

Aesthetics in Computational Design

A reflection on Max Bense's theory on aesthetics of information and state of things.

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Current dominance of functionalist and performance related approaches to computational design and methods in architecture are investigated under the precondition of Max Bense's theory of aesthetic potential. Establishing Bense's taxonomy of aesthetic potential and applying it to selected computational methods the level of aesthetic potential within the different computational approaches is investigated. Frei Otto's soap bubble experiments serve as a reference to illustrate different levels of aesthetic potential. Bense's aesthetic potential, which lies not in the eye of the beholder but is immanent to the object itself as a property of the object, suggests that computational design systems synthesising objects based on rules or embedded constraints appear to either have little aesthetic potential or receive their aesthetic potential from the outside of the computational system, namely the interaction with the user. Evolutionary design systems appear to create objects or processes with a certain aesthetic potential within Bense's theoretical framework.

Keywords: Max Bense, aesthetic states, computational aesthetics, aesthetic theory

A NEW STRUCTURALISM

Computational design approaches and form finding algorithms are often driven by performance related design criteria (Block et al. 2017) or by fabrication determinations (YUAN, Menges, and Leach 2018). Challenging Egon Eiermann's structuralism, Spaeth (2009) explored the idea of structuralism in Eiermann's signature ceramic tile facades. Not focusing on structures or engineering but by interpreting Eiermann's tile facades as simple rule based design system, where the basic element is the tile and the

design solution is to emerge from the inherent properties of the basic element and the respective design requirements transposing the structuralist idea onto computational design methods. Oxman and Oxman (2010) reiterated and postulated the idea of a 'New structuralism' in a homonymous volume by collating canonical work authored or dominated by structural engineers. The integrating brackets of these case studies are predominantly the consideration of materiality and the integration of physical material properties respectively behaviour into the design process

and the related computational approaches. Not surprisingly Oxman and Oxman refer to renowned engineers such as Peter Rice, Edmund (Ted) Happold, Ove Arup or Frei Otto, to only name a few, appraising their ground-breaking work in 'prioritising of materialisation', structural performance and the emerging form thereof over an artificially or artistically envisioned and morphologically or visually predetermined solution.

ARCHITECTURAL ARTICULATION

Schumacher argues that the articulation is the core business of architects. It is a necessary condition to distinguish the work of architects from those of engineers. Schumacher's "[a]rticulation is concerned with the subjective comprehension of the spatialised social order. Articulation cannot be dispensed with; it involves the central competency of architecture. Articulation contains the *differentia specifica* that demarcates architecture/design from all engineering disciplines. Articulation reckons with the fact that buildings function only via the user's active 'reading' of their spatial organisation. (Schumacher 2014, 144-45) He further argues that design tasks require not only articulation but due to their complexity in the current environment they need articulation strategies since "[a]rchitectural projects are now often confronted with unique briefs and institutional arrangements that require solutions of unprecedented novelty. Reliance on a handful of given character types can no longer exhaust the task of articulation. Articulatory strategies have to be devised that order the visual field and guide the eye to recognise abstract configurations and the focal moments or key distinctions within them." (Schumacher 2014, 147) Schumacher clearly extends the articulation of architecture beyond the functional aspect of functionality, fabrication and structure into the social realm. In the following the architectural articulation is extended into the aesthetic realm of computational architectural design methods.

AESTHETIC STATES

No doubt, many of the featured projects and designs in the 'New structuralism' (Oxman and Oxman 2010) hold aesthetical value of some sort and are perceived as beautiful and aesthetically outstanding. However, reflecting on Max Bense's approach and definition of aesthetical value or 'aesthetic state' (Bense and Walther 1997-1998, 288), aesthetics as a result of creativity appears not to be absolute and not to be related to a subjective perception. Aesthetics, after Bense, is rather objective, relative and immanent to the object itself and is dependent on the object's or phenomenon's level of determination in relation to the world. Consequently, a reassessment of aesthetic quality distinguished from one's individual and subjective perception of beauty would be required. Bense emphasises his efforts towards the mathematical, technical, or scientific aesthetics - an 'objective aesthetic', a 'material aesthetics', which is not speculative but analytic and rational. Bense's aesthetic is not interested in the effect that the object evokes within the perceiving individual, but in capturing the qualities of the object or the phenomenon itself.

Bense's establishment of the aesthetic state refines from Kant's account on beauty, where beauty and the judgment of beauty lies in the perceptive and cognitive potential of the perceiving individual but not with the object itself. Kant identifies the subjective feeling of pleasure as a necessary condition of pure judgement, but not yet as sufficient. Although Kant's aesthetics and the judgement on beauty is referred to the subjective perception and individual satisfaction, it also demands for a certain distance from the subject by demanding the subject's disinterestedness from the object. Achieving a pure judgement of the aesthetic quality of an object, the perceiving subject must have no individual interest in the object and in the satisfaction from its perception. The perception of the object must not be related to the individual's immediate needs or senses, i.e. thirst, hunger or usability and function in the wider sense. The concept that generalises the satisfaction from the individual perception and satisfac-

tion into an agreeable aesthetic judgement of the object is the concept of intersubjectivity. The aesthetic judgement and the argument for the aesthetic judgement can only be valid if it was able to receive general assent.

"The judgment of taste determines its object with regard to satisfaction (as beauty) with a claim to the assent of everyone, as if it were objective." (Kant 2006, 128)

Notwithstanding, an aesthetic judgement also cannot be a mere logical consequence of one's reasonable mind, because it is subjective. Kant says that it is impossible to 'proof' the aesthetic quality of an object. For Kant, beauty and aesthetic judgement cannot be achieved outside subjective perception.

"The judgment of taste is not determinable by grounds of proof at all, just as if it were merely subjective." (Kant 2006, 130)

Kant subsequently introduces the idea that aesthetic judgement would be based on a common sense determined by the reciprocal activity of the subject's imagination in its freedom and the universal understanding with its conformity to rules and laws. Agreement on beauty and aesthetics emerge from the interaction between the subjective satisfaction from the object and the understanding of the object's relation to convention.

Kant distinguishes consequently between art and science. Whether the representation of an object is artistic or scientific depends on whether its representation draws from and materialises the natural faculty of the object or whether the representation is a singular and isolated instance of such faculty.

*"Thus the critique of taste itself is only subjective, with regard to the representation by means of which an object is given to us: that is, it is the art of science of bringing under rules the reciprocal relation of the understanding and the imagination to each other in the given representation (without relation to an antecedent sensation or concept), and consequently their concord or discord, and of determining it with regard to its conditions. It is **art** if it shows this only in examples; it is **science**, if it derives the possibility of such a judging from*

the nature of this faculty as a faculty or cognition in general." (Kant 2006, 131-32)

Bense extends and develops this account on beauty and aesthetics by specifying the qualities of the object or phenomenon into three distinct states: the physical, the semantic and the aesthetic state. This preliminary classification characterises the world by the level of determination. The physical state is a state of strong determination. This is the given world, determined by physical and natural laws. The second class, which Bense articulates as the semantic state, is determined by convention or mutual agreement. In the semantic state, meaning is imposed onto an object by mutual agreement. Consequently, the object then transforms into a sign with meaning legible to others. It is an artificial convention and is not immanent to the object itself. Due to the arbitrary nature of conventions, the legibility of the object's meaning, the sign, is limited to those who are familiar with the convention, to those who know the language. Since this language is based on convention on a mutual agreement, it is not universal but arbitrary. But it is also not individual or singular, since it is shared between a certain group. The semantic state transfers an object or phenomenon from the mere causal existence into a state, transcending beyond being a mere consequence of natural processes. The third category in this classification of the world is the state of aesthetics. This state is characterised by a very low level of determination. Aesthetics consequently requires an object to be more than a consequence of either physical or natural laws on the one side or a consequence of conventional determination. The low level of determination also implies the absence of predictability or even requires a level of innovation.

Consequently, according to Bense's definition, the natural world, nature, is incapable of generating aesthetic states, because the emergence of nature, which may appear beautiful or of aesthetic value to us, is the necessary consequence of a completely determined process. Nature is not part of the 'creative scheme' but part of the causal one. Nature

and the morphology of nature is the result of highly determined physical processes and therefore it does not qualify for aesthetic states as established earlier. This is interesting in the light of recent developments manifest by simulating generative process from nature employed as tool to create aesthetic repertoires of the material world. The utilitarian approach to architectural production manifest in the call for 'The return of nature through computation' (Abondano 2013, 270) would clearly oppose for this process to generate or reach a state of aesthetics. Since all computational methods are systematically bound to algorithmic processes and consequently to the determination by rules. The immediate question that arises is whether computation is able to generate any aesthetical state at all. Articulated in a more general way, it poses the question whether computer-based processes are potentially creative.

THE CREATIVE SCHEME

Dissenting to Kant's idea of subjective perception Bense defines the aesthetic state as immanent to the object and the aesthetic object as the result of the 'creative scheme' (Bense and Walther 1997-1998, 285). The level of determination is low in the creative scheme and consequently to the object resulting from the creative scheme holding a high level of aesthetic potential. The aesthetic object cannot be the natural consequence of a deterministic process. It must be the result of an unpredictable process, existing due to the concatenation of events of low probability. The creative scheme locates beyond the consequence of natural science and physics and beyond semantic conventions. The creative scheme operates beyond the semantic scheme due the arbitrariness of the conventions. Because the agreed conventions which semantic understanding builds on are arbitrary therefore they do not satisfy the condition of low probability yet of a certain level of determination. Certainly, they are not a natural consequence of a physical process, but the semantic processes participate not yet in the creative scheme.

LEVELS OF DETERMINATION

Bense defines aesthetical states as states of low determination, whereas for example physical states are highly determined. Aesthetic states more explicitly are defined as individually or singularly determined. Physical states are generally determined; by general law of physics and nature for example. Any state or any order requires a certain amount of determination. Through the level of determination or order we can identify different states of the world and its objects. Semantic order would lay in between the previous two extreme orders of full determination in the physical state and low and singular determination of aesthetic states. This in-between order would be assigned to particularly determined states, they are partially determined by convention. This determination is not naturally given but is also not completely flexible and individual and singular but shared and determined to a certain level.

Aesthetic processes are the opposite of physical processes as shown above. Artistic processes often introduce aesthetic states not via the opposition - the physical process - but via the in-between state of conventional semantics. Schumacher's reading of space and the social potential of such spaces is a clear indicator for the approach of artistic processes from the semantic angle. It might even be an indicator that Schumacher's 'parametric style' is part of the semantic scheme rather than the aesthetic scheme after Bense, since it requires some agreed convention to 'understand' and 'read' its articulation. However, the architectural synthesis is not understood as a mere consequence of semantic articulation but as a wilful transformation of functional exigencies into an artistic concept. (Schumacher 2014)

AESTHETIC PONTENTIAL OF COMPUTATIONAL DESIGN SYSTEMS

Constrain based systems

Constrain based systems work in a predetermined environment where the set boundary conditions only allow for the synthesis of valid solutions. Non-computational examples of such a constrain based

Figure 1
Physical state: high level of determination representing the consequence of certain conditions.

system are Frei Otto's soap bubble experiments, or Gaudi's famous catenary models, representing constraint based design systems for efficient structural systems either for tensile and membrane construction or slender and efficient compression only structures respectively.

Integrating the constraint based systems into Bense's taxonomy of different states of the object and corresponding processes we would need to distinguish the processes and results thereof threefold: processes and results which fall into place due to natural laws, ones which exist due to conventions and those which would only emerge out of aesthetic process. Frei Otto's soap bubbles are immediate and determined consequences of the physical properties of the soapsuds and the geometry of the wire frame. The emergence of the bubble itself and the process of generating the bubble by dipping the wire frame into the soapsuds is classified as a naturally determined process, falling under the physical state and therefore would not be considered an aesthetic or creative process. Clearly, it is not the emergence of the soap bubble that is the creative process, since, as evidenced before, it is a natural and deterministic process, but it is the setting of the wire frames, it is the generation of the geometry of the wire that will make the soapsuds fall into its natural state of the minimal surface. How would one distinguish different levels of aesthetic potential within these emerging soap bubbles, since they are all the natural consequence of the physical and geometric properties of the system? Intuitively, we would assign different levels of aesthetic potential to different soap bubbles and their related process of emergence.

Figure 1 is a random and natural process that leads to the emergence of soap bubbles, following the physical laws and material properties of the ingredients. This configuration of soap bubbles would not fall into the creative scheme, because its emergence holds the same probability as every other random configuration. This or any other configuration of the same type will be as likely as any other.

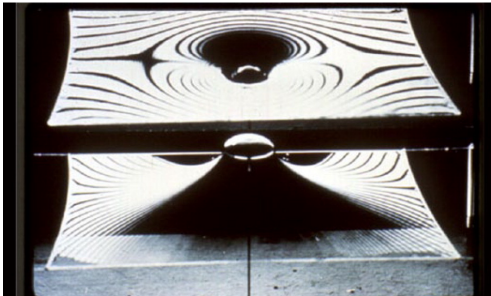
Figure 2
Synthesis of a single soap bubble.



Figure 2 illustrates a process with a certain creative potential, since the way the individual produces the soap bubbles will affect the result. Thus, it is not a merely natural process. However, bubbles of different sizes, that result from different air flow, would still hold a very low level of aesthetic potential since they are very likely to appear, regardless of whether a person or the wind would blow into the tool. Whereas the creation of a bubble in a bubble would hold a higher level of creative or aesthetic potential, because it is unlikely that this would be produced by mere accident. It is of lower probability of existence and higher order. Interestingly, it would not matter whether it would be created by the wind or by a person, since the creative potential is with the object and not the creator or the perceiver. It appears that through the interaction the probability of the emergence of some configuration over others change. Furthermore, we observe the probability of emergence corresponding to the order of existence.



The soap bubble represented in Figure 3 holds a high level of creative of aesthetic potential, because it is emerged from very unlikely conditions resulting in a high level of order and an included purposiveness, which the other two examples are short of. Many parameters must align and be adjusted to have this configuration emerging. It is of very high order and very low probability and result of the creative scheme, even though the soap bubble and its surface are pure physics.



Transposing this idea to computational design systems operating in constraint conditions, simulating certain boundary conditions such as gravity, the creative potential of the system and the respective results will be exposed. Rhino Vault as a representative of such constrain based design systems offers an environment where the user can set certain boundary conditions and the algorithm proposes a structural system comprising of only compression forces normal to its structural elements. Like all simulations Rhino Vault simulation is based on a simplification of the real world applying the “Thrust-Network-Approach” (RhinoVAULT 2012) to the design system. The system allows only valid geometric solutions within the compression only vault system. It is not an optimisation procedure where the system makes certain decisions or assesses specific solutions against each other. Consequently, the solutions are all on the same level of probability, depending on how the boundary conditions are set, the system will deliver the valid solution for the compression only geometry within the boundary conditions. Like the man-

ual soap bubble design system, the dipping into the soapsuds which doesn't represent the creative process, the use of the vault system is located in Bense's physical scheme, since it will fall almost naturally into the right and physically possible solution. Thus, it must be the setting of the boundary conditions and more specifically the setting of some unlikely boundary conditions which would synthesise a solution of low probability and therefore with a high level of aesthetic potential. Consequently, the aesthetic potential is not created by the computational design system but by the user and the supposedly iterative approach to find solutions holding aesthetic potential, according to Bense's taxonomy.

Rule based systems

Rule based generative design systems create objects applying a set of rules to an initial state of the object. (Benrós, Duarte, and Hanna 2012) Rule sets sometimes randomise the decision making in the course of the application or order of the rules. The systems are typically closed systems where no interaction from outside the system occurs. As a result, solutions hold the same level of probability, since they all follow the same rules and appear to be a logical consequence of the rules. Since no discrimination between the solutions is established, after Bense, they would hold the same level of aesthetic potential since the level of order and the level of the probability of emergence between all the solutions would be the same. The set of rules, which is not created by the computational system, but by external interaction from the user potentially discriminates progress within the design development. Notwithstanding, it appears that the computational system as such is not creating aesthetic potential, but the interaction of the user might.

Evolution based systems

Generative design systems, such as evolutionary algorithms mimic natural growth and selection processes. A set of certain environmental conditions, initial parameter, mutation and selection rules synthesis populations of solutions for the given design task. (Spaeth 2016) Such algorithms are typically optimi-

Figure 3
Aesthetic state:
Soap bubble
experiment Frei
Otto. (Goldsmith
2016, 26)

sation algorithms where the goal is to find the most fit solution for the set design parameters. Multiple and opposing design parameters often lead to solutions where a clear optimum is not emergent but several solutions which are leading the game in different combinations of the requested design parameter. Including randomised components into the algorithms attempts to simulate and integrate the unpredictability or the emulation of a human designer. Integrating an evaluation procedure which discriminates different proposed solutions referring to their level of achievement towards set design goals the probability of specific solutions further decreases. A very specific combination of properties of the elements of the object need to fall into place to dominate over other individuals in the population.

CONCLUSION

The application of Bense's theory of aesthetic potential to various computational methods in architecture revealed that the mere use of computational tools does not necessarily create aesthetic potential, while they might be very pleasing at times. Accepting that the aesthetic potential lies outside the perceiving individual but within the object and in relation to the level of probability and determination it appears that the evolutionary algorithm with the integrated assessment procedure can be regarded as part of the creative scheme. The explored constrain based system and rule-based system appear to create the aesthetic potential outside of the computational system but within the interactions of the user. The latter two methods do not provide sufficient distinction of level of determination or probability. Arbitrariness is not a sufficient condition for aesthetic potential since the probability of a certain occurrence is shared across all objects or processes. To create aesthetic potential the computational method must be set up to create an environment that restricts the probability of certain solutions but avoids at the same time to be a natural consequence of the set conditions.

Observing the soap bubbles it appears that the creative scheme and the aesthetic object emerges at

the boundaries of solution spaces. Not only is the probability of emergence very low, but also the determining parameters appear to be very sensitive to change. The aesthetic object would not sit on a platform of a local or absolute maximum of the solution space but would be located on a fine peak within a solution space not necessarily at the highest level of the entire solution landscape.

The further development of design systems will have to consider their aesthetic dimension beyond the subjective and individual preferences of visual appearance or the utilitarian and technical justification of performance requirements if we move towards design systems, which are driven by artificial intelligence, to enable the creation of aesthetic potential which is independent from individual and subjective perception of beauty and pleasure.

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