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# RAPID PROTOYPING IN ORDER TO IMPROVE BUILDING PERFORMANCE SIMULATION FOR DETAILED DESIGN SUPPORT

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## ABSTRACT

Building performance simulation (BPS) is a powerful tool to support building and system designers in emulating how orientation, building type, HVAC system etc. interacts the overall building performance. Currently BPS is used only for code compliance in the detailed design, neither to make informed choices between different design options nor for building and/ or system optimization [Wilde, 2004].BPS could/ should be used in a way of indicating design solutions, introducing an uncertainty and sensitivity analysis and building and/ or system optimization.

This research is about enhancing the use of BPS in the detailed design by supporting design and system optimization.

## INTRODUCTION

BPS could/ should be used in a way of indicating design solutions by for instance numbers and graphs, introducing an uncertainty and sensitivity analysis for guidance, supporting generation of design alternatives, providing an informed decision making, choices between different design options and last but not least building and/ or system optimization.

In order to enhance the use of BPS especially during the detailed design, it leads to a need of decision support tools, appropriate optimization tools and user-oriented design analysis facilities among others [Poloni, 2005].

The current project will focus on developing ideas in optimizing the current design during the final stage of the design process. Therefore first of all literature will be reviewed to analyze different optimization techniques. Secondly, the state of the art of the use of BPS in the final design is checked. This is done in finding answers to the following questions:

- How is software currently used in the final design?
- What are the requirements during the final design?
- What should be improved in current available simulation tools?
- What is the relation between design development and design optimization?

The requirement specification will then be used to assess an existing tool and to identify the applicability of this tool to optimize the design. Performance aspects considered of high importance to be optimized will be thermal comfort, energy efficiency, indoor environmental quality etc.

Fields of interest cover the following areas:

1. Optimization techniques
2. Design decision support systems (DDSS)
3. Uncertainty analysis (UA)/ sensitivity analysis (SA)
4. Knowledge management systems
5. Multi-objective decision making
6. Integrated performance view

One important aspect that is currently regarded in this research is uncertainty and sensitivity analysis which is taking a significant role in this area. This originates from the uncertainties in the parameter input of simulation tools which is based on experience but also assumptions. This introduces uncertainties on which the quality of the simulation output is dependent [Hopfe et al., 2006]. It is obvious that there is a demand for analyzing and quantifying those uncertainties regarding their impact on the building design. Some results of UA and SA are already presented in [Hopfe et al., 2006]. In this abstract some further results will be briefly shown.

## METHODOLOGY

General research methodology is rapid prototyping in order to receive valuable results in a short time. In this case existing simulation tools are used and for the implementation shells are build around those tools. For the sensitivity analysis for instance a standard in the Netherlands well-known simulation tool VA114 is chosen. The experimental set-up using an UA and SA performing tool called Simlab is coupled with VA114. Input parameters are for instance construction boundaries, material properties and room conditions. The output of interest is energy consumption as well as heating and cooling peak loads.

Aim is it to experience which parameters are important and which to a lesser extent. The Morris method is one screening method which uses the oneat-the time (OAT) experiment, where only one input parameter is varied.

By reason of limiting the given results, only the outcomes of peak heating and peak cooling are demonstrated. Totally 46 input parameters are considered.

Altogether 188 simulations are executed. From those 46 variables 3 different input files necessary for one simulation were generated, one with all the material properties, one for internal heat gains and one for air change rate. This procedure was done 188 times via one macro in Excel. The simulation of the chosen tool VA114 can be easily started by a batch file whilst providing the different material files.

## PRELIMINARY RESULTS

This research covers multiple aspects in order to enhance the BPS during the detailed design. Therefore the following actions have been already completed or are still in progress:

1 Critical Software Review: Several building performance simulation tools were tested and assessed for their use to the conceptual design stage

2 Interviews with Design Professionals: A number of interviews with international design professionals were conducted.

3 Literature research: On subjects as evolutionary computing especially in genetic algorithms, analytical target cascading etc.

4 Design team observations

5 Development of prototypes

Prototypes are developed covering multiple directions. The next paragraph shows some brief results of a prototype implementing SA with Morris analysis regarding peak loads.

### Sensitivity Analysis

The minimum number of simulations for Morris analysis can be calculated as follows: 4*n +4-= 188 (n is the number of parameters). The results of this analysis consist of one graph where the averaging coefficient for each parameter ($\mu$) is compared against the dispersion ($\sigma$) from this coefficient per parameter. One high averaging means a higher tilt angle and consequently a big sensibility; a small averaging one implies less sensibility.

The most sensitive parameters for maximum heating are conductivity of the fiberglass layer followed by the thickness of fiberglass layer; the most sensitive for maximum cooling is specific heat capacity of the timber flooring layer.

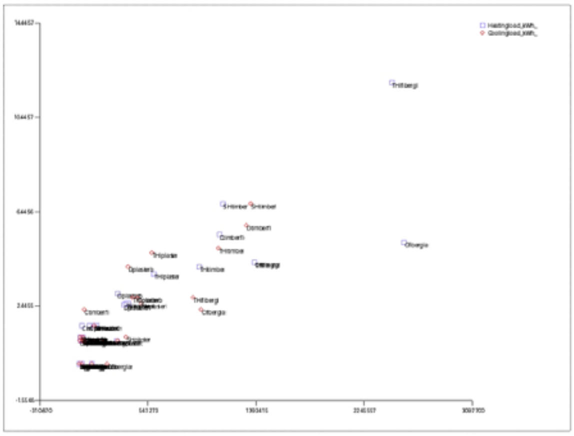

*Figure 1 SA Morris*

## FUTURE WORK

This is an ongoing research where different directions will be considered. In this extended abstract only some general results are presented. For the future work the developed prototypes will be iteratively improved and tested. A very important role in the further development of those prototypes will be feedback from professionals (design development vs. design optimization).

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