Dissertation Review Form
-for members of the Dissertation Commission-

Please write a review of the dissertation taking the following criteria into account, where appropriate:

- General remarks
- The significance and status of the dissertation in the field
- The sufficiency and quality of the material
- The adequacy of the methods used
- The validity of results
- The logic of the dissertation's structure
- The knowledge and use of literature in the field
- The project's contribution to the research area
- The author's input into the achievement of the dissertation results
- Language
- The shortcomings of the manuscript

Name of the PhD Candidate : Mr Leung Tze Ming
Planned Date of Graduation : October, year: 2019

Title of the Dissertation: «Principles of comprehensive device generating urban spaces (utilizing parametric technologies)»

Would you please elaborate upon your review with reference to the above mentioned criteria in the box below. Please add extra pages if needed

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- General remarks

  The focus on a proof of concept, limits the actual claims that can be made from this PhD. Yet, this is not a problem if the author tackles a problem that has proven to be a serious obstacle in a field that many have attempted to tackle. Given the current state of the work, this is somewhat dubious. If for instance a more complex relationship between various interacting design parameters and the performance objectives would be explored, the outcomes might result in fundamentally different urban design proposals. Subsequently, the proof of concept would entail a true design innovation which would elevate the work significantly. I understand that this would require a significant amount of work, i.e. a major revision which might not be feasible in the given timeframe.

- The significance and status of the dissertation in the field

  Sufficient. Performative architecture is a logical and important next step in the design discipline where the role of architects and urban designers shifts towards spatial consultants in a broader multidisciplinary team. Furthermore, increasing environmental standards, cost efficiency as well other requirements, pave the way for a scientifically oriented systematic design approach in which proposals are evaluated and adapted iteratively. Advancements in modern computing (incl. parametric design) make the production and evaluation of large numbers of design alternatives feasible. In time this might lead to a different design methodology based on “research by design”. The context of this PhD is therefore highly relevant.

  The author does not explore the question if the proposed methodology actually leads to (fundamentally) different design alternatives that might be left unexplored when adopting a traditional design approach (i.e. where the designer directly drafts ideas onto paper/computer). From the example provided in the dissertation, the outcomes merely lead to an optimization without actually changing the design fundamentally. Although important, this does not necessarily lead to innovative approaches. I am convinced though, that for a large set of design problems, bifurcations can be found when composing candidate solutions. These bifurcations exemplify fundamentally different solutions to a given task or goal. This would really increase the importance of the developed approach.

- The sufficiency and quality of the material

  Sufficient. The overall quality and description of the material is sufficiently detailed. The methods are described in detail yet the outcomes often lack interpretation. This is especially needed at the end of Chapter 5.

- The adequacy of the methods used

Sufficient. The author seems very literate in Rhino/Grasshopper. Yet, this seems to make him somewhat biased in the scope and evaluation of alternative platforms. A classic procedural design tool like for instance SideFX's Houdini is not mentioned. The evaluation of Esri's City Engine is limited; wtih the SDK for instance, different workflows in Python as well as integration into other platforms are provided that make the tool versatile and flexible. Obviously, every tool has its strengths and weaknesses but it seems the author picked Rhino/Grasshopper merely because his familiarity with the tool that provides a procedural approach without any programming knowledge. That is fine, but present the choice merely as an example (which fits in a proof of concept) than a deliberate choice after a thorough evaluation of alternatives.

In my opinion there is a fundamental issue regarding the inverse simulation approach that the author proposes: If an “inverse relationship” requires that a mathematical relation between input parameters and output performance is known, the function can simply be solved using classic mathematical optimization tools. The example provided could simply be solved in Excel. In this case the computation of the UTCI is performed by a Grasshopper plugin (Ladybug). Yet this could be done in any other design environment. Could the author clarify this and explain where his approach differs? I would understand this better if there would be a direct relation with the spatial features of the candidate solution that requires also an evaluation by the designer, i.e. a co-evaluation process between designer and “performance” (i.e. fitness function).

- The validity of results

The results seem valid within the scope of the experiments. Yet, they are partially incomplete. For instance, the acoustic performance as a function of the centre coordinates of the fountain is not calculated/presented as for instance was done for dUTCI and the Connectivity. Note that the latter performance indicator is never explained in the dissertation, which makes it difficult to evaluate the validity of the results. Hillier & Hanson (1984) state that “Connectivity measures the number of spaces immediately connecting a space of origin”. How this is actually operationalized in the Depthmap program used in the dissertation is unclear. The produced connectivity values show an increase for decreasing tree densities. In contrast dUTCI increases when increasing the tree density. Here the role of the designer is important when evaluating the combined outcomes; I argue that this is not merely a question of choosing which “performance” (i.e. objective) is chosen as the most important. Furthermore, a pareto-optimization approach (which is mentioned) could be followed; this would lead to a set of optimal alternatives that indicate a combined maximization of values.
Furthermore, the outcomes are not discussed. Are they correct or optimal? There is almost no interpretation of the outcomes which is common practise in any experimental setup.

- The logic of the dissertation’s structure

Good. The structure and logic of the argumentation holds. Yet, although the research questions (1.3) are implicitly answered in chapters 2, 4, 5 and 6, the

author never actually answers the RQs explicitly. This should be included in Chapter 7 or in a dedicated chapter.
The abstract does not explicitly state what is the scope and goal of the dissertation

- **The knowledge and use of literature in the field**

Sufficient. Although throughout the manuscript sufficient literature is used to develop the context for the argument as well as to support some of the claims, there are a few areas in which appropriate references are missing:
Optimization using evolutionary methods. This author sticks very much to references from the field of parametric modelling. Yet, evolutionary computing is a much wider field in mathematical optimization, dating back several decades. A reference to a classic textbook (e.g. Eiben et al, 2003) would not only broaden the context but might also help the author with explaining the basic principles of evolutionary computing. These are currently kept somewhat vague.

- Eiben, Agoston E., and James E. Smith. Introduction to evolutionary computing. Vol. 53. Berlin: springer, 2003.

Research by/through design. The author's motivation for per formative architectural and urban design is not really embedded in a debate that has gained importance in the design community over the past decade: research by/through design. The approach in which different design alternatives are evaluated and adapted in an iterative process is not new. A reference to this field should therefore be included (e.g. Godin et al, 2014). Some reflection on this field in Chapter 2 would also be beneficial for the reader.

- Godin, Danny, and Mithra Zahedi. "Aspects of research through design." Proceedings of DRS 2014: Design's Big Debates 1 (2014): 1667-1680.

Water management and climate adaptation. It is somewhat striking that climate change and urban water management, which in many cities across the world are dictating the urban development agenda, are hardly mentioned. Yet, while for instance in China the Sponge City-program is focussing on stormwater management in a truly performative manner (e.g. capture ratio). These goals fit perfectly in a performative approach the author is introducing but are sadly left untouched.

- The project's contribution to the research area

Sufficient. As already stated, I think the contribution to the research area is limited and could be increased. The focus of the proposed model is to optimize a design solution with a set of (semi) independent parameters. While the functions ("performances" that are to be optimized are relatively straightforward, the actual optimization is outside the scope of the dissertation. This limits the actual contribution to a proof of concept, without any claims.

- The author's input into the achievement of the dissertation results

Good. As far as I can observe, the author has developed all essential models, ran associated experiments and analysed the outcomes by himself. This suggests that the outcomes as well as the argumentation in the thesis are the sole property of the author.

- Language

Good. Generally, the level of English in the dissertation is of sufficient academic level. Before actual publication though, I recommend proof reading by a native speaker. There are some annoying mistakes like for instance improper use of “adapting” and “adopting”.

- The shortcomings of the manuscript

Overall, the author hardly uses examples when explaining theoretical concepts. Yet, this might provide the necessary clarification that makes the difference to truly understand how the concepts become operational.

Detailed remarks:
These are a reflection of the notes I made when reading the dissertation. They should be guarded as comments and guidelines but not necessarily need to be all implemented.

1.1 Framing could be more comprehensive and should include a few more references. For instance, the statement that more people nowadays live in cities than in rural areas needs a reference (e.g. a UN Habitat report)

1.3 The notion of inverse simulation is not introduced prior. A definition is needed before using the term.
1.3. RQs: it is not clear how the "spatial performance" is defined.

Language:
"Performance" is used both as "objective" and as "performance"
In many cases, by performance (as input parameter) the author means "constrain"

Some issues with the tense of sentences, e.g. "would be reviewed and tested"

2.1 rectangle example: four sides instead of sizes

2.1.2 in parametric design knowledge becomes more explicit. That could also mean that parametric design is open to a team of experts instead of relying on a single designer. This is not discussed.

2.1.2 Scripts can be completely deterministic, i.e. a given set of parameter values would result in the same design. There is no stochasticity.

2.1.3 Evaluation and performance are not well explained

Figure 2.3. The issue of nesting is not addressed; scale interactions between design components

2.2.3. P23: promising design solutions. What is meant by a 'promising design solution?"

2.2.4 The introduction to evolutionary methods fails to address the notion of an optimization method where different generations of designs are based on parameter value recombination and mutilations commonly found in a genetic algorithm

2.2.5 The explanation of inverse simulation is somewhat vague, i.e. it is not clear what the interpolation of pre-computed simulation results actually means. It seems it refers to a state or set of states the design prototype has to exhibit, where a state can be the manifestation of indicator which in turn expresses a pre-defined objective.

Solution space is introduced but not explained.

When combining performative design with inverse simulation, the other seems to suggest that the method comprises of i) optimizing solutions to reach each preferred state ii) combining those solutions to reach a global optimum, i.e. an optimal combination of the combined states (although it is questionable how that optimum would be defined other than a concatenation). Also, isn't this merely reaching a pareto optimum?

Figure 2.6 requires more explanation, especially c & d. Would c be consistent with a brute-force search method?

2.2.7 Terminology not necessarily clear, e.g. Here, urban data was analysed and translated into the grammars for design generation of the parametric model.

-Factual: Maya was developed by Alias Wavefront but is currently owned by Autodesk
-Since you give a rather selective overview of tools, you could also add SideEffect's Houdini, a procedural modeller which adopts parametric design in its creation of geometry.

-The author does not differentiate between general parametric tools, e.g. grasshopper & Rhino; MEL and specialized urban planning tools like Esri's city engine.

-The choice of PHP/JavaScript as an alternative seems somewhat arbitrary.

2.3.2 Requirement: no pre-set workflow. This is strange, it least there is an overarching workflow I assume. The author should better describe what elements of the workflow should be unconstrained and which should be prescribed. The choice for Grasshopper/Rhino 3d seems somewhat arbitrary

3.2 The environmental benefits are poorly described, e.g. the importance of green infrastructure in urban water management (flood risk management, water quality) is not mentioned at al.

3.3 The thermal and acoustic performance is constantly investigated by researchers. Is that so?
3.3.1 The author fails to mention evapotranspiration which is the general mechanism for the cooling effect in urban vegetation

The choice of UTCI as an thermal indicator was primarily due to the availability of a third-party tool. That's ok, but just state that

3.3.3 What are integration & connectivity values in Space Syntax. This seems important but not explained. Ibid for visual integration

3.4.1 I don't understand the classification: how are seating orientation or focus a facility in the same order as fountain or sculpture?

4.2.1 Figure 4.2 & 4.3 might look important, but is not more than high school set theory
When parameters are dependent, the optimal design solution is a set along a pareto front. Possibly, there are many different pareto optimal solutions

The forward procedure is nothing more than a function, i.e. a mapping of a scalar of vector by some transformation.

Solving equation 3 is simple linear algebra. Yet it is presented as something special, i.e. an 'inverse simulation'. Yet the question remains how many solutions there are to a given matrix to vector transformation

The argument on page 60 in which the author argues for 'less complicated equations' to reduce the complexity is not very convincing. This has been tackled in optimization problems already ages ago. Some basic insight in machine learning would really help. The whole point I'd argue of using a computer in the first place, is to tack the complexity issue!

4.2.3
eq. 4 is incorrect: constrains should not be noted as a set on which the function is operating

4.3 The notion of controllable and uncontrollable variables is strange. These should be dependent and independent variables

5.2 optimization problems can be simply solved by minimizing the least squared error

5.3.1 Design scenarios: site dimensions range between 50 - 200m in steps of 50m. That doesn't leave many possibilities.

5.3.2 Yet, the smallest site dimension does not result in the smallest UTCI Reduction. The author does not observe this.
Furthermore, it is quite obvious that a linear equation can describe the relation between the variables quite well (see Figure 5.3)

5.3.3 Why was the tree density not considered? This would have made the issue interesting since the two performance indicators would interact?

Why is the acoustic performance not calculated as was done for dUTCI?

5.3.4 It is not clear what 'connectivity' actually means or how it is defined (even though the method is developed by others, it has a prominent role and should therefore be explained without requiring to read the papers)

What's r2 in 5.10?

The conclusion that when performances are related, the designer can only optimize a single performance while the related performance can only be derived is disappointing.

Recommendations:
Statement IV summarizes the shortcomings of this study: a focus on simple, linear relationships between some key variables and performance levels. Yet this does not cover many of the applications that could be actually interesting...

Statement 8 finally mentions a ‘pareto approach'. Yet this should have been a basic prerequisite of the model; the model should output a range of pareto optimal design solutions from which the designer picks his/her preferred option. The author states "Optimization technique was out of the scope of the current study and it would not be discussed further". Yet, in my opinion this study is all about optimization; hence the inverse simulation and focus on performance.

Statement 10: As opposed to probabilistic?

Conclusions and discussion

-In evolutionary approaches it is perfectly feasible to keep a number of solutions instead of a single optimal solution. In fact, for the evolutionary process to occur (e.g. in a genetic algorithm) a population of candidate solutions is required for cross-over, i.e. the optimization process.

-The author repeatedly mentions life cycle treatment as a future enhancement of the system. Yet he does not mention how that relates to a parametric design. Please clarify!

Name of the Dissertation Commission Member : Willem Veerbeek, PhD, MSc

Chair / Function : Senior Lecturer/Researcher

Date : 14 July 2019

Signature : *

** No signature required when submitted per email.*

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