CONTENT

Introduction

In most situations of our lives, we do not need somebody to guide us. We already have the knowledge to know what is right and what is wrong. All what we need is just to stop and think thoroughly of our needs and potentials on one hand; and our values and backgrounds on the other. In that case, we can effectively evaluate the outputs and their consequences. None is better than ourselves to comprehensively specify and evaluate the pervious factors and attributes.

Being in academia and research, we have more responsibilities to point out the coming problems, to diagnose their causes, and to propose their solutions. We have to think and act ahead for our society. We have to be the thought leaders. Architecture, our area of academia and research, is a face of the nation and its civilization; it is not a subject to underestimate.

The conference coverage area has heritages, especially of architecture, that are extremely valuable. Many top ranked universities in the world have especial sections of Islamic and Arabic Architecture. Our rule as architects is to extract how these architectures were successful in reflecting people needs, rather than to imitate or use their old shapes and forms. Traditionally, the society believes and cultures were the most influential factors that formalized the architecture. Whereas, it is usually said that form and content are two faces of one coin. The importance of conformability between form and content emerged from the fact that architecture can impact the culture of society if it was not the reflection of this culture. And with time passes, this impact can be a negative one if the architecture originated from some values that are not of society believes and cultures.

The use of digital media has become a major part of the architecture and all related areas. The new paths and opportunities continuously offered by both software and hardware are much beyond the need for either highlight or manifest, especially in this event. The endless benefit list is so long not only in design area but also in construction, for example computational processes of biological inspiration. It is one of our responsibilities as thought leaders specialized in CAAD to contribute in developing this digital use, and to equip our students and alumnae with the latest applications. Nevertheless, formalization resulted from the digital use has to be directed in terms of conforming our architectural content and society cultures, rather than fully concentrated on the formalization process itself.

The conference theme is to focus on this conformability, and to link between the architectural content of society cultures and the form-creation processes of digital media. The importance of these essential links is clear. As I previously mentioned, all what we need is to stop and think thoroughly. Our responsibility is clear to all. We have to balance between benefiting from the new technologies and catering our cultures, and to stress on bridging between the new digital forms and the traditional human content.

I hope that the conference was successful to create this proposed stop for thinking.

Wael Abdelhameed
Scientific Committee of the Conference
University of Bahrain

Conference in Numbers

The conference accepted two types of papers: long papers of well completed research that are about 14 pages including the images (about 7000 words); and short papers of research that are about 7 pages including the images (about 3000 words). All papers (long and short) will undergo international blind reviews. The conference accepted full paper submission in either English or Arabic according to the ASCAAD paper formatting guidelines.

The conference received 78 abstracts from 24 countires, and only 72 were accepted. The scientific committee decided to give a chance to as much abstracts as possible to follow reviewers' comments. 54 papers were submitted, and only 42 were accepted. The number of published papers is 35. 7 papers withdrew or did not apply reviewers' comments.

The papers, short and long, are classified into different themes, namely: Urban Modeling and GIS, Design Integration, Virtual Reality, Simulation, and Animation, Digital Design Tools, Design Methods, Digital Culture and Heritage, Generative Forms, and Design Systems, Information Visualization, Digital Methods: application and theory, Design Education, Design Knowledge Based Systems.

PART 1

DESIGN EDUCATION
AND
DESIGN METHODS

HOW MUCH IS IT?

About the Use of the Element Method in Conjunction with Optimization Techniques

THORSTEN M. LOEMKER, ALBRECHT DEGERING
Technical University of Dresden
Zellescher Weg 17, 01069 Dresden, Germany
thorsten.loemker@tu-dresden.de
albrecht.degering@mailbox.tu-dresden.de

Abstract. It is obvious that the preparation and compliance with cost estimates for a proposed architectural design is indispensable for successful realization of building projects. A variety of methods exists that can be used by the architect to achieve this objective. However, most of these methods are regularly not used until the design is completed. In many cases this procedure leads to cost overruns. Hence, our paradigm is to estimate the total building costs prior to the generation of detailed designs and thus use the costs of building elements as design parameters right from the beginning to produce design solutions which entail the least possible costs. For this purpose we invert the customary process through the use of building element costs as a means for the automatic generation of monetarily assessable design solutions. For various reasons we concentrate on the design of housing projects. The methodology however, can be adopted to any other kind of building typology.

1. Normalcy

One of the most famous architects of our times recently elucidated that responsibility for building costs is not the business of an architect. He completed that his core competence is the arrangement of urban and architectonic space and that accountability for costs and deadlines is neither the architects' competence nor his duty. Logically consistent it is not astonishing that the list of cost overruns in the building sector is incredibly long. This is especially true for public buildings and large-scale projects. Scores of projects could be named that are exemplary for the architects' lavish handling of the clients' fiduciary resigned capital. It is an eminent matter of fact that many of these architects are experienced colleagues working in huge offices. The amount of cost overruns in the private building sector is certainly significant as well. Nonetheless it is the private investors' marginal lobby that not too much attention is paid to these clients. Beyond doubt this certainty leads to a decreasing reputation of the architectural profession in the public. It also questions belief in the architects' capabilities. It astonishes not any longer that more and more private clients call upon the engagement of general contractors that are sometimes not even architects. It should also be denoted that many families tend to buy prefabricated instead of individually designed houses. This development is not necessarily dreadful for clients but certainly a disaster for the architectural profession.

Increasing building costs lead to cost overruns throughout all planning stages. This is equally true for construction costs that are founded in the design phase and accrue during the construction phase, as well as for operation and maintenance costs to be incurred during the utilization phase of a building. The reasons for this development are manifold. For the construction phase it can be stated that missing early cost estimates lead to planning errors that increase building costs. It can also be said that the architects' digital toolbox offers no real support for asset-related cost planning. Indeed, many solutions exist for determination of building costs but their drawback is that they can only be used at a later time in the design process, i.e. at the earliest after completion of the preliminary design phase. Considerable influence on the design work at this point in time is impractical. As we know that it is essential to determine building costs in the early stages of design, the only practical course of action is to utilize cost parameters as an impetus for the design work on a par with the many other factors that influence design decisions.

2. Not as you like it

Asset-related cost planning is not the only aspect that is conducive for cost-saving planning and building. It should be unmistakably clear to the client that compliance with a specific low budget might imply abandonment of luxury and appointments. From the architectural point of view costs can by way of example be decreased through a compact design of the structure, the use of low priced materials as well as utilization of low-priced production- and construction methods. This is especially true for the use of prefabricated materials and for the deployment of standardized components such as uniform window- and door openings. By this means building costs can be controlled right from the start. Moreover, this procedure gives leeway to the architect for further design decisions and possible extensions of the building design. It should be noted that the measures mentioned beforehand first and foremost aim at the reduction of construction costs. It goes without saying that a lot more instruments are required to assure complete control over building costs.

2.1 CHANGE HAS COME

For years architects use CAD applications and related software to determine and calculate building costs. Unfortunately it must be said that the process deployed is linear not parallel, i.e. cost determination happens after the production of detailed drawings. The approach to determine costs and design solutions simultaneously is not supported. With the introduction of Building Information Modeling into the architectural practice this predetermined procedure might have changed. Nonetheless, actual applications are still missing. There is also no support for optimization engines in BIM products, which are yet an essential component of our methodology. Therefore we had a stab at several different applications from mechanical engineering, namely CATIA and VisualDoc which proved not to be useful due to limitations in their solver engines. Our decision to use ILOG OPL Studio was made with regard to the robust optimization engine and algorithms this package provides. It was also made due to the fact, that OPL (Van Hentenryck and Lustig, 1999) is a programming language that gave us the freedom to write our own code with its own algorithms implemented.

2.2 THE WISH LIST

In our system design users are provided with the possibility to interactively formulate their specific requirements, which are then parsed and passed to an optimization engine. With the aid of this engine it is possible to solve layout-planning problems through the use of optimization algorithms. It is also possible to optimize the arrangement of elements like walls and windows to obtain buildable and cost optimized floor plans. Our current research references previous results, in which we demonstrated that layout-planning problems can successfully be solved with our application (Loemker and Degering, 2008a, 2008b). To achieve the main objective - the reduction of buildings costs - we decided to split the optimization process into two parts. At first hand the optimization of the arrangement of spaces according to constraints is defined by the user. This process is then followed by the optimization of the arrangement and number of elements (walls, etc.) within the building. An environment is provided that gives the user the possibility to define constraints easily (OptiPad) as well as to present the results of the optimization runs (OptiDisplayer). Both applications are integrated into an environment named OptiCoin.

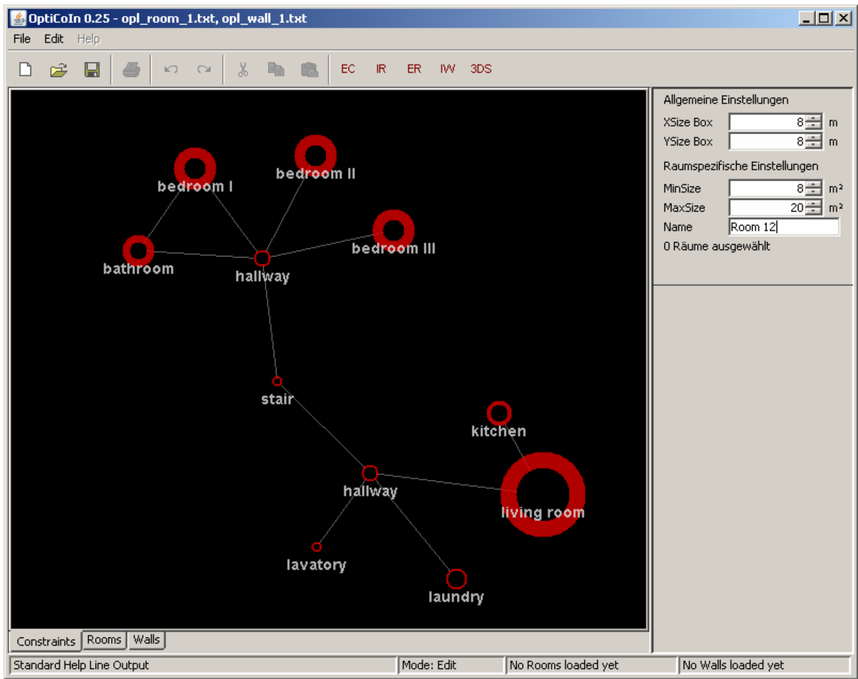

Figure 1. OptiPad – A component of OptiCoin to define spaces and constraints.

3. The method

The element method we use is a well-established method for the appraisal of building costs. It is based on a pricing of building works and building elements by means of which the overall costs of a building can be determined through summation. In comparison to other methods the advantages of this procedure constitute in the fact that it is already adequately precise in the early planning stages. Cost estimates can also be accomplished with comparatively low effort. In contrast to estimates of building costs that rest upon the calculation of the buildings cubature the element method is considerably more accurate. Like all other methods for the estimation of building costs the element method demands the existence of architectural drawings or models, from which masses and quantities of building components can be extracted to calculate the costs. In detail this denotes that the precision of the method increases the more data and information is available about the projected building. Although this methodology is plausible it usually adds up to be a severe burden for the client in the planning- and decision-making process. His concerns are certainly the arising expenses for the building and understandably his request is to be informed as early as possible, preferably prior to the actual design phase, about the accruing costs. Furthermore, in many cases clients have to be in line with a fixed budget which may not be exceeded in the planning. The traditional planning approach cannot produce relief according to these facts. Reasonable and mandatory statements with regard to the expected building costs cannot be made prior to the submission of design- and construction drawings. If the worst comes to the worst it may lead the client to withdraw an order, since otherwise his budget would be exceeded. In any case a cost overrun entails that amendments to the design have to be made which in turn generate additional costs in the planning. It is obvious that these additional costs are also not beneficial for realization of the project. Therefore our paradigm is to use the specific costs of building elements as design parameters right from the beginning, to pass these parameters to the optimization engine and produce design solutions which entail the least possible cost. As a result the preparation of cost estimates is shifted into the design process itself. Each and every solution that is generated by the optimization engine is consistently rated with regard to the accruing costs. Furthermore, those solutions that entail the least possible costs are always generated. Likewise no solution would be computed that exceeds a certain limit specified by the client.

3.1 GENERAL METHODOLOGY

In concrete terms, we describe the advised utilization of a building in form of a space allocation plan. On the basis of this description and by making use of numerical optimization techniques we automatically engender proposals for the arrangement of the various spaces within the future building. Through performance measures which rely on pre-defined and neutral criteria we ascertain the fittest solutions to be integrated in a second optimization pass.

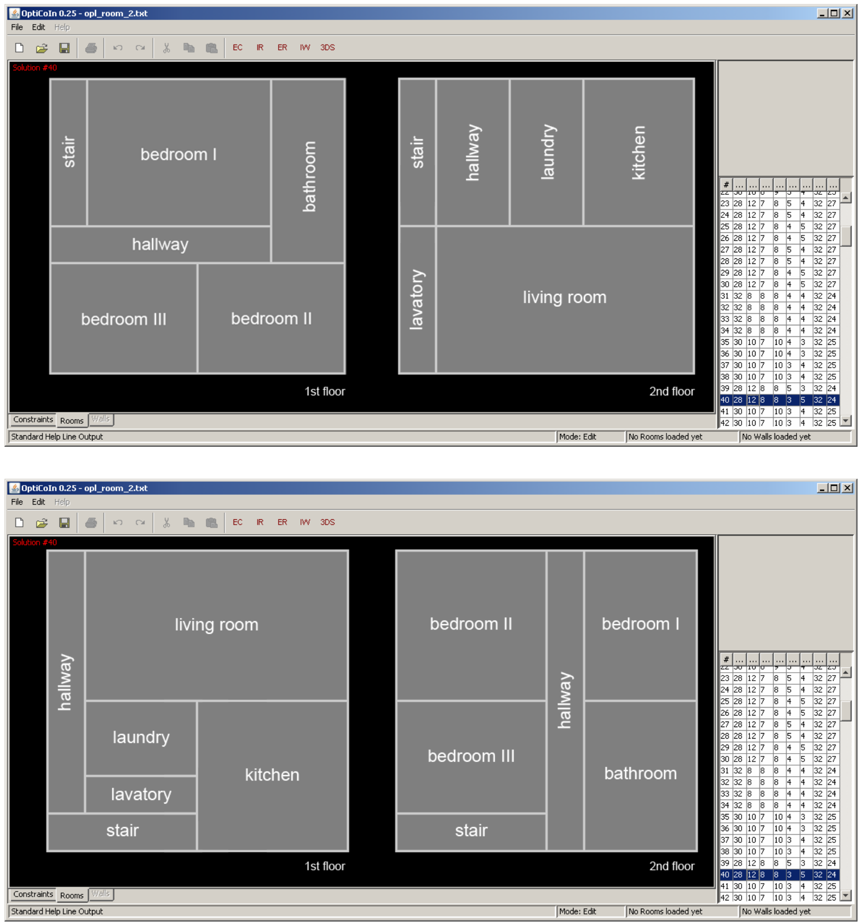

Figure 2. OptiDisplayer visualizes two different results of the same optimization pass.

In the following process these solutions are conveyed into buildable design solutions. Therefore the optimization algorithm deploys a set of standardized building elements with the corresponding estimated prices. As a result of this second optimization pass various arrangements of spaces and building elements can be observed, that are explicitly rateable with regard to the defined utilization and the resulting costs. The assembly of the various building elements follows from rules that were specified beforehand and take architectural aspects such as load bearing strength of building elements, static behavior and illumination into account. Due to the fact that the optimization process is carried out under the premise of cost reduction all solutions generated are perfect solutions with regard to building costs, i.e. they represent the cheapest possibilities to a specific design task under consideration of the building elements' predefined properties. As a matter of course our code is also flexible enough to configure optimization passes that gain more relevance to the precise attainment of an objective function instead of trying to minimize specific parameters such as building costs. By way of example this course of action allows for determination of the maximal floor space that can be financed with a fixed budget.

3.2 SEQUENCE OF OPERATION

The normal course of action is as follows:
- Definition of a basic room set and constraints (architectural)
- Optimization of the room set according to the constraints
- Selection of a solution
- Definition of additional constraints (static, illumination, costs)
- Optimization of the arrangement and size of walls and windows
- Selection of a solution that meets these requirements

This modular course of action, gives the architect the possibility to interfere the process at every point in time to prevent inconvenient solutions. It is necessary to let the architect perform this task, as software is not able to factor in all marginal constraints. Decomposing the process in smaller steps furthermore helps to lower combinatorial diversity. The user can change constraints or cancel the progress if it is predictable that the results will not solve the problem defined. Selecting a solution fitting the problem best from an economic point of view, but also under architectural aspects, is an important step to good design solutions. Manual selection means that the optimizer sometimes produces hundreds of different solutions that fulfil all constraints and objectives defined during the previous optimization run. Hence, the manual selection process provides the option that the selected variant might imply other subjective features which improve the overall architectural quality, but were not specified as constraints or objectives.

3.2.1. Arrangement of Spaces

For spatial design we concentrate on the arrangement of spaces with given size limits within a rectangular plot. Thus, the user can define interior spaces (like hallways and rooms) as well as exterior spaces (like terraces). A Constraint Satisfaction approach usually leads to a wide variety of results, giving the architect the choice to select a solution under manifold aspects. Respectively we defined four steps, which assure diversity of results. The first step is to define the constraints for the space program within OptiPad. The present algorithm meets the requirements of multi-storey buildings and was adjusted to work in cubic plots. The algorithm was also developed to find solutions that fit structural requirements. Consequently, the arrangement of rooms can then be optimized to cost allowing for good floor plan solutions.

3.2.2. Arrangement of Building Elements

The elements used in this approach are walls, windows, floors, ceilings and stairs. The term ‘element’ results from the cost estimation procedure described earlier. With regard to the optimization of multi-storey buildings, stairs, floors and ceilings are not fixed in size. Also and with regard to the evaluation of existing buildings we defined the term ‘room’ to be obsolete and replaced it with the term ‘space’. The classical concept of a room implies boundaries. For a given arrangement of spaces, which determines location and size of walls, cost optimization would be performed to allocate solutions with the minimal amount of walls and windows necessary. With the equivalent definition of space, the spaces themselves are separated from each other with the least amount of walls. This definition is not new due to the fact that contemporary architecture often makes use of this principle – open and floating spaces do not depend on specific room usage anymore.

Figure 3. Cost optimized floor plans with appropriate building elements resulting from the second optimization run.

3.2.3. Determination of Constraints

The determination of constraints is important for the tasks performed by the optimization engine. By way of example it is necessary to pass data anent adjacent buildings, not just for preventing windows in neighboring walls, but also to prevent the calculation of redundant walls for static reasons. Other constraints are necessary to meet requirements of sound insulation or to screen residents from view. The user can define these constraints interactively. We marked out three different possibilities - to close a space, to close a space in specific directions and to close a space to the outside of the building. This convention covers most of the cases relevant to the design process. For all other cases, the algorithm is flexible enough to handle them.

3.2.4. Optimization Passes

Flexible but fast algorithms to generate optimized and multifarious solutions are still the most difficult aspect of our research. This is due to the fact that the algorithms always have to cope with the factor of combinatorial explosion. The algorithms developed were described in (Loemker and Degering, 2008a, 2008b). Once a solution is generated an automated evaluation of the results allows the comparison of the design from different points of view. In the first instance this is indeed done with regard to building costs. The user selects one of the solutions found, which are displayed on a board and for which the minimal price is calculated. Furthermore OptiCoin comprises an interface, which allows the solutions to be automatically exported and rendered in a visualization package. The calculation of the building costs is based on the element method described in DIN 276 (Deutsches Institut für Normung, 2008). For every element we detail prices that are used in the calculations. The price of an element depends on its size, i.e. width, height and depth and a cost characteristic. For performance reasons the parser overlays the ground plan with a quadratic grid pattern with a side length of one meter. The squares themselves act as a coordinate system for the communication with the optimizer. Every wall is described as a tuple of integers, two of them representing the coordinates, the other two referring to the direction of the wall. Thus, typical wall sets consist of four integer arrays with the same length according to the number of walls. Four fields at the same index in the corresponding array represent a one meter part of a wall. Furthermore, the parser already separates exterior from interior walls. This classification according to wall types was implemented to allow for more flexible cost calculations as well as to provide different types of walls, according to their specific location. Thus, an exterior wall can either be closed or open, whereas closed walls provide load-bearing capacities. Interior walls can be of two different types; by now, they are closed and either non-supporting or supporting. In two arrays, each of them representing one type of wall, the type of wall can be turned on or off. A Boolean value for each wall segment is set to represent the walls of the building. Through the use of a mathematical operation the values of walls not relevant can be masked out. During the optimization process the optimizer determines which kind of wall to choose from the given set of walls to fulfill all constraints that were applied to the building. Thus, the reduction of the total number of walls and the selection of a minimum of walls that is able to fulfill the constraints and to achieve a perfect solution (Domschke and Drexel, 2005) impacts the total costs of the building.

Figure 4. Visualization of a cost optimized floor plan.

4. Conclusion

In summary our system design comprises an efficient and sophisticated optimization engine that parses parametric data about a projected building into a priced design model. Therefore an easy to use interface has been developed within which the client and the architect can formulate their ideas about the building design. This data is integrated in an input model that is passed to the optimization engine that computes various design proposals. These proposals are then optimized with regard to construction costs. The system aims at giving the client and the architect a first overview about these accruing costs. Other expenses that influence the total cost of a building are not yet implemented. The methodology however, allows further extension of the package.

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