Associative Processes

Adaptive Potential of Script Based and Generative Design

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Script Based and Generative Design

Within the last four years the department for experimental architecture.hochbau in Innsbruck has set its focus on script based and parametric design research, aiming to explore new design methods in order to advance the field of contemporary digital architectural design. During this time, various new approaches to digital design were developed, iteratively tested, improved and applied in different architectural scales, the urban scale, the building scale and the ergonomic scale. A general introduction into the agenda was presented in a previous conference (Neumayr, R. and Budig, M., 2009).

All Investigations conducted can be subsumed under three conceptual categories within the proposed field of design research: Generative Processes, Cumulative Processes and Associative Processes. A stringent examination of the design process and constant refinement of its underlying procedures is common to all three areas of research and appears to be a crucial issue in order to achieve highly adjustable and controllable digital models. The results of these processes are further differentiated and articulated into architecturally viable configurations, in which aspects of associativity and adaptivity demand the designer's attention when applying different external and internal parameters which will be discussed in this paper.

Work Space

Design studios at the department for experimental architecture.hochbau are strongly based on an 'open-source model', meaning that previously acquired knowledge is collected, organized and stored in the institute's wiki database and subsequently passed on and redistributed among participating students. This becomes a very important aspect since the fluctuation of students is high and the time one student is allowed to spend on a research project is strictly limited by university regulations.

Students with different levels of experience work together in self organizing teams, complementing each other's individual skills. It is considered an important didactic aspect that students, according to their specific abilities and ambitions, can set out their own procedural methods when working within the paradigm of scripted or parametric systems.

Parametric Models

Whatever concepts are carried out more deeply, projects are required to meet the following common principles, which could be seen as the studio's general assessment criteria:

Emergent behaviour – all processes are at the same time emergent, morphogenetic and form-generating (as opposed to more traditional form-finding processes, where evaluation relies rather on visual or personal preferences than on pre-established performance criteria). Although results cannot be predicted from the very beginning in such a bottom-up process, systems stay adjustable and are capable of generating diverse results on different levels of recursion.

Modulated field conditions – overall schemes are organised as systems with different yet gradually changing densities and properties that are held in dynamic equilibrium whereas individual elements are embedded in such larger systems and modulated according to their current position's parameters.

Gradient transitions – a field is seen as one continuous system of changing dependencies, where each singular modulation becomes an environmental condition to their neighbouring entities.

Coherence – caused by their strictly rule-based nature, resulting field conditions show a high level of coherence, not primarily (or only) in aesthetical terms, but rather in the sense that consistent conceptual and abstract logics necessarily become embedded into the system.

Differentiation – due to their adaptivity and associativity field configurations and singular elements can be assessed according to their functional and programmatic potentials and be continuously differentiated in order to become smarter and multi-programmed.

Complexity – systems slowly yet continuously build up complexity through series of rather simple interacting sets of logics.

Generative Processes – Proliferation

In a first series of investigations the research focuses on a rather general survey into the nature of script based and algorithmic design. Starting with very simple sets of rules, aspects of iterative and cumulative design strategies are thoroughly explored in order to investigate their potential of producing architecturally and structurally viable results. First investigations are often carried out in two-dimensional set-ups that draw their inspirations from various scientific disciplines, such as mathematics, physics or biology and include a wide range of concepts from quite simple geometric systems to more complex fractal systems, dynamic systems, crystallisation systems, self-optimizing systems, behavioural systems, cellular automata or network theories.
Once a basic logic has been established and transformed into a flawless procedure, additional procedural layers are added and refined into a complex morphogenetic process (see Fig. 1; establishment of two-dimensional soft patterns, derived from the analysis of fluid dynamics).

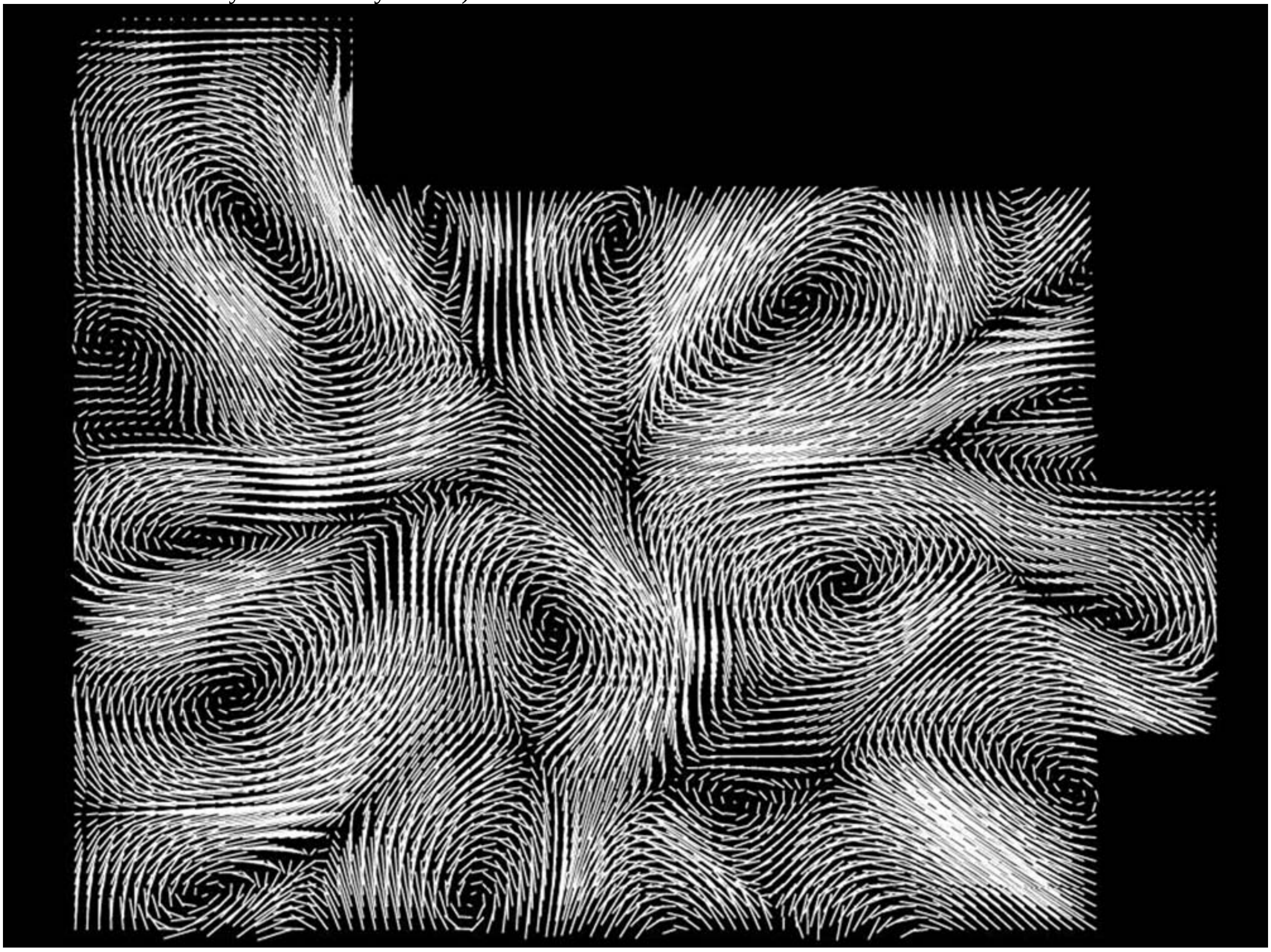

Figure 1: Interiorities; Urban Distribution Pattern (Schaiter and Seiss)

In this way, working in constant feedback loop, iteratively reorganising and expanding the parametric model becomes an important issues of the design process. Slowly building up a system of high complexity starting from a rather simple logic leads to increasingly elaborated, unpredictable yet controlled results, thus shifting the research focus beyond the point of mere digital representation.
Developed and successfully tested patterns are further analysed and evolved to deliver solutions for the systematisation and organisation of both architectural and urban field conditions (see Fig. 2; architectural typologies are proliferated on an urban field according to an initial logic).

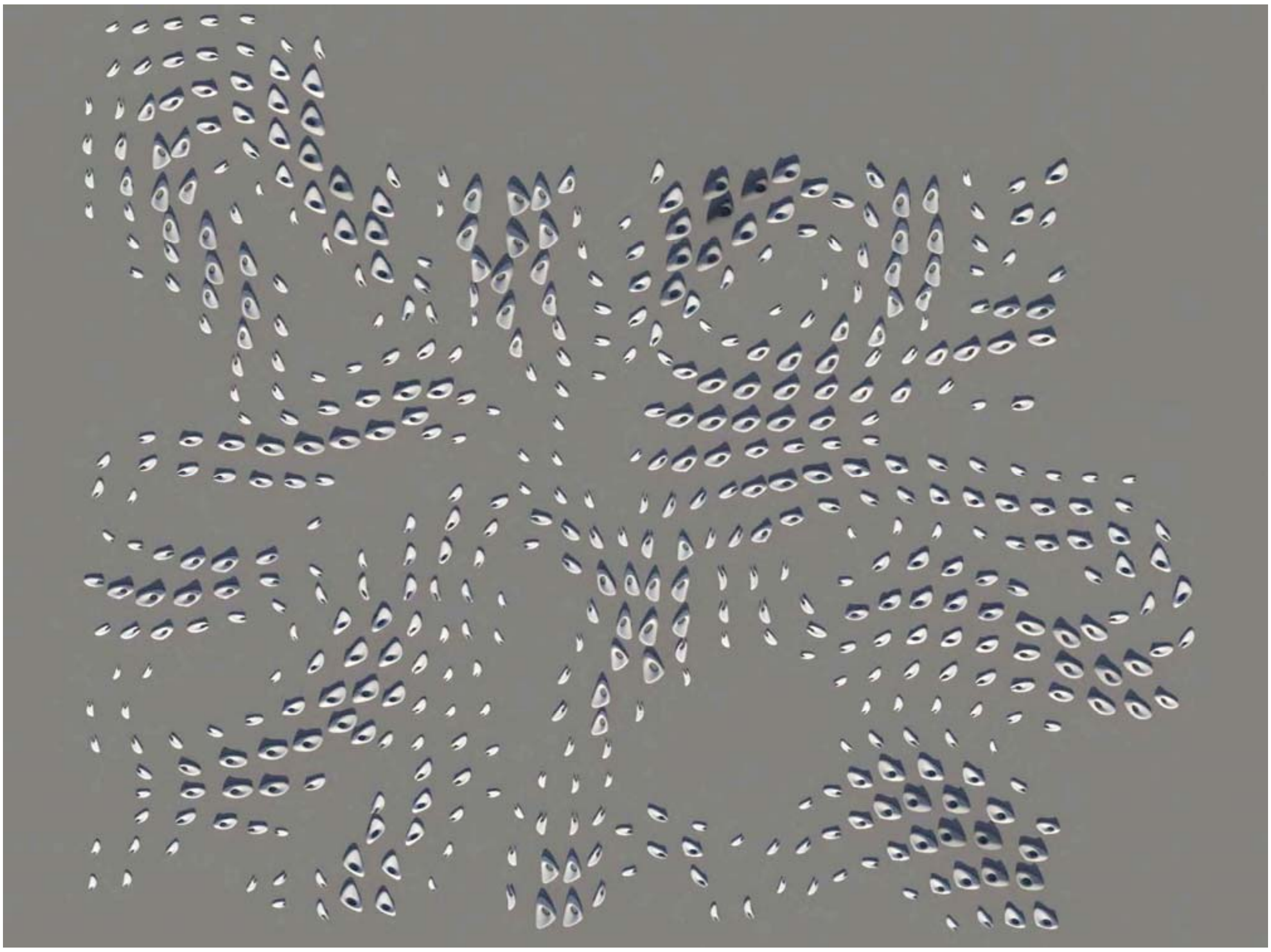

Figure 2: Interiorities; Urban Masterplan (Schaiter and Seiss)

> Only if virtual evolution can be used to explore a space rich enough so that all the possibilities cannot be considered in advance by the designer, only if what results shocks or at least surprises, can genetic algorithms be considered useful visualization tools. (de Landa, 2001: 117)

Cumulative Processes – Differentiation

Having evaluated the results of these initial investigations, it becomes evident that in order to stimulate the morphogenetic character of the design, the transformative potential of intensive qualities (indivisible but gradient values like environmental conditions, structural logics or effective or affective architectural qualities) had to be favoured over extensive quantities (changing geometrical values like length, area, and volume).

A parametrically differentiated architectural form can thus not only be seen as the result of coherent relations between geometric conditions (of an interdependency of geometric bodies, e.g. components in relation to their contextual parameters) but also as a result of a systematic variation of their internal values (exploration of values that are derived from a structural root element to the sub-elements that are proliferated in a field of elements). The scale of variables is subsequently released from its extensive values in order to achieve a wider range of possible outcome, always driven by the evaluation of its performance criteria.

For example, one concept that has been explored during this stage of design research starts with manipulating simple geometric shapes by exposing them to scripted mutations in order to achieve relatively smart components and provoke a series of iterative and self-similar transformations. These manipulations exert their influence on a specific sub-layer of the base object whereas the topological properties of the overall scheme stay unaltered in order to attain a homogeneous and cumulative system with gradient transitions in which differentiated modules are subsequently distributed across the field.

In a next step, a divergent series of cumulative geometries have emerged by exposing the initial components to a field of thematically linked yet varying and very specific contextual conditions using script sequences. Developed from one single generic element they take shape in different scales and environmental conditions and perform on multiple levels incorporating different functions and programmes (see Fig. 3, 4; the distribution of a geno-type geometry produces various pheno-type within different contextual conditions).

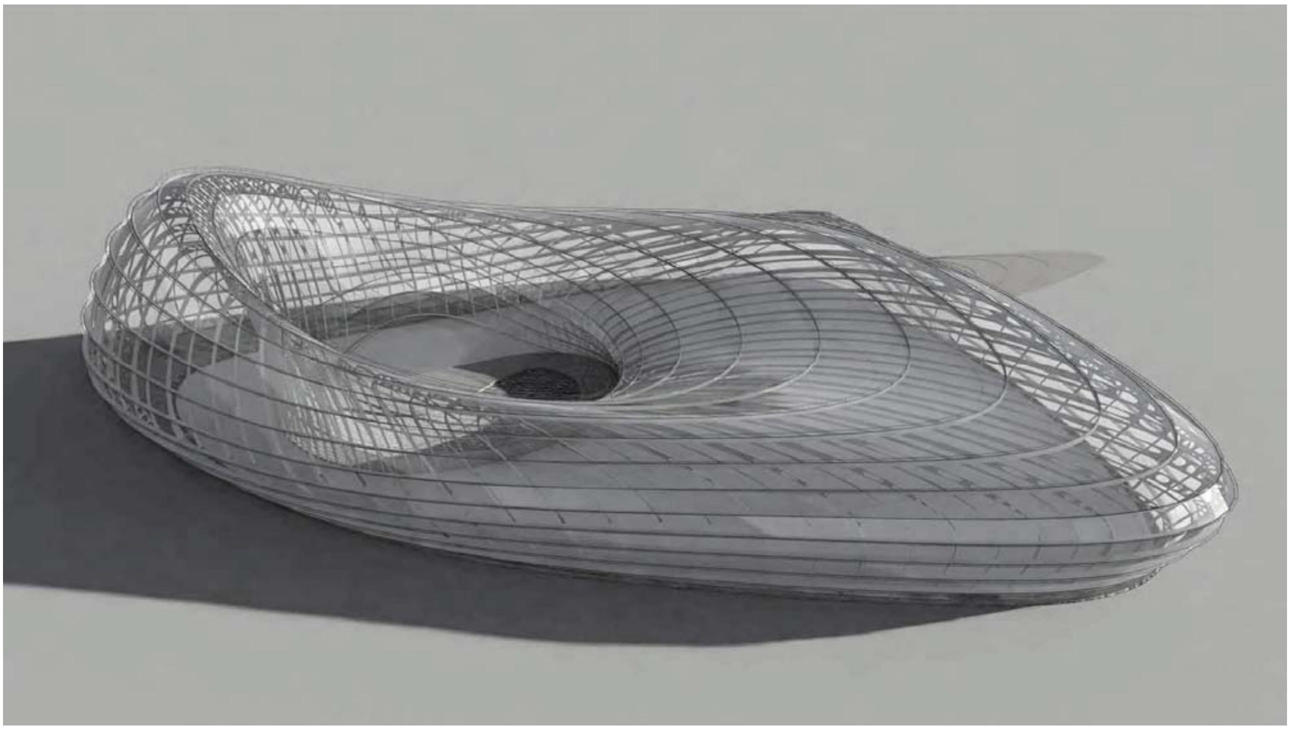

Figure 3: Interiorities; Genotype (Schaiter and Seiss)

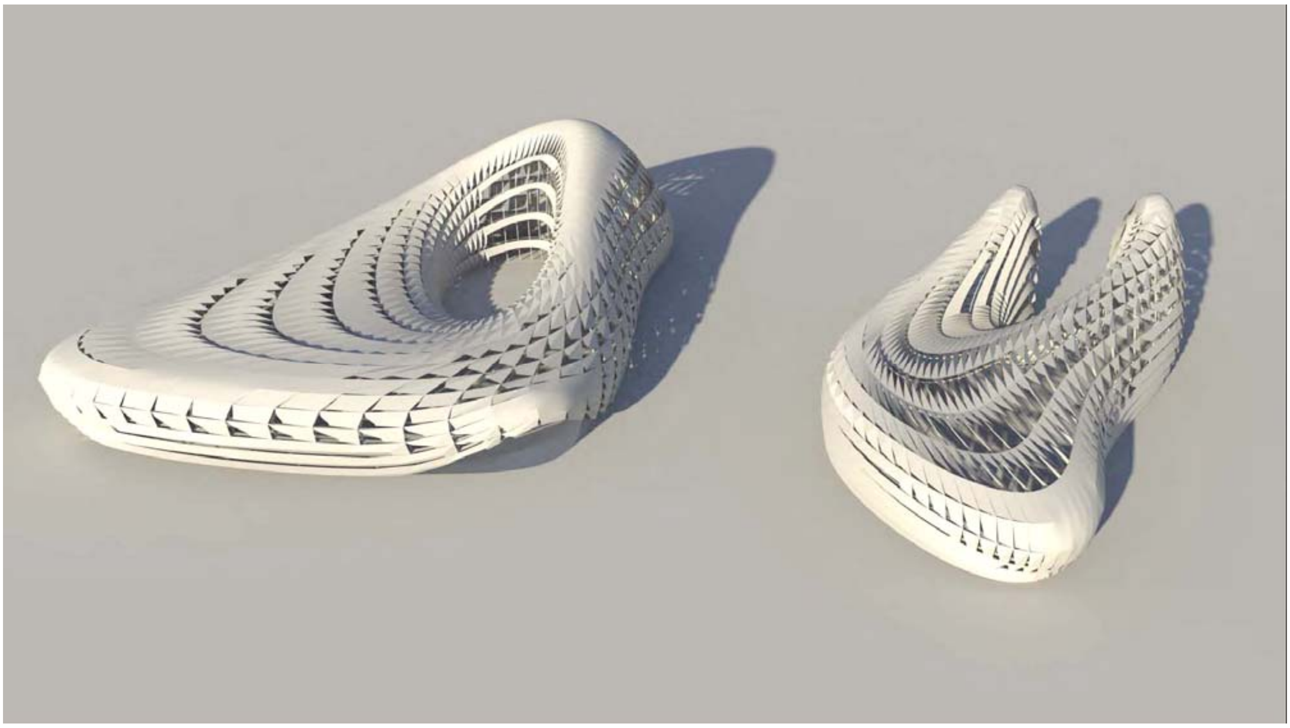

Figure 4: Interiorities; Differentiation of Phenotypes (Schaiter and Seiss)

Associative Processes – Integration and Inter-articulation

The methodical development of these systems aims towards the generation of elaborated and parametrically controllable geometries, which contain high adaptive potentials and connectivity (soft patterns).

Iteration (as in opposition to simple repetition), variation and continuous differentiation of basic elements are crucial aspects in this process, as the respective driving forces are applied in order to articulate complex architectural systems. According to their scale, all evolved systems and their subsequent components are designed to eventually form integral parts of an overall system, ranging from large urban schemes down to precisely defined functional architectural elements. This implies controlled and simultaneous development of function, form, structure and material, and requires attention on the associative qualities of all single constituents.

> It is the sense of organized (law-governed) complexity that [it] assimilates parametricist works to natural systems, where all forms are the result of lawfully interacting forces. Just like natural systems, parametricist compositions are so highly integrated that they cannot be easily decomposed into independent subsystems – a major point of difference in comparison with the modern design paradigm of clear separation of functional subsystems. (Schumacher, 2008)

The formal differentiation of different functional and programmatic layers within an architectural system can be achieved by two main concepts of articulation.
The first concept is the inter-articulation of various systems, sub-systems and components, which implies that various systems complement each other in order to fulfil architectural, structural and functional criteria (see Fig. 4, 5; a layer of facade panels is added as sub-system upon the structural system and differentiated according to environmental parameters; Fig. 6; both systems stay associative to each other and adaptive to their internal and external conditions whereas a new system is introduced containing interior functions and even furniture).

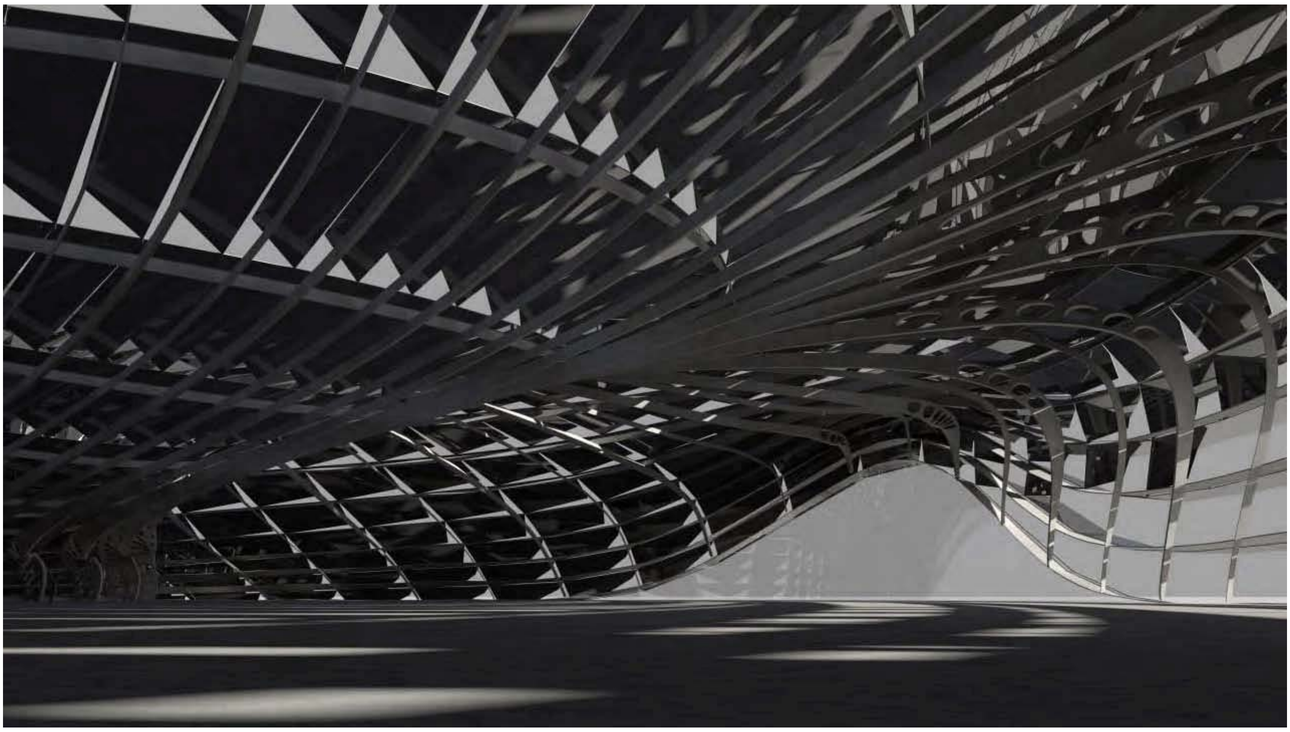

Figure 5: Interiorities; Articulation of Structural Sub-system (Schaiter and Seiss)

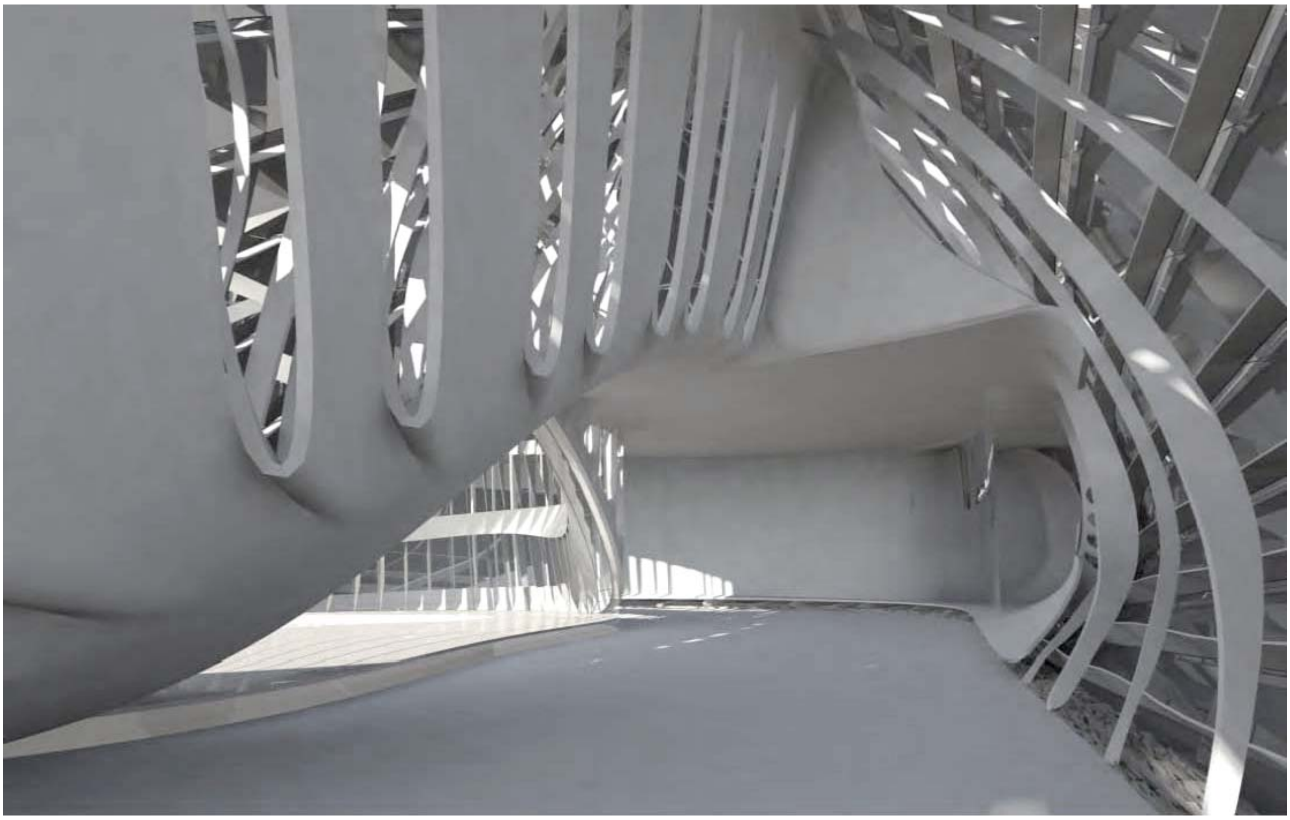
Figure 6: Interiorities; Interarticulation of Different Sub-systems (Schaiter and Seiss)

The second concept is that of integrating functions and programmes by systematic differentiation of one pivotal system which makes one system work on multiple functional layers. (see Fig. 7, 8, 9; a singular geometric component becomes articulated after a series of recursive iterations and is capable of adapting to external parameters along its edge conditions as well as to its internal conditions; similar geometric types perform as various architectural elements ranging from facade perforation patterns to distribution logics of urban elements at various scales).

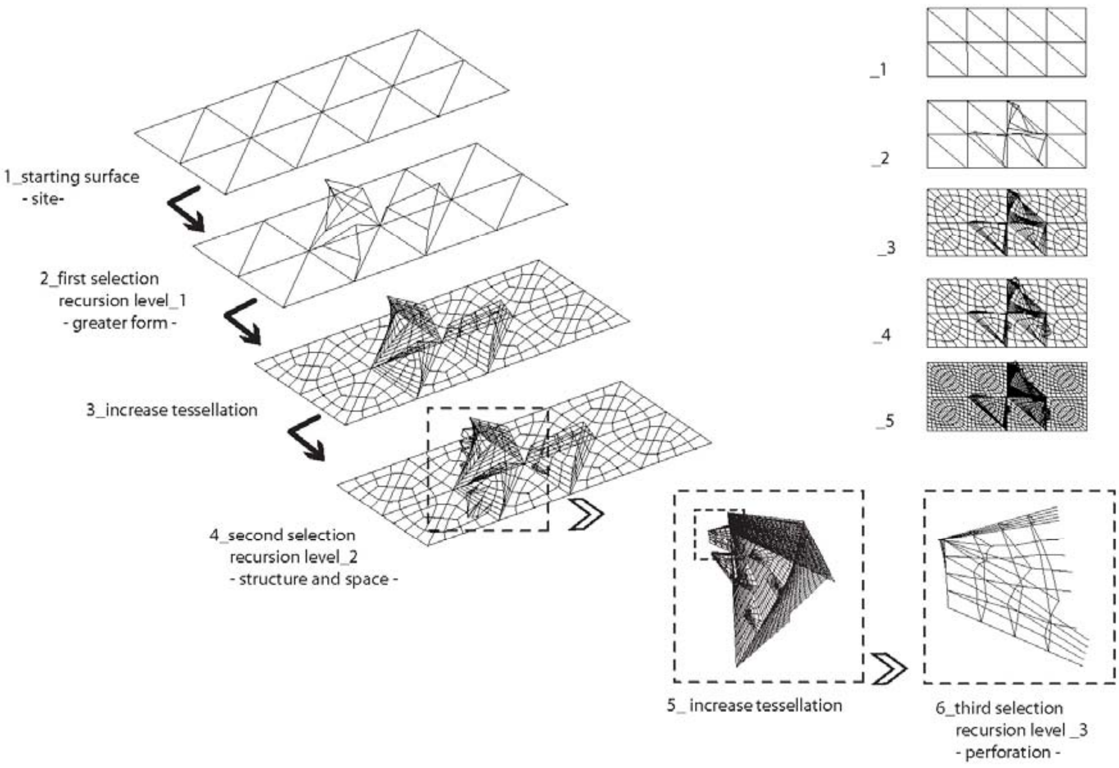

Figure 7: Cumulative Processes; Differentiation of Single Surface (Mandler and Siebenfoercher)

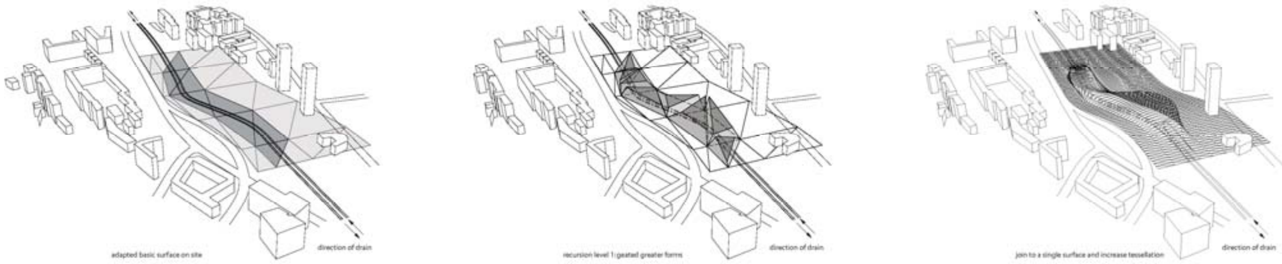

Figure 8: Cumulative Processes; 3 Iterations of Differentiation (Mandler and Siebenfoercher)

As an essential issue of every script based investigation, the potentials of associative modulations extend far beyond the mere abstract geometrical exploration of basic design research and work towards an inter-articulated elaboration of integrated architectural systems, which allow for direct design interaction.
Some of the more self-referential algorithmic operations of initial research phases were altered to form part of more open script sequences that can be associated to yet another set of sequences, distributed between repeatedly adjusted edge conditions or assembled around diversified field conditions, which leave more room for adjustment and refinement from the designer's point of view.

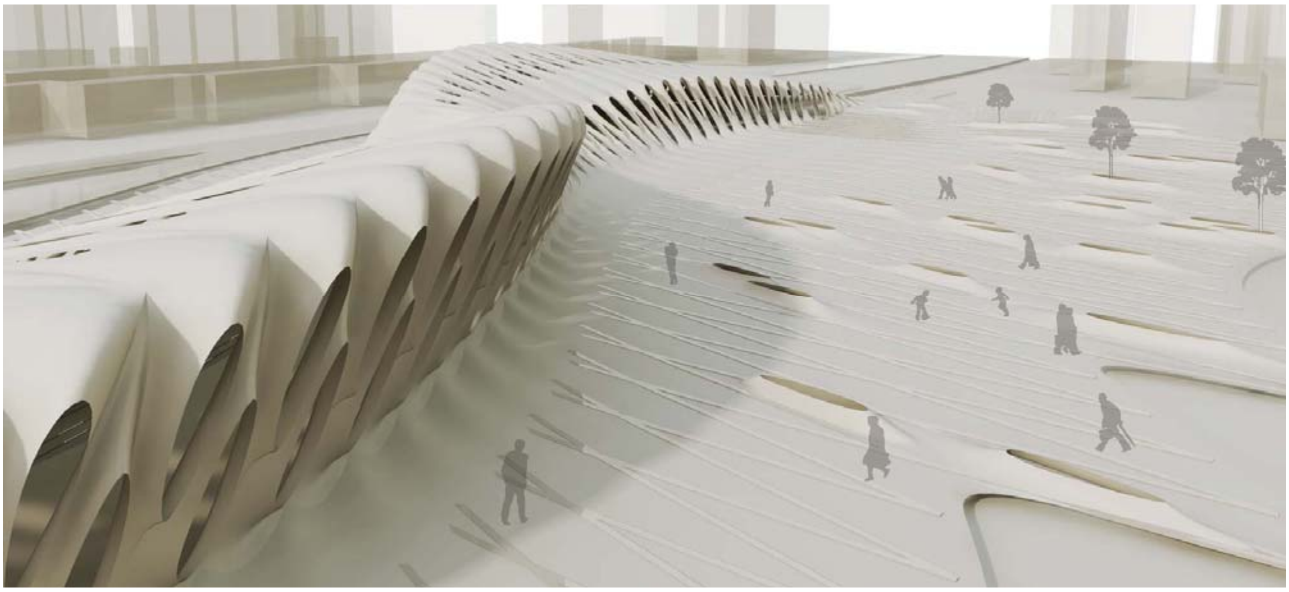
Figure 9: Cumulative Processes; Exterior View (Mandler and Siebenfoercher)

Creative Potential
Architecture always encompasses a concurrent series of different design problems, which require a complex architectural solution. However, most scripted systems cannot but solve one aspect of its underlying logics and complexities, which then guide the rules for the generation of project-specific geometries and shapes. This architectural layer, which is added onto and connected with multiple systems and sub-systems, will vary according to the designer's capacities and should be understood as an integral part of the overall design process.
Sophisticated tools produce, when applied, a series of possible outcomes and enhance responsiveness between the designer and his design project. However, they can neither substitute creative potential nor are they capable of producing viable architectural results without the constant intervention of the designer.

The student projects presented in this paper are selected from design studio work done at the department for experimental architecture at the Technical University Innsbruck, Austria. Professor: Patrik Schumacher. Teaching assistants: Michael Budig, Markus Malin, Robert Neumayr. http://www.exparch.at

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