# Reflection

The ultimate goal of the research is to explore ways of how to rationalize and formulate mathematically a configurational design problem. This design problem refers to how to arrange a residential program into an existing building not only in terms of available space but also in relation to two design criteria: proximity and illuminance.

The initial approach aimed to formulate the problem as abstract as possible using mathematical procedures. The procedure that seemed the most promising was to understand what spectral graph theory is and how it is possible to formulate the above mentioned configurational problem by using principles of graph theory. In a later stage these principles could be (ideally) written in a programming language (such as Python or C#) but this was not feasible in this case because of lack of programming skills from the author. So the most feasible scenario seemed to be to try implementing the graph theory principles needed into the workflow of Grasshopper environment. However, the initial approach was abandoned after the second presentation (P2) because it was realized that it was not possible for the author to gain knowledge in advanced mathematics topics of discrete mathematics (spectral graph theory, topology) and rest topics relative to calculus and linear algebra needed in such a short period of time so as to develop a methodology on how to apply these methods to the design assignment. Under these circumstances the approach of a fully automated methodology - although well-grounded and challenging - would be way beyond the MSc graduation thesis purposes of a Building Technology student.

The next step was to find another approach to achieve the ultimate goal of the research. According to research methodology set at the beginning of the research, stages 1 (research framework) and 2 (theoretical background) had to be repeated. After completing the new literature review, generative design using existing computational tools seemed to be the most promising approach. The visual programming environment for this purpose was chosen to be Grasshopper, because of its popularity among the architectural community and its ability to support generative algorithms. The proposed approach is a systematic approach in which it is investigated until what point it is possible to automate a part of the design process in primary design stage according to the user's wishes (manual input) in respect to rooms' connectivity (proximity of rooms) and daylight criteria (illuminance) using computational methods.

The research methodology was set at the very beginning of the research (P1) and was followed until the completion of the research. It can be summarized in the following stages:

- Research framework
- Theoretical background
- Tool development

- Evaluation
- Conclusions

The first two steps were repeated after P2 retake and resulted in the new approach which is dynamic relaxation. During the tool development phase the specifications and assumptions were set so as to structure the tool. In the beginning, the main skeleton of the tool was defined by relative research, but it was not fully developed until it was applied in the case study. By following the proposed methodology it was possible to produce and evaluate the outputs. If the result was not satisfactory the process was repeated but this time the chosen parameters were adjusted to see which parameter had the greatest impact. By trials and relative research in literature the tool started to take its final form. The evaluation step was necessary so as to check how the tool performs in future applications. The last step includes the discussion upon the results, the conclusions drawn from the discussions and recommendations for the tool's improvement.

As far as society concerns, renovation was and still is an import design assignment, especially in countries where its available to build area is limited. Converting existing buildings into residences is a way to tackle the housing problem many people (locals and expats) from all over the world face. In a professional point of view, finding a way to systemize the renovation design process could have a great impact on the way architects would approach a renovation project since the very beginning. As soon as they have an initial design idea by following the suggested methodology it would be possible to insert the necessary data and produce the schematic residential layout based on the two –most important according to the author- design criteria: proximity and daylight. One of the main advantages of computational applications is that they can handle a respectable amount of data simultaneously. This means that many levels of complexity can be added to the tool and in that way help the architect find the optimum layout. This could speed up the design process and also produce non-conventional but still functional layouts.

The current graduation project is directly related to MSc Architecture, Urbanism and Building Sciences and the Building Technology track. Firstly, the computational methods proposed are intended to be applied in existing buildings, in real life scenarios, which is what architecture and building sciences is about. The case studies selected empower the practicality and the usefulness of the tool. The intention to contribute to systemize the renovation design process is an architectural intention interwoven with sustainability, that is one of the main aspects of Building Technology. Building Technology is also the field where architects are more oriented towards engineering. Mathematics and physics is some of the fundamental subjects of an engineer. Engineering is also about improving existing methods as well as inventing new ones. In this dissertation the innovation lies in developing a methodology on how to systemize a renovation design project using principles of computer science, mathematics and physics.

The peculiarity of this graduation topic, as well as most topics of generative design, is that the methodology followed during the research is in fact the research product. In this report is presented not only the final methodology that led to the desired results, but also the process of exploration; all trials and the logic behind them. This is also the main teaching objective of this research: to learn from successes as well as from failures.

To sum up, the proposed tool succeeds to do what it is asked for; namely to produce the optimal configuration regarding proximity and illuminance results. The framework used, dynamic relaxation was successful as my main mentor predicted. The tool has a lot of potential to be enlarged and include more climate aspects to the optimization such as thermal, noise, drift, etc. The same framework could be used and add these requirements as extra connections (springs). However, the environment chosen (Grasshopper) was not the ideal choice, because it still a project under development, is limited in capabilities and it not open source. Therefore, coding in a programming language (such as Python) would be the ideal environment for this project.