropriate data and/or they do not have comprehensive knowledge in this field of analysis. However, even for investment experts it is not possible to quickly verify if architects found the most profitable and most

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**Table 1: Service Model SIA 112**

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<th>Invitation to bid</th>
<th>Implementation</th>
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<th>Data visualisation and analysis (input &amp; output)</th>
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economic solutions. Any optimization based on the feedback and estimations of investment experts’ is translated back into the architectural solutions, which then have to be recalculated, etc. This process is highly time-consuming and still does not guarantee that the best solutions are found. Therefore investors expect a great variety of well-documented proposals, so that they have a wider choice and better chance of finding good solutions.

Yet another problem is that architects and investors usually do not have an easy access to reliable data sources about building costs, statistical data and economic conditions. Moreover, such data are generally difficult to obtain and gather, mostly because of high competitiveness of the building industry.

All in all, if our aim is to create a reliable decision-support tool for strategic planning, we should build a tool that, basing on reliable data, will generate and optimize strategic solutions and calculate its costs with high accuracy.

Digital decision support during strategic planning in development process – current situation

Commercial software

Fig. 1 presents some features of the most popular software used in Switzerland during the designing and building process for cost calculation and preparation of building documentation (CAD excluded, examples from Switzerland and Germany).

None of the applications support the generation of new solutions (which could be useful during the Strategic Planning phase) or optimization of a given design (which could be extremely helpful during the Project, Invitation to bid and Management phases). Usually a user has to enter numeric data about the project to typical tables (fig. 2), with the exception of some FM software, supporting 2D plans. There is no 3D analysis combined with costs calculation provided for any phase of the designing process.

Related research

While commercial solutions for strategic planning in architecture focus mostly on the support of costs calculation for given scenarios, some academic centers have been carrying out research on digital generation and optimization of new scenarios. What these projects focus on varies in the size of analyzed area, initial aim of research, basis analysis criteria and digital technology used, but mostly does not concern the financial aspect of the investment process. Several projects will be briefly presented below.

Future investments can be generated as part of an urban fabric (here the solutions are usually schematic) or in a more isolated context (with more detailed results). Different factors can be a base for such generation, for example daylight estimation, urban regulations, density, location preferences of future residents (see Grazziotin 2004, Raposo 2001, www.kaisersrot.com), natural characteristics of the site and existing neighboring buildings (Celani 2005) or low-energy analysis (Caldas 2003). Solutions generated in these projects are said “to allow dwellers and planners to refocus their attention on the decision making rather than on the tedious task of satisfying normative constrains” (like in Donath 2006).

There are several digital technologies that seem to produce promising results in supporting designers in early phases of the development process. Numerous experiments with evolutionary algorithms (EA) are carried out (for example, genetic algorithms used together with Pareto multicriteria optimization techniques in Caldas 2003). Case-based reasoning
(CBR, Maher 1997) and situated CBR (Liew 2004) is used to generate new solutions for architectural problems, too. These two technologies, i.e. EA and CBR, can actually be combined (like in Gomez 2001, model for a residential floor plan layout) and we consider such combination to be the most promising in relation to our project.

As was mentioned above, the main focus of investors by strategic planning is the financial aspect of the future investment. Unfortunately, the optimization of investment costs and incomes already during strategic planning has not stimulated a great interest among architecture researchers, even if it is critical for the investor. Instead, financial managers try to optimize the return on investments in their research, without taking the architectural aspects into consideration, even if they are related (see for example genetic algorithms in economic context in Pacheco, 2000).

**Presentation of the research idea**

The aim of our research (scheduled for the next 3 years) is to create a digital tool that will provide investors and architects with more accurate costs estimations already during the strategic planning phase of the development process. Moreover, schemas for architectural scenarios will be generated and optimized by a digital engine, using high quality statistic data.

We will try to combine the two different approaches for the analysis of the building site: that of architects (volumetric analysis of possible investment) and that of cost estimation experts (calculations based on reliable, statistic data) into one complex decision support system.

**Data**

As was mentioned above, one of the crucial aspects of successful strategic planning is access to reliable and detailed data. In Switzerland, some commercial and government organizations independently gather information about the building process, its costs and other related statistical data. However, there is an initiative from the Swiss Research Centre for Building Rationalization (CRB) to try to collect all these data into one extended databank available online. Not only general information about real cases (built objects) will be provided, but also collections of building elements with their average prices and maintenance costs will be put at planners' disposal, maintained by CRB, but updated and extended also by users themselves, thanks to the functions such as adding new elements or analyzing the popularity of existing ones. Such “alive” databank will be a perfect basis for a tool that will generate and optimize solutions during strategic planning, because in order to achieve reliable costs estimation already from the very beginning of planning process, building proposals should be digitally composed of real building components, with real prices and accurately estimated masses. That method corresponds to the one carried out in later phases of the design process (Project, Invitation to Bid phases of SIA 2001), when quantities of respective building components are already defined.

**Case-based reasoning and evolutionary algorithms**

As was mentioned before, the following two technologies seem to be the most promising as far as generation and optimization of strategic planning solution is concerned: case-based reasoning (CRB) and evolutionary algorithms (EA).

CBR is the process of solving new problems based on the solutions of similar past problems. The problem in architectural strategic planning can be formulated as follows:

“For a given building side, some initial investor expectations and urban regulations, what kind of building could be constructed and how much it will cost?”

The simplified process of looking for the solution to this problem can be divided into three steps:

1. Analysis of the building site, based on geometrical information, GIS databases and urban
The first step does not seem to be a challenge for a machine – projects focusing on generation of building bulk have been already carried out (for example, Donath 2006). Our aim is that the volumetric analysis in our project is be fully customizable – it should be possible to generate volumetric solutions for every site in every country, within any possible legal restrictions. To achieve such flexibility, we need to design an easy system for inputting the geometry data. Moreover, the geometry analysis of the building plot should be integrated with modern GIS (geographic information system) tools and databases. Additionally, not only do we need to provide the user with some predefined sets of building regulations, but we also make it possible to add new rules, regulations and restrictions easily.

During the second step we plan to use the case-based reasoning technology. It will provide plausible solutions, by adapting relevant “cases” – descriptions...
of already constructed buildings (fig. 3) – to the new environment and expectations.

Extended use of evolutionary algorithms is planned to be implemented in the third step. The building technology description of an investment will be considered as its “genotype” (fig. 4) and then can be handled and optimized with the use of evolutionary algorithms techniques.

**GENERATED CASE**

floor to area ratio (FAR)
parking spaces
land-to-value ratio
bulk
site plans

Building technology genotype level 1:
for example:
superstructure: reinforced concrete
facade: brickwork
roof structure: flat roof, reinforced concrete
service complexity: medium
fit out (interiors): brickwork

Building technology genotype level 2:
elements (like for example concrete pillar \( r = 25 \text{cm} \), with all labour and materials costs)
amount based on volumetric estimation

By comparing real case studies with generated and optimized ones, we aim to fine-tune this process so that outcomes closely represent real life scenarios. It should be possible to enter every stage of the process – for example optimization of not only generated, but also traditionally designed solution should be possible. Moreover, the project should make a contribution to contemporary efforts of building...
industry to use universal, common accepted model that will serve all participants of the building process (www.iai-international.org).

Fig. 5 shows an example of real case comparison of cases compared with possible description of design solution, fig. 6 – volumetric representation of the solution. The output of the generation/optimization process should be a volumetric proposal of a building – a bulk, with functions disposed (arranged) on floors (but not necessary with specific
layout proposal), summary of technologies used (construction, façade, roof, interior, installations, in next phases of research – also building elements as “building genotype”), costs and incomes calculated for a given time span. This proposal should be reliable enough to serve as a base for further architectural planning and if its main characteristic is kept, its costs should remain within the limits estimated during digital generation.

**Conclusions**

There seem to be no technical problems hindering the implementation of the concepts presented in this paper. In fact, all the technologies needed are already well established in both in and outside the academia. The novelty value of our approach lies in an attempt to unify these technologies into one complex solution with the use of high-quality statistical data.

The outcome of this project will not be “one-click” magic tool, replacing architects in the investment development process – it will be a support to them as well as for investors, saving their time and assuring more financial security in planning.

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