The becoming of form: morphogenesis as paradigm to preserve identity in complex architecture

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Abstract

A design process is dynamic and infinite. An architect has the demanding task to tastefully shape and materialize the environment in support of a program supplied by a client or situation. Solutions are naturally diverse and subject to an ever changing field of functional and aesthetic criticism. We have grown to know the computer as an instrument capable of providing strong feedback during the design process. This increased the possibilities to embrace the complexity that can be found in a contemporary architectural design challenge. Nevertheless, most software currently used in the architectural field still only operates as an enhanced drawing tool and the majority of designs are based on settled strategies.

This research paper is a study towards a possible application of the computer, contributing in the morphogenesis of a complex architectural structure using a bottom-up approach. The main issue addressed in this paper is how contemporary architects could benefit from an evolutionary design approach.

The proposed paradigm requires a shift in the way the architect is operating. Rather than working on a single design solution, the architectural program is to be expressed as a dynamic body plan, capable of unfolding into a variety of design alternatives. This relational diagram should contain all relevant information regarding the functioning of the different building components in time and space. Based on the relationships that are found in the body plan, generative procedures consisting of logic rules and constraints between building components can be invented. By implementing these procedures into a computer script, the geometry of possible design solutions can be generated.

1. The necessity of building

Five hundred million years ago, the first mineralization took place. [1] At that point in time creatures came into existence that had a stiff, chalky material in their bodies: bone. This new endoskeleton allowed a greater degree of mobility and therefore introduced opportunities to conquer new territories on land, in water and in the air. This development has led to a large range of different species, including man as a relatively intelligent mammal. The development of the endoskeleton and the different species are the result of long transformation processes in which the bodies of organisms have slowly adapted to their environments. A magnificent happening one could say, even hardly imaginable from our current notion of time. Not only has this process taken place a long time ago, it also took a remarkable amount of time to
complete itself. *Complete* is actually a rather wrong term in this context, because in terms of evolution things never really finish. As a matter of fact, it even remains questionable what evolution is heading towards. To return from this notion to the present, we can remark that in contrast to nature, mankind has learned to embrace the idea of completion. From an evolutionary point of view this is rather questionable.

The *second mineralization* took place about 8000 years ago, when man established himself in what we could call the first primitive settlements. This *city* is to be interpreted as an *exoskeleton* of houses that were constructed of material that was found in the direct natural environment, like clay, stone and animal skin. Most remarkable in this summary is the fact that some million years have passed between the development of the endoskeleton and the exoskeleton. Indirectly this indicates that a bizarre amount of creatures have died under environmental conditions or attacks of enemies before the idea arose to create some sort of urban shelter. This principle might seem trivial to our concern, but this architecture with its one dimensional functionality of protection must have been an absolute culmination for a primitive being in that time. This shows that *context* is an important issue when we consider the performance of our built environment. In more correct evolutionary terminology we refer to this as *fitness*.

Mankind developed itself as a herd animal towards what we now call a higher degree of civilization. One of the most important characteristics of civilization is the development of some sort of organization, mostly related to a hierarchical division of labour to ensure social functionality. One of these tasks is to maintain the built environment, the discipline of architecture. “*Civilizations head forward. They leave the age of farmer, warrior and priest to achieve what we can rightly call culture. Culture is the end of a selection process. Selection means to refuse, to prune away, to clear off, to bring forward the essential loud and clear.*”

[2] Regarding this expression by Le Corbusier in his work *Vers une Architecture*, we can state that architecture is a product of civilization that can only exist when primary livelihood is taken care of. This implies that there is an explicit difference between the trite necessity of building and architecture. If architecture is considered to be a part of a civilization’s culture, it is also subject to the selection process proposed by Le Corbusier, in which only the most representative cultural elements are retained. The actual state of cultural identity is therefore intrinsically bound to the context of society and time. If the architect is not only occupied with the development of the built environment but also honoured for his contribution to or reflection of the cultural identity of the society by doing so, then where does this urge for cultural expression originate and what do we consider to be tradition?

2. The development of ingenuity

If any form of culture exists above the natural urge to survive, we could state that mankind has intellectually overgrown the slowness of the evolutionary process. By achieving a prominent civilized establishment on earth, a significant transformation has taken place regarding the frame of reference for human progression. Measurement of improvement is no longer based on the position of a primitive man in a rural environment, but that of an intelligent being in an increasingly complex society. In this context, culture appears highly
related to cultivation. The development of the human intellect is naturally depending on its perception of the environment and the opportunities to master it. Knowledge is a prominent factor in this process. The possession of knowledge regarding another person, and therefore the possibility to explain phenomena, means power. This classic hierarchical construction can be depicted as a psychological result of the curiosity of man. The intellect desires explanations and wants confirmation regarding its position in the environment. Architecture reflects this conviction both qualitative and quantitative in its buildings. The construction of immense religious structures like temples and cathedrals is a clear example. This sort of massive effort can banally be interpreted as a collective inability to accept human life as uncertain and unconditional. Generally these buildings are nevertheless considered to be valuable elements of the cultural inheritance of society. According to Le Corbusier's expression, they must then form such a cultural essence that they have survived several cultural selection processes during their existence. Considering the relativity of their absolute reason for existence, this is at least remarkable.

In 1633 Galileo Galilei created a sensation in the powerful Catholic church by claiming that his predecessor Copernicus was right a couple of centuries earlier when he stated that not the earth but the sun was the centre of our universe. The commotion turned out right because in contrast to Copernicus, Galilei was able to actually proof his claim with evidence. An advanced telescope allowed him to discover four moons circling around Jupiter, hence proving that not everything is spinning around the earth, as stated in the bible. Galilei was banned from society. [3] Mankind learned its lesson to verify the reliability of sources and the social belief gradually changed to a more scientific dogma of argumentation. This also brings to attention that technological achievements can be very influential regarding the perception of our world. The relative slowness of development in such intellectual processes shows its character when only in 1992 pope Johannes Paulus II declared that the church was mistaken in the case Galilei.

But what happens to the built environment in such circumstances? In spite of the resulting fluctuations in the social position of the religious regime the cultural value of their buildings remained remarkable ever since. The answer is to be found in the fact that the quality of a building is not only related to the actuality of its functional program or symbolic power, but also the way it was constructed technically or socially. From this point of view, a city can be interpreted as an opportunity to carve the development of a civilization in stone. Buildings that mark an important part of social history are therefore being referred to as *monuments* and are being protected in the cultural pruning process as mentioned by Le Corbusier. We can state that if a building is impregnated with cultural quality, its chances regarding prolongation of its existence are significantly increased. For a building, culture means surviving. If we consider culture in a passed era that identifies a society from a contemporary point of view, we can speak of *tradition*. The urge for cultural expression can then be interpreted as the desire to propagate contemporary convictions and fashions as well as the prolongation of those as tradition.
The architectural design task is positioned right between the traditions of the past and the possibilities of the future. This implies that a design task can be interpreted as an opportunity to rethink established paradigms and propose new directions for the future. Architecture is then capable of reflecting social developments by preserving a critical attitude towards means and methods. The question for the architect is how. This proposition in fact addresses the key architectural problem. How can we succeed in successfully shaping architectural buildings using contemporary technology and establish some sort of connection to the existing environment? After all, as cosmic essence an architectural form is nothing more than a meaningless collection of material and energy. [4] Only when a form is introduced into a context something can be said about its qualities regarding that context. In this case, man with its personal reference can already be interpreted as an extensive context.

The design process takes place in an interaction between the physical world of the location and the mental world of the architect. [5] This process is socially defined by the time that is available from the formulation of the assignment until the moment that the design is to be transferred to its final material implementation. Naturally, a design process actually doesn’t have either a starting or endpoint. Critical fundament in this proposition is that design solutions cannot be judged in terms of true or false, but only better or worse. [6] Nuances that can lead to differentiations or improvements are principally infinite and an architect can therefore never mathematically prove that his design solution is the absolute best. Completely conforming to the process of evolution, a design process will therefore never naturally finish, but only possibly reach a sufficient amount of qualitative satisfaction. This quality can be interpreted as a compromise between functional and technological but also social aspects of the architectural building. Quality, or the beauty of the solution, is therefore highly subjective and by definition dependent on its context.

Nature has always been one of the most important sources regarding the characterisation of beauty. It’s not coincidental that many principles and proportions that can be found in classic architecture are based on observations from nature. Next to that, we often find morphologic similarities of buildings or objects with organisms or other natural phenomena accounted under the mystical term organic. Although it seems that mankind has grown away from its natural instinct, the appreciation of the natural environment has never disappeared. Perhaps this fascination originates in the fact that nature will always be the primeval context of our environment.

“All things in nature have a shape, that is to say, a form, an outward semblance, that tells us what they are, that distinguishes them from ourselves and from each other. Unfailingly in nature these shapes express the inner life, the native quality, of the animal, tree, bird, fish, that they present to us; they are so characteristic, so recognizable, that we say simply, it is "natural" it should be so. […] Unceasingly the essence of things is taking shape in the matter of things, and this unspeakable process we call birth and growth. […] It is the pervading law of all things organic and inorganic, of all things physical and metaphysical, of all things human and all things superhuman, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, that form ever follows function. This is the law.” [7] In this explanation of the term natural beauty by Louis Sullivan in 1896, it is not
hard to understand that he is in fact referring to the natural evolution of organisms in nature. Natural beauty, he says, is the result of an endless adaptation process of functional and morphological improvement of organisms, based on their fitness regarding the environment. From this point of view, we could say that natural beauty achieves itself. Remarkable problem is that the time span of such evolutionary process simply exceeds the human frame of reference. In a way we could say that mankind is being confronted with the limits of its own intellectual victory over the speed of the evolutionary process. Next to that it is highly doubtful whether a structure emanating from our own intelligent building traditions will deploy in a desired way when it is left to the ravages of time. There is a simple reason for this. The dilemma in Sullivan’s proposition is the paradoxical equation between buildings and organisms regarding the process of formation. It is there that we can allocate a crucial difference, explaining why an organism will develop itself and a building will decay in an evolutionary process - a matter of life and death.

An organism is a living system. A living system is characterised by *autopoiesis*, meaning that is able to reproduce itself. [8] As Sullivan noted, natural organisms morphologically express their inner beings. This is actually a very true diagnosis because the identity of an organism is quite literally imprinted in its DNA. The morphologic development of an organism is directed from this DNA, a process which in biology and cybernetics is being referred to as morphogenesis, the becoming of form. [9] This way, the species to which the organism belongs is able to survive, and develop itself over many generations towards a better version of that species. In contrast to that, a building is a dead system. It is being used, eventually being adjusted, until it is finally declared useless and being demolished. The life cycle of the building is then completed, while the life cycle of an organism will principally never finish. Worst case scenario for the species is when it becomes extinct due to a fluctuation in the biological equilibrium. From a human perspective it is hardly imaginable that architecture will become extinct, but it is even more unlikely that buildings will physically develop themselves towards natural beauty without morphogenetic properties.

### 3. The rise of the machines

The opportunities of man to interact with its environment have always been restricted by the available instruments. Craftsmanship has traditionally been the social framework in which forms of production were established with available methods and means. Along with the intellectual development of mankind, this way of production was eventually conceived as too slow and too inefficient. The moment at which technological improvements finally introduced a new way of producing, capable of permanently replacing the physical intensity and irregularity of traditional crafts, is being acclaimed as a scientific culmination, forcing a breakthrough in the possibilities of the civilized man.

“The Machine is Intellect mastering the drudgery of earth that the plastic art may live; that the margin of leisure and strength by which man's life upon the earth can be made beautiful, may immeasurably widen; its function ultimately to emancipate human expression! [...] Now let us learn from the Machine. It teaches us that the beauty of wood lies first in its qualities as wood. [...] The machine has emancipated these beauties of nature in wood. [...] The essence of
this thing we call the Machine [...] is no more or less than the principle of organic growth working irresistibly the Will of Life through the medium of Man.” [10] With his entitlement as regenerator of the creative conscience, Lloyd Wright clearly adopts the machine as an opportunity for man to put organic growth to operation in architecture. [10] Regarding this expression we could conceive the machine as an industrial variant of the natural reproduction process. Next to that, Wright also addresses that with the introduction of the machine, architecture is finally able to get rid of excessive ornamentation, hence corroborating the natural beauty of pure materials. For Wright the machine is obviously an important step towards a naturally achieved morphology.

This story changes when the position of the machine regarding nature is reversed. According to Amédée Ozenfant and Le Corbusier “the machine applies natural laws inherent to the order of the world with more precision than ever before.” [11] According to this thought the machine rather than nature is granted with a higher degree of rationality and capability to develop morphologic perfection. The most important motive in this proposition is again the need to get rid of the juiciness of the fine arts that are embedded in a language “that is full of terms with a complex, weakly or undefined meaning” and “only intend to excite immediate emotional feelings“. [11] The difference in both approaches appears when the glorification of the machine as cultural-morphologic curator results in excessive standardization and repetition in urban architecture.

“He [the farmer] wanted to build himself, his family and his cattle a house, and he succeeded. Just like his neighbor and his ancestors succeeded and like every animal succeeds that follows its instinct. Is his house beautiful? Yes, just as beautiful as a rose or a thistle, or a horse or a cow. [...] The urban citizen is uprooted.” [12] Apparently the machine can not only be honored, but also rightly feared because of its potential to remove emotion from art. This quotation from an article by Adolf Loos from 1910 expresses a significant difference between the modern architecture of the machine and the trite architecture of the farmer. The example illustrates that tradition cannot be removed from architecture without losing culture and identity. Tradition is hereby demonstrated as the process of cultural inheritance from which the built environment originates. For Loos, modernity refers to the actualization of tradition using contemporary techniques. This is contrasting with the radical superposition of industrial-modernism as proposed by Ozenfant and Corbusier. The celebrated conception of automation in architecture deteriorates into ambiguity regarding its position in society.

The machine phenomenon has been subject of exponential development during the last century. At first existing mechanical production technologies were being improved under ongoing revisions, but it didn’t take long until the machine age spread its wings to infiltrate other disciplines. Intrigued by extension of its cognitive boundaries, man captured earth in a net consisting of infrastructure, wires and radiographic connections. Eventually mankind technically gained victory over as good as all its classic restrictions by which its perception was physically bound to a location on earth. Not only does man become highly mobile because of an exponential growth of transportation possibilities, but also capable of audiovisually sharing knowledge around the globe due to a tremendous development of communication methods. In fact we could state that during the last century a revolution has been accomplished in which mankind disrupted its traditional four-dimensional self-centered
living space into a new hyper-reality. This revolution can be interpreted as a significant increase of complexity in our direct social environment to which architecture as Cartesian science has barely found an answer yet.

That’s an interesting remark. If we have stated that mankind has long started to behave as if it intelligently vanquished the slowness of evolution, but after all it appears that a fundamental part of its existence, the organization of its environment, cannot keep up with the global development, this raises questions. We could suppose that architecture in regard to the global cultural progression is stuck in old dogmas. And what about knowledge? Knowledge means power, but now that information is almost literally on every corner of the street nearly everybody is able to declare himself supreme. Then again, due to the public character of contemporary propaganda it is almost a necessity to question the validity of information. Mankind has not only developed itself into an intelligent, but also an autodidactic self-regulating being. Question remains what this could mean for architecture. During the second half of the twentieth century an antiperistaltic architectural movement came into existence fronted by Team X, Archigram and architects like Yona Friedman and Robert Venturi with the aim to tackle the reigning modernist order. In several ways the introduction of complexity and variation as motive or morphologic characteristic was celebrated to dislodge the monotony of modernistic architecture. Nevertheless, no fundamentally refreshing paradigm arose, unless we consider the large amount of derived trends like postmodernism, deconstructivism or minimalism as a conglomerative paradigm.

As stated before, we can easily relate the development of mankind to the available methods and means regarding the perception of our world. Not by accident we can indeed appoint an important scientific transformation parallel to the hyper-cultural revolution. “Complexity theory focuses on complex relationships of elements, which are not random but subject to mechanisms that generate order on various levels of organization. Traditional science emphasizes stability, order, uniformity and equilibrium and focuses on closed systems and linear relationships. In contrast to that, complexity theory brings attention to disorder, instability, diversity, disequilibrium and unstable equilibria, and nonlinear relationships, which describe temporality and causality found in real-life phenomena more accurately than traditional scientific methods.” [13] Mankind finally accepts the uncertainty of its existence scientifically and therefore implicitly embraces the character of evolutionary behavior. In a complex system, perception is dynamic rather than static. The object is no longer the key element of the system, but rather the processes in which an object is embedded – the possible behavior of an object in its context. The morphogenetic process by which an organism is developing in order to let the species to which it belongs survive can be easily understood as a complex system.

When considering the architectural design process from complexity theory, we could state that the architect should no longer occupy himself with designing a building, but rather the possibilities a building provides to its context. In a way this is not spectacularly innovative, but a philosophical shift regarding the same problem formulation. The context of the building is to be interpreted as a complex system of social-cultural vectors, in which the architect has the possibility to apply new opportunities by adding material. These opportunities emanate from a given assignment, in case of an architect often the requirements of the functional
program. This way the architectural design task is automatically placed in a Deleuzian space-time continuum, where virtual design solutions influence the development of the space in time. **Virtuality** is in this case to be interpreted as the opposite of **actuality**. During the design process the architect makes decisions, thereby actualizing certain virtual solutions in the design. This way the architect can be seen as a director of the location.

Since the personal computer – the indispensable digital pet of the hypermodern era - found its way to everyday society, the architectural design process has practically undergone significant changes. These changes are mainly demonstrated in the architect’s way of working. The computer offers a framework in which the design can be virtually produced. In this case **virtuality** is actually to be interpreted as the opposite of **reality**. The virtual space can be considered an addition to the classic design unities of the mental and the physical space. [14] Main characteristic of the virtual space is the lack of set characteristics, allowing the architect to mould it according to his own needs. The virtual space is principally fold of air – meaning an absence of gravity – and is at best interpreted as an objective version of the mental space. Although the difference between the computer and the traditional pencil as design tool is essentially not radical, the computer offers a significantly higher amount of visual feedback with its available amount of projections and an increased procedural insight because of the infinite amount of possible virtual revisions during the design process. Enthusiastic progressive architects have therefore conceived software originating from the animation-industries as a true morphologic Mecca and most marvelous creations have emerged ever since. Sadly, a vast majority of these designs lack a technological sense of reality and possibilities to be integrated in the traditional four-dimensional environment both socially and culturally. As a result of that, the morphologic miracles, if finally producible, end up landing into the existing environment like UFO’s one by one. This in fact shows a suspicious resemblance with the invasion of repetitive modernist buildings in the first half of the twentieth century and still doesn’t give proof of an environmentally embedded natural beauty.

4. Scenario

Although architecture is mainly being development using the virtual space in a computer, the function of the computer itself is currently still rather passive. That is remarkable, because the processing power of the computer can be applied as a method to simulate an accelerated artificial evolution in the virtual space. The research regarding the application of evolutionary architecture has started in the second half of the twentieth century under commandment of John Frazer amongst others. [15] From an evolutionary point of view that is still very recent.

If natural beauty is to be achieved from an evolutionary process by morphologically adapting as optimal as possible to the environment, the definition of a building as an artificial organism seems necessary. The building is to be equipped with morphogenetic qualities - meaning it has to know how it is to be built. This seems rather paradoxical, because of the simple fact that a building is a dead system, only represented by its geometry in the virtual space of the computer in a passive way. Without human interaction in terms of revision it can principally never change and therefore not evolve. This might change when architects no longer express
their designs as geometry, but as morphogenetic procedures. The architect is challenged not to
design a building, but a **body plan** capable of unfolding into an amount of design exemplars.
This body plan is to be interpreted as the DNA of the building species to be created. In this
DNA the relational aspects of different building components, for example the connection of
certain rooms or circumstances when geometrical barriers are to be erected, are defined. The
proposed geometry will have to be based on realistic building components and techniques, to
prevent the design to lose the possibilities of physical implementation. The body plan is then
to be implemented in a morphogenetic computer script which commands the design software
to create geometrically represented design alternatives.

The generation of these alternatives can be very useful in an urban design assignment. Rather
than repeating a singular housing exemplar in a building block, a generative approach can
offer different housing solutions based on the same body plan, hence avoiding a monotonous
character on an urban scale. This could as well strengthen the possibilities of expression
regarding the cultural identity of individual citizens with common technology. In architectural
design however the goal is usually not to create a collection of building variants but a single
design solution, particularly an optimal solution to a given assignment. In daily practice,
designs for new assignments are often based on experience and successful examples from
earlier projects. Usually the architect first creates an amount of design alternatives, after
which one exemplar is chosen to be elaborated. In this sort of top-down approach the question
always remains in retrospect whether the chosen variant was the best solution. When
designing morphogenetic procedures, the architect is challenged to rethink the building
essence rather than profound characteristics, resulting in a typical bottom-up approach. The
generation of design alternatives can be interpreted as a way to keep the amount of
possibilities as wide as possible during the entire design process, hence preventing artistic
lock-in. Next to that it is even possible that generated variants exceed the intentions of the
architect, thereby stimulating the creative process.

A generative design strategy will not lead to optimal design solutions without artificial
evolution by using for example the Genetic Algorithm. [16] The generation of design
solutions is then to be used as a reproductive system, allowing virtual building species to
survive just like organisms in nature. Question remains what sort of fitness functions are to be
applied in order to let the building evolve towards a **better** version of that building. The
crucial problem is in the word better. It was stated earlier that design solutions cannot be
judged in terms of true or false, but only better or worse. [6] This statement remains true for
the design solution as a whole. However, individual design issues can be distinguished as
either qualitative or quantitative problems. While solutions to qualitative problems can still
only be good or bad, solutions to quantitative design problems can actually be judged as true
or false by defining a goal range for the problem and checking if a value is within the
specified range. Quantitative problems in architectural design are for example spatial issues
regarding the available building plot, distances between rooms, storey heights or ramp and
stair steepness, but also calculations regarding energy performance, construction constraints
or climate control. Generally, quantitative calculations have to guarantee that a building will
perform within ranges that are related to human convenience, no matter how complex the
design solution gets. The fact that the computer is very well capable of calculating values for
a large amount of interrelated qualitative fitness functions and therefore optimizing the
functional state of the building makes it a very powerful design tool. The generative design approach therefore has the power to make complex design problems controllable. Question remains if this implies that the generator, the computer, is capable of designing.

The difference between quantitative and qualitative judgement seems very important in this matter. One of the most influential, and maybe therefore also one of the most difficult qualitative aspects of a design solution is the aesthetic fitness. Since the formulation of aesthetic fitness is highly influenced by social and cultural fashions as well as personal taste it can be declared subjective by definition. As a result of that, the aesthetic fitness cannot be calculated through an objective rational approach familiar to the computer. Unless a computer is trained through techniques like inductive learning or equipped with distributed knowledge in the form of for example agents, it can never formulate a verdict regarding qualitative aspects of a design solution. Because every decision a computer can make will always be the result of human programming it remains philosophically questionable if the computer will ever exceed its status as a design tool. Its role is simply that of transforming the morphogenetic procedures into geometric representations and the calculation of quantitative fitness. In a generative design approach the qualitative fitness of the design solutions as well as the materialisation of the building components are mainly defined in the procedures derived from the body plan. It is in this part and the definition of striking fitness functions where the identity of the building is actually being designed and where the main creativity takes place, no matter to what level of complexity the building eventually might evolve.

In order to make evolutionary design a successful strategy a lot of practical research remains. Nevertheless it seems that technological achievements in the field of automation technologies already provided the means necessary. Perhaps we can state that John Frazer, similar to Copernicus a couple of centuries ago, has appointed a new architectural order. The wait is now for the rise of a new Galilei. The ultimate goal of evolutionary architecture will be that a building will conform to the cultural identity of its complex environment through artificial evolution, in a way that the building expresses its program morphologically in its context – the natural beauty.

5. References


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