DYNAMIC DESIGN MATTER[S].

Practical considerations for interactive architecture

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Interactive architecture – vision statement

Interactive architecture is a new concept in architectural design which is rooted in the global development of the information technology. However, unlike other recent developments which are a result of the employment of digital technologies that exponentially increase the amount of tasks that we have to deal with on our daily basis, interactive architecture has the potential to provide solutions to complex problems and information overflow which has emerged as a result of the new conditions of the digital era.

Development of radically new architectural qualities has become a necessity. Changes in lifestyles and in other cultural developments are now occurring faster, are more radical and, like never before, are highly unforeseeable. On the other hand, global society of today calls for architectural solutions capable of sustaining themselves in its dynamic spatial, social and natural environment. Since contemporary ways of life are so rapidly evolving in all their aspects, there is an urging necessity for architectural spaces to be enhanced in ways that would allow them to perform an active dialogue with their fluctuating content; to dynamically deal with changing needs of social groups, as well as to directly serve particular individuals. This trend forces architects to design flexibly, to take into account potential emergence of new spatial requirements that cannot be anticipated before the actual building use comes to place and which can dynamically change over time.

It has been commonly acknowledged that architecture has to be sustainable. This means that it has to sustain itself by its own means, instead of being sustained by external forces. Environment in which architecture has to perform consists of numerous layers. Those layers: the natural, social, cultural and many others, form local and global ecologies of all possible kinds, creating very rich networks of dependencies and relations. If demands towards architecture, coming from any factor of such intricate ecologies, under certain conditions abruptly change, architecture may have to either adapt itself in order to accommodate those new demands, or it has to give feedback to its environment to reconsider its requirements. In either case, this means that buildings have to develop an ability to react to unpredictable and rapid changes in demands for specific functional qualities. Serious consideration of these trends in architectural design leads to a concept of a new kind of architecture which treats architectural matter as a dynamic substance.

Such new kind of architecture has to be efficient. It hast to efficiently perform in its energy consumption, economical feasibility, in its structural aspects. It also has to efficiently deal with its surroundings and most importantly, with providing necessary spatial conditions. In other words, architecture has to satisfy various demands of its users and its environment. The difficulty is that those demands are never constant; they change over time and depend on numerous variable conditions. Additionally, we have to acknowledge that many of these demands can not be met due to reasons of logical or technical nature. Therefore within its ability to adapt, architecture also has to be able to deal with its own limits. It should go beyond the level of performance of a fully obedient savant. Buildings and their spaces should provide more sophisticated behaviour than the one of sheer response to our needs, simply because such unconditioned responsiveness cannot provide solutions in case of complex spatial situations. If linear problem solving doesn't provide satisfactory answers, solutions need to be found in a creative manner. For that reason, in addition to adapting to changing conditions, built spaces should be at the same time pro-actively counter affecting our lifestyles and activities. They have to actively negotiate with all external demands. In other words – they have to become interactive[1].

The notion of Interactive architecture is being commonly oversimplified, by being used to refer to buildings and built spaces which are capable of simple responsive adaptations and spatial customizations of various kinds. Indeed, automation of adaptive and customizable qualities of buildings leads to creation of architecture which is active in the core of its nature. However, only consequent replacement of linear logics that guide their behaviour with an ability to reason and learn results in achieving true interactivity – creation of spaces which are able to maintain a dialogue with their users, not only responding to their demands, but pro-actively engaging themselves in all kinds of featured spatial activities.

Interactive buildings are to be more than just simple customizable spaces. They will posses all features of traditional architecture, however, in addition to it; they will develop a subtle will of their own. They will serve us pro-actively, creatively coming up with features that depend on their constantly gathered, updated and validated knowledge. Interactive architecture will provide unprecedented experiences and aesthetics, which are not just one time, singular states, but which are going to be evolving processes. Architecture will become an active medium, mediating between individuals, between entire social groups and with other phenomena that have never been mediated with before.

Architecture as an open system - approach

The new vision of architecture and architectural design leads to a theory of treating architectural constructs not as finite singularities, but as multidimensional multiplicities, resulting in offering a wide range of solutions for varying environmental conditions and for flexible socio-spatial ecologies. This concept would have been in all probability an entirely utopian speculation, if it was not for the most recent possibilities emerging from the application of computers and other latest digital technologies in architectural practice.

As a result of employment of those new technological means, we are now witnessing an ongoing, radical shift in architectural design methodology. Firstly, linear and centrally steered “top-down” designing becomes replaced or supplemented by creation of parametric, procedural and relational digital design models. Consequently, those models become final design products themselves, making traditional, fixed plan drawings less important or even completely redundant. Secondly, mass production is being replaced by mass customization of building elements, made possible with data-driven manufacturing technologies. In this way, in many cases, it does not make a significant difference from the manufacturer’s perspective whether a building consists of repetitive components, or if its every single element is fully unique in its form. Thirdly, the use of latest digital technologies for digital sensing, data processing and actuating of buildings practically opens up a vision of architecture that can be flexible and adaptive not only during the design process but also after being built.[2]

The other consequence of, both virtual and physical, employment of such dynamic, multidimensional architectural design matter is to naturally include time as one of considered dimensions. In this way, architectural multiplicities can be comprehended as dynamically steered processes unfolding over time. Normally, such processes begin as virtual constructs and gradually become materialized as parts of the built environment. Various approaches that are being employed to deal with creation of such processes vary. On one hand there are reductionist ones; starting from an infinite amount of dimensions and gradually imposing constraints on the project and in this way reducing its dimensionality. On the other hand this problem can be dealt with by starting with a limited amount of dimensions and by subsequently gradually increasing their amount throughout the project development, leading to a design process resembling in its mechanisms the evolution or natural growth of living organisms. In any of these cases, architectural design methods have to be practically reinvented from the beginning. In place of designing spatial, singular forms, architects are now expected to design processes that produce architectural spaces. The nature of these architectural systems can be very diverse. However, providing that the aim of architecture is to be interactive, these processes have to be designed in an open and extensible manner.[3]

The definition of open systems can be formulated in opposition to traditionally more common closed systems, which despite the easiness in which they can be optimized for reaching certain clearly defined optima or for solving predefined problems, are not capable of self-improvement. Open systems, on the contrary, can evolve over time in non predetermined ways, which gives them a very high degree of adaptability to unforeseen circumstances. Complex adaptive systems are a specific kind of open systems which consist of a high number of autonomous elements. Even though each of these elements may be driven by very simple, linear logics, the entire system as a whole is likely to exhibit very intricate properties. It can develop an ability to learn and to perform simple reasoning processes. It can also be easily expanded and altered by increasing the number of elements or by changing behaviours of all or of a selection of its contained parts. Those features make complex systems ideal for architectural applications, which normally deal with a very high number of variable factors and undetermined, variable dimensions.[4]

3. Spatial consequences – opportunities and threats

It is impossible to exactly foresee what are going to be the long term consequences of applying the theory of developing interactive architecture as an open, complex system. It definitely leads to radically different ways of not only creating and thinking of architectural spaces, but also of using them.

If we look at three basic qualities of architecture originally defined by Vitruvius[5], we may realize that each of these qualities undergoes a radical transformation when architectural spaces start to be considered as being interactive. The beauty [*venustas*] of interactive architecture will lay not just in its one time appearance and proportion, but it will emerge from the manner in which proportions are maintained over a changing architectural form in relation to its also changing environment. The functionality [*utilitas*] of architecture will reach a wholly different level, since it will be fully dependent on changing functional demands. In this manner we will no longer evaluate the functionality of buildings as a definite quality, but we'll judge their efficiency in addressing unpredictably appearing functional needs. The reliability of architecture, which normally derives from its firmness [*firmitas*] will be probably the most difficult of the three qualities for the interactive architecture to fulfil. It will most likely take many experimental developments to eventually reach a fully reliable level of interactive architectural performance. However, although it is easy to think of many discouraging scenarios, perpetuated by science fiction films in the sorts of "Space odyssey 2001" or "the Matrix", it should not hinder us in trying to advance the quality of our spatial environment.

What may be the real difficulty however, is that implementation of interactive architecture requires radical changes in the way we culturally deal with architecture. The perception of architecture has been often based in confidence of a static model of the society. Architectural monuments, from tombs of Egyptian kings to modern churches have been designed with the intention of everlastingly conveying firm meaning and symbols. These symbols however devaluate faster than any of their creators might have ever expected. Therefore, the method has to be altered in which these values are being expressed by architecture. We have to become accustomed to the idea of change as a permanent element of spatial environment.

Prototyping the new kind of spaces – investigating practical solutions

Normally new milestone developments of human civilization are brought to common use gradually. Such is also the case of interactive architecture. Its creation cannot take place instantly because of the involvement of the very wide range of difficult problems that need to be solved to allow architecture to reach true interactivity. The least of them are of the technological nature, the most difficult problems to overcome relate to theoretical, cultural and social questions. In any case, these questions can only be answered by testing these new concepts in practice. For this, however, first a general methodology needs to be defined, which would suit best the development of interactive buildings. Yet, in order to propose a new design methodology, we first need to know what is the actual nature of things that are to be designed.

As argued earlier in this paper, interactive architecture has to be comprehended as a system. This task has already been faced by architects in the beginning of the 20th century. The “smart home” concept is probably the most common contemporary evolution of early modernist attempts in creating buildings as machines. In all these concepts elements of buildings are always centrally controlled in a predefined manner. This approach leaves no space for any further evolution of such creations, which practically rules out the idea of interactivity.

Instead, developing a system as an open network of interconnected elements is highly extensible and adaptable. Applying this idea to architecture means that buildings can be seen as a network of interrelated building components. Such networks in their principle are easily extensible and adaptable. However, the most important feature of open systems is that they are capable of developing what’s often referred to as “swarm intelligence” (Fig. 1). It is a holistic theory of intelligent behaviour that can emerge from systems which consist of a high number of simple interconnected agents. Those agents in case of buildings are the active building components communicating with each other, with people using the building spaces and with their environment.[6]

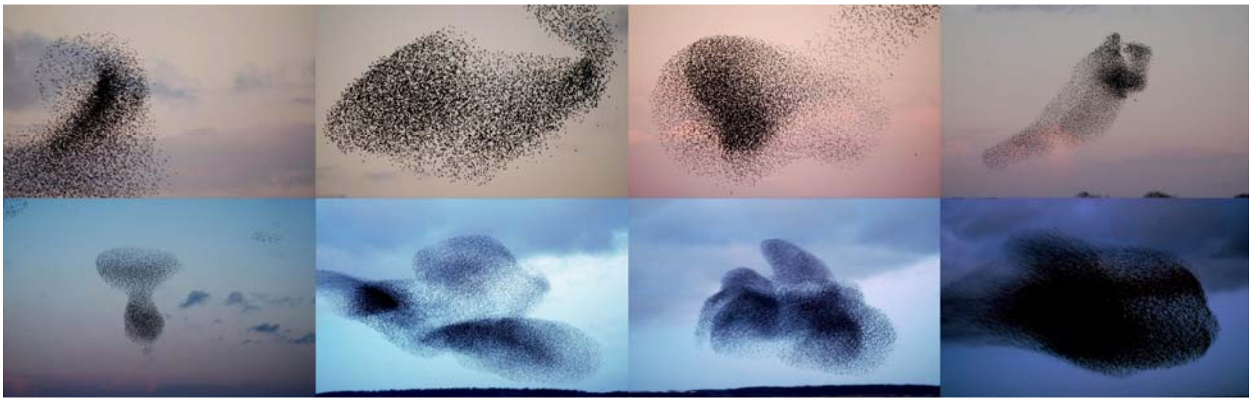

Fig. 1. Swarm “intelligence” in nature

In finding practical ways of creating complex systems, a lot can be learned from nature. In fact, every living being, seen as composed of countless smaller and simpler elements, is a complex system in itself. If we trace processes that form living organisms, it’s obvious that none of them had initially been shaped in all its intricacy. They always start with a single cell which multiplies itself numerous times. When a critical mass is reached, cells start to differentiate; they begin to form tissues and organs. Analogically, buildings can be designed and created in a similar manner. Originally consisting of a small number of components and gradually increasing their complexity, while a higher number of more advanced components are added. What’s more, with the process-driven approach, division between designing, construction and maintenance of buildings becomes very vague. Those three phases don’t have to be carried out in a sequence anymore; they can be in many aspects simultaneous or even mixed with each other.[7]

To validate the presented approach, several concepts have been tested and prototyped on 1:1 scale in numerous case projects. New materials became sensing and actuating organs of buildings and digital information processing worked as their neural system. This allowed creating unprecedented adaptive and performative qualities developed within designed spatial installations.

Interactive building elements

An interactive building can be composed of diverse active elements. Most interesting ones for feasible experimentation on real scale are those which build up "membranes" that separate distinct building spaces. In traditional terms membranes would be building facades and internal divisions. For interactive spaces it is important that a membrane can create either a connection or a boundary between separated spaces. What's more, it can actively generate and modify various spatial conditions on its two sides.

An interactive membrane (Fig. 2) can provide many functional features. If applied on small scale, apart from its primary role as a space organizing object, it can provide seating elements, light sources, atmosphere creation, ambient and direct communication, active monitoring, acoustic control, access control and many other. If applied on a larger scale, the range of possible functional implementations becomes even greater, giving hypermembrane potentially a role of a communication medium not only between individuals, but between entire social groups. What's most important, however, is that all these features are to be provided in a dynamic manner, as an intelligent derivative from information gathered by interactive membrane from its surroundings. The process governing the behaviour of the membrane will constantly improve its logic, given the ability to learn from different precedent situations and their effects on the environment and people. Applications of an interactive membrane idea can vary in scale and technique. Hyperbody has formulated a number of projects which will explore this concept in its many aspects and forms, ultimately providing knowledge to implement the hypermembrane commercially and solve a wide variety of complex spatial problems.

Fig. 2. Interactive membrane

From the technical point of view a membrane can consist of a number of connected autonomous segments which can serve as spatial divisions, but also seating places, display stands or sound and light sources. In this way it can provide adaptive spatial conditions by learning how to respond to variable information coming directly and indirectly from participants of space.

A number of technical solutions needed to be tested in order to select building techniques which will provide the best balance between the range of movement, structural stiffness, stability, strength, slimness, possibility of dynamic openings in the surface, aesthetic qualities and cost. Several options have already been tested within other projects related to the hypermembrane development, although limited financing and lack of open access to preferred technologies hinders investigations of many potentially applicable solutions. Developed as part of various projects these solutions include active pneumatic elements, dynamic flexible surfaces, separated objects visually appearing as one whole as well as several hybrid solutions (Fig. 3, Fig. 4). Kinetic features of such systems can be supplemented with light, sound, colour and information display using new kinds of digitally driven active materials.

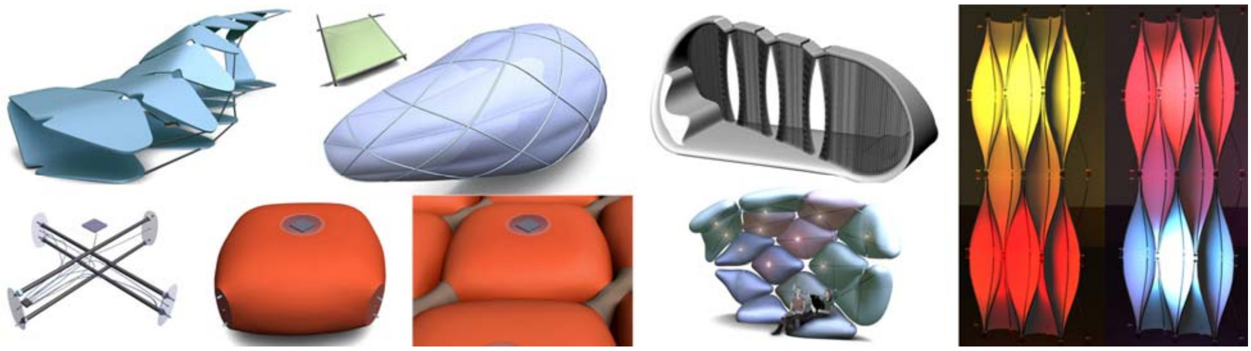

Fig. 3. Technical solutions for membrane implementations, concepts

Fig. 4. Technical solutions for membrane implementations, case projects

Another potentially interactive feature of buildings is their structure. Due to technical constraints two sorts of structural adaptation can be developed. Structural reconfiguration (Fig. 5) can take place if changes in structural geometry are not needed more often than in weekly or two-weekly intervals. In that case static elements can be rapid-manufactured using cnc technologies and added to the structure, while other redundant elements are removed. In case of dynamic spatial adaptation, dynamic structural components can be employed to allow instant changes in structure, without affecting the structural topology (Fig. 6). The third group of interactive investigations of Hyperbody covers furniture scale elements, which can freely populate building spaces, but still operate as parts of the building system.

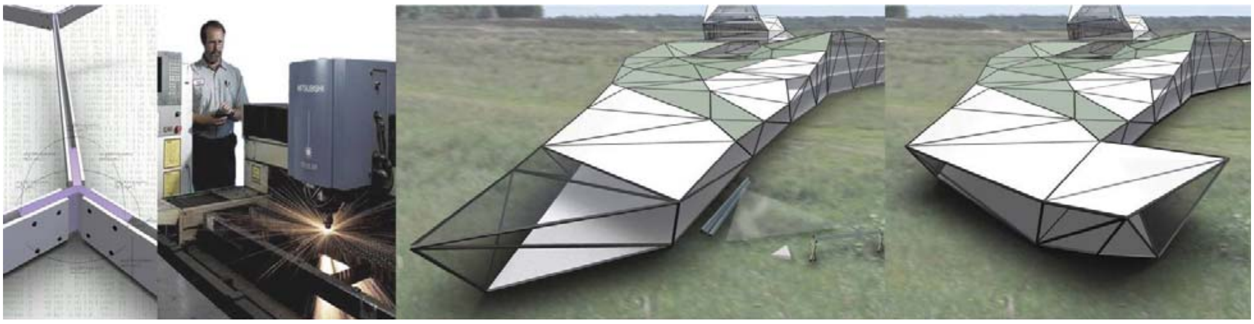

Fig. 5. Reconfigurable building structure

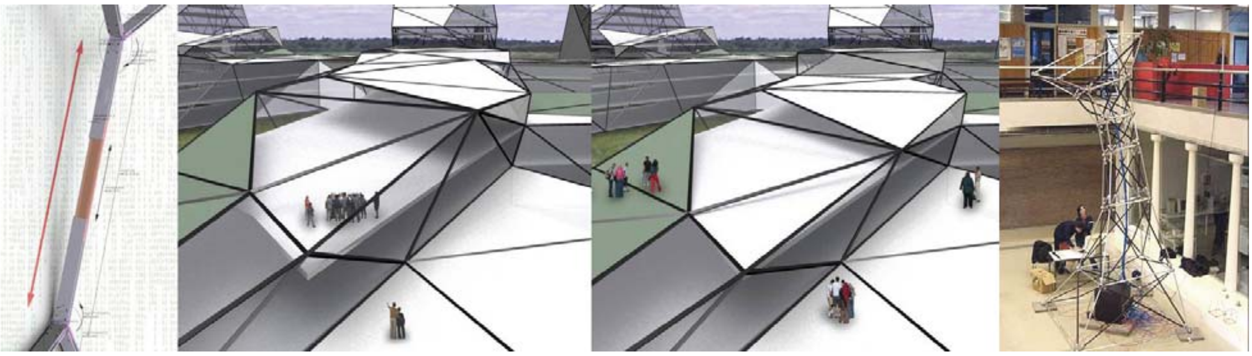

Figure 6. Dynamic structure concept, implemented in Muscle Tower project

Future of interactive architecture

If current research and implementation of interactive architecture proves successful, in a more distant prospect, this development may become a foundation of what Marcos Novak refers to as “neuroarchitecture”. Future architects may be using nanotechnology to create complex systems on the level of neurons and atomic particles. Those constructs will be able to operate in a manner which will be very close to the behaviour of biological living organisms.[8]

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