

# Shifting design work from production to evaluation: an evolutive design tool

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*In an experimental student design and research project where architects and computer scientists collaborate, we are developing an evolutive design tool that seeks to facilitate a shift in the focus of the process of designing architecture: away from the production of design alternatives or options towards an evaluation of semi-automatically generated ones. We work towards outsourcing the production of design alternatives in a given design task to a CAD tool and thereby give human designers more time to evaluate and discuss those alternatives and guide the tool in the production of improved alternatives. Though the project is in a very early stage, our aim is to ultimately shift the focus of human designers' involvement from production of design options to the evaluation of those, in order to give humans more time to think, discuss, find, analyze and include many different points of view and make it easier for them to be impartial in finding optimal solutions. We extend and continue research that was presented at the eCAADe 2007 in Frankfurt (Kurth & Barczik 2007).*

**Keywords:** *Genetic Algorithm, Evolutive Design Strategy*

## **Background and Introduction**

An important part of designing architecture consists of producing and testing alternative possible solutions for the given architectural design problems, and then evaluating the test results to produce a next generation of alternatives. Then repeating the process until, with luck (and time running out before a submission deadline) the process converges and one alternative is chosen as an appropriate solution. Such a production- and test-intensive process has proven to be feasible because usually at the start of a design project, not all criteria necessary to recognize a possible solution for the best one are known

and have to be found out as part of the design process. The process has two large interconnected problems: firstly, production of alternatives takes up a lot of time: they have to be developed mentally and represented as drawings and, ideally, physical models. Alas, the more time used for production, the less available for evaluation. Together with the human tendency for laziness, this secondly often seduces designers to quickly narrow the production of alternatives to those resembling already known or personally - instinctively - preferred ones. This is problematic, because it in fact restricts the browsing of the solution space without having any sort of proof that

the restriction does not rule out viable, indeed better solutions than the ones studied. Our aim is to remove both problems by providing designers with a tool that - partially - automates the production of design alternatives both in number and diversity. Thus, designers would be able to use more time to evaluate solution candidates and would be presented with new, previously unthought, options that could both provide new paths of enquiry and better solutions than the ones generated purely on the basis of pre-existing experiences. Such a tool could help to overcome personal limitations and biases and furthermore free up time for controversial discussions of provocative solution proposals, helping to incorporate valuable ideas.

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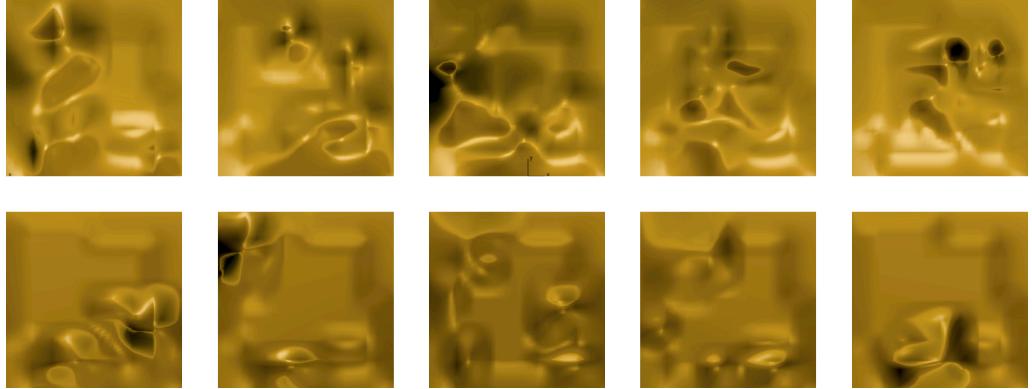
### ***Experimental inter-disciplinary student design and research project***

We conduct this research and development in a collaboration between architects and computer scientists. Students from both disciplines discuss and question the concept and develop strategies and prototypes for the envisioned tool. Different styles of thinking, working and expressing ideas are juxtaposed, forcing architects to state clearly issues they rarely discuss let alone think about (i.e. how to actually create a shape) and forcing computer scientists to be much more inquisitive than they are used to in order to tease out the aforementioned issues.

### ***Design Tool: Subdividing Space and arranging the parts over several generations***

The criteria for what actually makes a good design option good are reason for endless quarrel between practitioners and users of architecture. In order not to get lost and be able to start producing a usable tool, we greatly narrow down the tool's actual functionality to the mere subdividing of space. Designing any kind of architecture can be partially understood as simply subdividing space. Or put differently: to arrange a known amount of built volume (that is capable of housing the desired functions of a building) within a larger given volume, the allowed building envelope. This envelope is the result of a given

Figure 1  
Massing studies  
semi-automatically  
generated by the  
proposed design  
tool



site and the allowed height. Any architectural design therefore has to answer the question: exactly how (in which shape and form) does the desired volume reside within the allowed enveloping volume? Both volumes are relatively easy to determine from the site, local building regulations and the desired functional programme for the building. Our tool produces a user-defined number of possibilities for this inclusion or residence. The users' task lies in studying and evaluating the produced alternatives, and communicating the result to the tool by simply choosing a number of alternatives. The tool will then produce variants of the choices and the study, evaluation and choice repeat. The new generation of variants is produced by cross-breeding of the choices as well as by random mutation to prevent locking oneself into a narrow part of the solution space.

### **Technical Implementation**

To create the mass or volume we at the moment employ a very simple method: the allowed building envelope is divided into voxels, the resolution choosable by the users. These voxels are then filled one after another, starting from a number of voxels in the base plane. This number of starting voxels can also be chosen by the users. Voxels are filled until they together make up the desired volume. The first prototype is built with web technologies (HTML, CSS,

Javascript and WebGL) to allow easy access just with a modern web browser and without installation. One can load a b/w-bitmap as definition for the building site. Several parameters can be set for the model generation: maximum height of the building volume, number of variants to be created, total volume of new buildings, number of initial locations (germ cells), algorithm for generation. The system then generates several variants and displays them in an interactive 3D viewport for analysis and rating. Currently model generation and storage is done within the browser. This will be shifted to a server backend, which will facilitate to implement remote collaboration.

### **Semi-Automatic Protoarchitecture as a basis for further manual work**

The current output of the tool as a matter of course does not proclaim to be a piece of architecture. It is merely a pile - or several piles - of voxels. But it is also a possible form of the desired building volume. As such, it can be taken as a basis for further development towards architecture. The voxels may for example inform a continuous curved surface. Such development options and possibilities and their possible automation by inclusion into the tool's display and/or output are on our - admittedly long - list for future development.

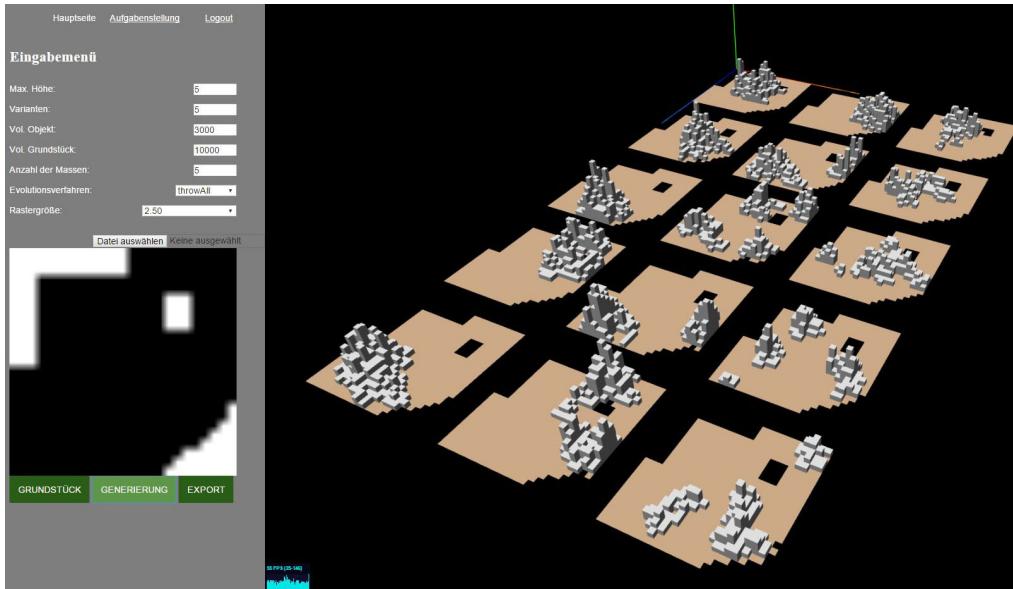


Figure 2  
Screenshot of Tool  
Prototype showing  
15 automatically  
generated massing  
options on the basis  
of a site uploaded  
as pixel image

### ***Evolutionary Aspects of the Tool***

The choosing of automatically generated variants from one generation to the next together with cross-breeding and random mutation constitutes a genetic algorithm, although one in which the fitness criteria for survival are not known initially. They co-evolve with the actual population: the population is created by the tool, the fitness criteria emerge from the discussion amongst the designers who evaluate the options. This eliminates the problem of pre-defining the fitness criteria, something which architects find notoriously impossible to do (DeLanda 2001 [1]), as it constitutes defining architectural quality in general. It also means that the fitness criteria may vary from one generation to the next as designers learn more and more about the design problem with each discussed generation. This effect turns out to be startling to the computer scientists, but well-known to the architects. In fact, in architectural competitions, which in their selection process somewhat mimic evolutionary algorithms, projects which have been ruled out

earlier are not rarely 'brought back' into the discussion. Occasionally, a project that had already been discarded in fact wins the competition, examples being Jorn Utzon's Sydney Opera House or Zaha Hadid's Hongkong Peak Proposal.

### ***Designing without Prejudice***

The initially random generation of design alternatives means that designers' personal prejudices (i.e. preferences in terms of formal style) can be avoided or at least made apparent through detection of trends (see below). This, we propose, facilitates a wider search of the solution space and therefore the finding of better design solutions.

### ***Future development***

We aim to equip our tool with the capability to detect trends in the designers' choices and to point those out to the designers so that they can choose whether they want to follow and reinforce the trends or work against them to avoid too early convergence of so-

lutions. Such 'trend detection' could furthermore be coupled individually to different users so that the tool can be personalized and, more importantly we find, team discussions be facilitated. One important feature to implement next is the exclusion of unwanted proposals. The parameter range of the remaining suggestions will serve as input for the next iteration.

### Outlook

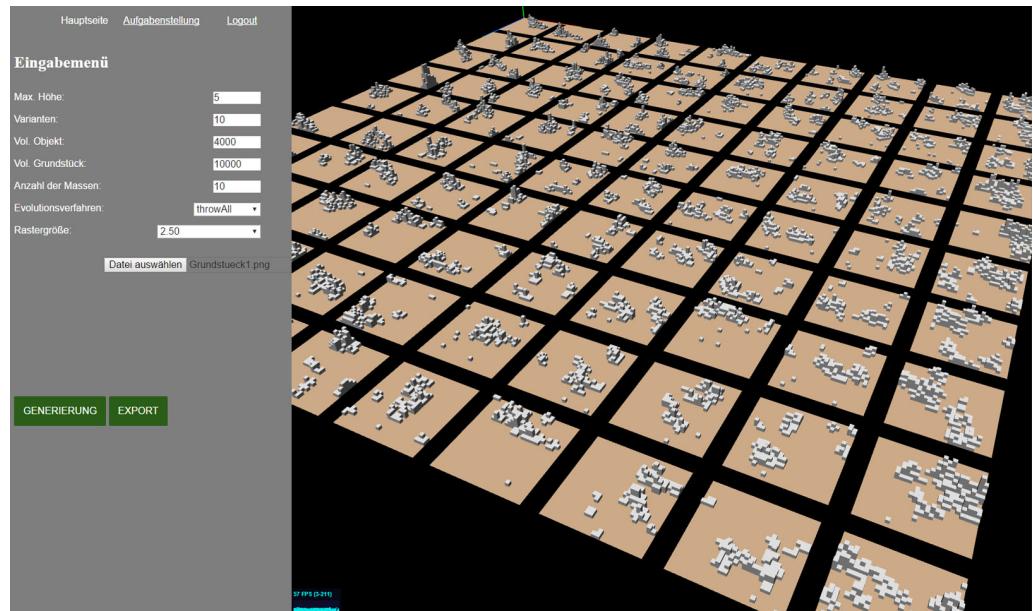
We are very well aware that the project is at a very early stage. However, communication between architects and computer scientists is now established, common language and goals found and development work commenced. The next steps will be the actual implementation of the features described above. Eventually, we envision a change in designers' day-to-day work: away from the production of designs by single individuals to their discussion, analysis and evaluation by teams. At the start of every work period, design alternatives previously automatically produced are assembled. The work period is

spend with discussion and ends in the selection of only several alternatives deemed viable. Those are used by the design tool as a basis for the automated nightly production of the next generation, which is presented to designers at the start of the next work period, and so on, until the team of designers evaluate one alternative as the end result.

### REFERENCES

- Kurth, W. and Barczik, G. 2007 'From Designing Objects to Designing Processes', *Proceedings of the eCAADe 2007*, Frankfurt a. M.
- [1] <http://www.cddc.vt.edu/host/delanda/pages/algorithm.htm>

Figure 3  
Screenshot of Tool  
Prototype showing  
100 automatically  
generated massing  
options



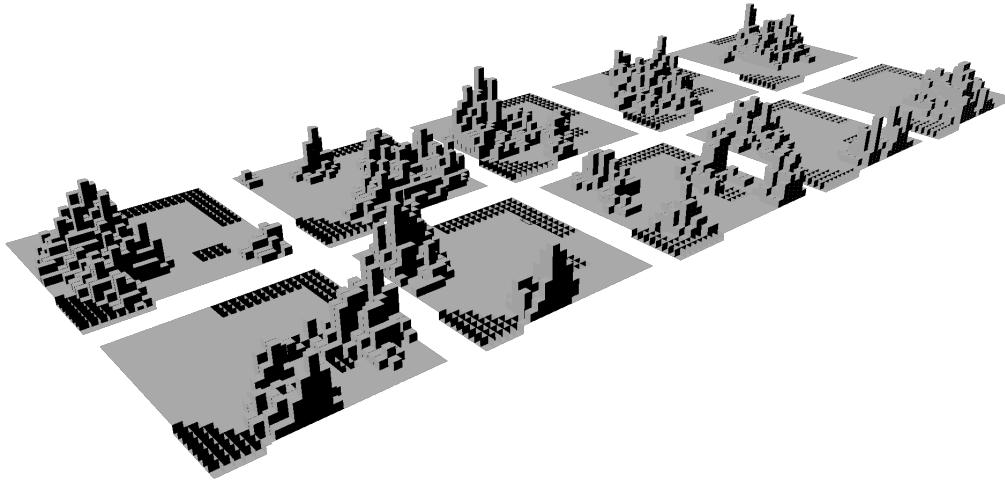


Figure 4  
Automatically  
generated massing  
studies as raw voxel  
arrangments  
directly output from  
the tool prototype

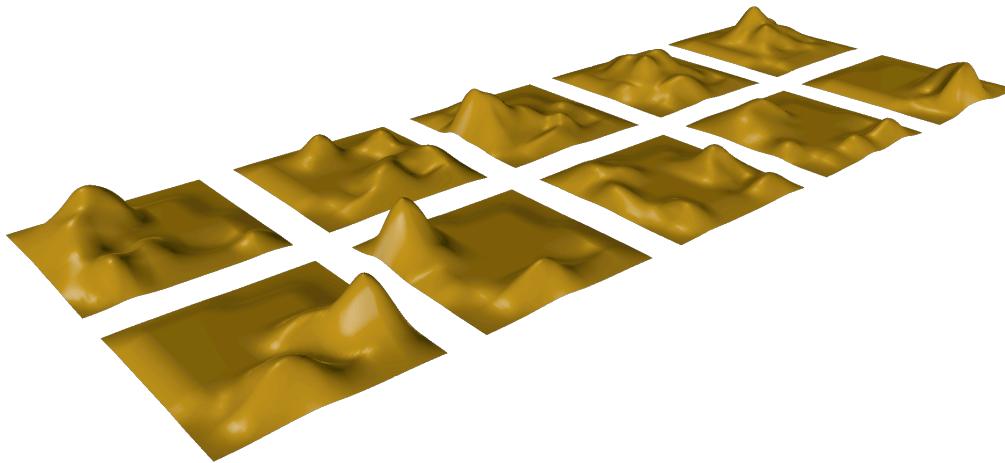


Figure 5  
Automatically  
generated massing  
studies manually  
developed as  
smooth surfaces  
enveloping the  
voxel arrangments  
directly output from  
the tool prototype