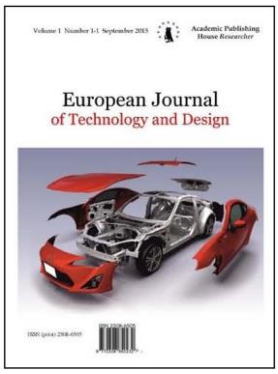

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Interactive Architecture: Development and Implementation into the Built Environment

Kristina Boychenko [a, *]

[a] Polytechnic University of Milan, Italy

Abstract

The article explores Interactive Architecture as a new trend in design, based on communication of user and space, the ability of space to respond in real time and to accommodate different and changing needs of users in a more effective way, creating continuous relationship between society and built environment. It describes the emergence and development of interactive architecture, evolving through time, philosophy behind it and ways of implementation in the built environment, studying realized projects and means and tools required to obtain specific structural performance.

This article considers various types of interactive behavior, kinetic abilities and classification of systems, ensuring the responsiveness of interactive architecture. It shows a new approach to construction techniques and interdisciplinary collaboration of different fields, explaining why is it important to consider new trends and introduce embedded computation into structure on the early stages of design process in order to obtain the most effective spatial performance, ensured by abilities of interactive design.

Keywords: Interactive architecture, responsive design, space, behavior, design, embedded computation, structure, motion, information, swarm.

1. Introduction

The main key words of the modern life is the motion and the information. Now days it has become more obvious because of the development of information sources and ability to get any information fast and easy, and our habits to live in well-organized space full of devices becoming more fantastic day after day. The further the technologies and development go – the more requirements they meet and more questions they have to answer. In everyday life people tend to look unconsciously for the answers on questions they haven't asked yet. They want to be aware of everything and to communicate with each other and with the environment, becoming receivers, processors and mediums of the information. The static architecture is limited in its ability to interact with the changing circumstances and what is more important, with the users. It is frozen in one state while nowadays there is an ability to make it fluent, changing, communicating with people. People need an immediate response from the surrounding area and the modern technologies are able to provide it. Now the built environment can understand itself and better perform its function. It can understand people within it and outside, furthermore it can help them to understand themselves better.

* Corresponding author
E-mail addresses: tina.architect@gmail.com (K. Boychenko)

The dissolution of borders between silent and responsive, static and dynamic, emerges in society. For instance, frontiers between body and machine, interior and exterior, virtual and real tend to diminish thanks to innovation and technological progress. Nowadays, we can live at the same time in both real and virtual space. Even the cities are organized according to both physical and virtual activities. Therefore, one can wonder how to join these two extremes? How to keep the identity of place and body in such a fluctuating world? How can architectural objects keep their identity and, at the same time, be connected to the world, be everywhere? Stable identities as well as fixed space are no longer possible, because they do not correspond to the reality of today's world. This introduces a transformation of the real and mental space. Such a conversion asks for the invention of the new words and the new spaces, using new already invented techniques.

Interactive architecture is a recent phenomenon that is related to the development of new technologies. Interactive architecture transformed into stream of information, claims its continuous metamorphosis in space and time, it affirms the permeability between the body and the technology, between the subject and the space. This reminds us the conception of the Flesh of Merleau-Ponty, as the interactive architecture effaces the border between object and the subject. The body is considered as an interlacing of vision and of movement (Mahdalickova, 2009).

Using emerging images, light, sound, moving and changing its spatial configuration intelligent space makes the user sink into the atmosphere that is created for each of the activities taken within it and able to project information in the outer shell. Smart environment proposes the whole situation for the user to get involved into this conversation with the space, full of information, hidden or exposed possibilities, choice of activities, details, games and even jokes and allusions that the user is free to intemperate as his intelligence, experience and sense of humor lets him to.

Frank Lloyd Wright re-phrased a well-known quote of his mentor Louis Sullivan by saying that form and function should be one, joined in a spiritual union. It can be not only a narration about the space's function, but also an invitation, an engagement, a promise or a warning of what to expect of it. An answer on the questions before they appeared. In some way it should actually foresee the question to respond in a most correct way ("Frank Lloyd Wright", documentary).

2. Implementation into different space types

Numerous and widely diverse examples of interactive architecture, intelligent space and responding environment can be found in

- Public spaces,
- Living space (House Automation),
- Working space,
- Kids' space, and
- Medical environment

Interactive architecture has great benefits in optimization of structural performance of the building, especially when it has to deal not with people, but to response to the forces of nature. Right implementation of modern technologies and embedded computation in sustainable architecture can help in avoiding over-engineering, providing better climate control performance, shaping a more comfortable internal environment and safety in seismic areas. Not even mentioning how economically feasible it has become to use these technologies in improving energy consumption of the buildings.

3. Development-Philosophy

According to Betsky the architecture is not allowed to be frozen. It has to glow in all senses, to be like a fireplace gathering people around it, telling stories that unite us into a society (Cohen).

It's not enough just to build elegant compositions in plans and facades and to solve sculptural problems in modern society conditions. Architects are still aimed to do it but they also have to do it in terms of existing urban chaos, globalization and internet and mobile phones use, as Aaron Betsky puts it. The construction of separated buildings is not enough anymore. Architects cannot ignore the environment: messages and symbols, providing a non-stop information flow. In other

words, a XXI century human lives in a reality different from the XX century, and the new shapes, functions and spatioal solutions are needed to ensure good relationship with this new environment.

Architecture cannot idealize the reality and distance itself from modern life anymore, imitating the styles from the past. The modern architecture knows no limits. It has no defined beginning and end, it's presence is everywhere. Virtual and real are entwined in one infinite and continuous space. Intangibility of architecture is the new feature of the modern times (Cohen).

Beauty comes from inside and at the same time is superimposed on the outer side of the product. Buildings are the complex adaptive systems, communicating with both external and internal environment (Belogolovskiy, 2006).

Interactive Architecture is architecture – interface, architecture – appliance. Interface defines the parameters, procedures and characteristics of the objects' interaction. The appliance performs the actions set by the interface. At the same interface can be built between the customer, the designer, manufacturer and environment.

From the point of view of degree of interactivity, interaction can be divided into following types:

- Linear interaction – when sent message is not related to previous messages;
- Reactive interaction – when message is related only to previous message;
- Interactive (Dialog) interaction – when the message is associated with a lot of previous messages and with the relationship between the two (Interactivity, 2010).

In similar way that the inert gases are not mixed with other gases, the objects that are not moving - do not communicate. Interaction is a kind of communication in motion. Interaction is not possible without motion.

4. Changeability, Uncertainty

Essentially, all the products begin to live when they are in the hands of the consumer, after the designer finished working on them. Project is a social process, it reinforces the idea of adaptation as a basic human desire.

Interactivity here should be seen as an active dialogue, and as a reactive interaction, i.e. corresponding to a single request. This adaptation can be expressed not only as an immediate response to this request, but also as an assumption of the change embedded during the design process.

The practice of post-occupancy evaluations (POE) is also relevant for considering this case. This entails a visit and evaluation of building after it was built and occupied by residents. Post-occupancy evaluation is intended not only for understanding how people actually use the facility together and how do they change the environment if they feel such a necessity, but also for the training of architects. It brings back the idea of the project as a process, and like the designers of the need to engage in as much as possible with the products or events after they are built. Most architectural projects do not imply regular post-occupancy evaluations because of financial limits. It should be assumed that the interactive project can be carried about in a way that makes financial sense, remaining equivalent to the post-occupancy evaluations (Hill, 2006).

The uncertainty principle works in Swarm Architecture. The result of the process is not predictable in traditional sense. Although the system is playing by the rules, the game outcome cannot be predicted. There are billions of possible outcomes, all of which are adequate as a response to requests of the system. Some results are more favorable to some experts, some are more favorable to the others, who limit the solution area, though still in the theory of infinity, a specific number of opportunities/options responds within the area of solutions. Nevertheless as it happens in sports, not all of the games are thrilling and beautiful. Strong and intelligent players are required to start an exciting game, experienced designer with a strong desire is required to perform with the best result. This understanding implies that the game takes place in accordance with the principles of uncertainty, probability and chance of quantum mechanics, something unexpected always might happen. Submitted in real-time the game is set for the unfolding fabric of reality. The player can surrender, the player can be much better than expected. If the project does not start the game, it is simply just modeling (Negroponte, 1995).

5. Digital Environment

Architecture reached the boarder of the digital and postdigital era. Not having time to learn and try out all the achievements of screen technologies, it began an experiment of reification of potential of information. Buildings are appointed with media properties of a screen, or on the higher level, turning them into polyactive gadgets with many interaction directions (Eshun, 2000).

In recent years architecture as a screen acquired a larger scale due to the simplification of the technological representation and relative cheapness and diversity in the interpretation of the Screen with its' pixel characteristics. The pixels are the data carriers, going through active development. The screens can be divided into two types according to the Pixel performance:

- surface screen projects
- mechanical screen projects

The surface screen projects include those that use light, representing the bacteria, the metamorphosis of materials. Such projects include the D-Tower by Lars

Finally architecture started to be based on it's changing performance in time, it's no more only simulation within isolated sectors of design process, it is a space-time experience. The experience of swarm architecture when the visitors start being connected through network, they communicate and flock together. Knowledge connects them, their intelligence is common, their contribution in collective design process gains effectiveness, growing in geometrical progression, that can be expressed through an equation of multiplication instead of summing up the contribution of each member. Independent intelligence is negligibly small in comparison with common one, when knowledge, sense, wisdom, emotions are now born in connection with the others. Development and very existence of any component of the system require network of similar components, ensuring the information exchange between them. The world becomes a whole installation space, the space that is being computed, creates new unexpected events by itself. The buildings are the new interface between the external environment conditions and the users (Mel, 2011).

6. Self organization

The world now goes through a technological revolution, the internet is going to be substituted by the new super-network, the grid, that would allow to use computational power remotely. This new network-environment would be able to visualize processing, memory and the communication, and to transform the computer resources of the world into a giant multi-processor with almost unlimited computational capability.

It is argued that architecture stands out in its ability to synthesize large number of mediums involved in the formation of design. Information exchange era brought non-trivial and simultaneously legible synthesis into high demand and increased engagement with complexity, so now architecture possesses a powerful tool to start the way towards applications beyond what is traditionally understood as a domain of design.

The matter as information enabled by computation brings architecture to the whole new level of operating information from the finer-grain physics of matter. This not only expands technically enriched material formations, but also activates previously hidden material powers toward designs beyond our anticipation in both formal imagination and performance.

The conception of swarm architecture introduced by Kas Oosterhuis may be considered as an alternative of accumulated super-power, in which all the members of the system behave according to specific algorithms, estimated by each member independently. This concept does not exclude possibility of all the elements' actions being controlled by one central computing node, distributing the computational power of all the grid (Oosterhuis, 2003).

7. Relationship between the nodes

One of the front men of integration virtual reality technologies and interactive architecture concepts, Kas Oosterhuis, develops his ideas through a system of easy rules, alternative to a system of data streaming. These ideas are based on some of the existing concepts, such as the Smart Dust (grids of very small simple, low-powered devices dubbed "motes" that monitor the environment and wirelessly pass data to a central collection point for analysis. The motes are linked to sensors which detect temperature, air flow or humidity, and wirelessly inform systems which monitor building security or manufacturing processes. The swarm basically is a Fractal Robot, made up of

trillions of smaller bots, the active polymorphic materials made up of tiny identical nano-robots or foglets) or the Flock behavior.

This concept is based on construction of local relationshops, where the each node or each member of the system is aware of the neighbour but not aware of the whole system (the swarm, according to Oosterhuis) performance. Here the intelligence can not be programmed using top-to-bottom methods, it has to be a result of bottom-up evolution process of the system of members (nodes) relationship. This king of intelligence does not have to be intelligent by it's nature, it can emerge from a well organized collaboration of relatively stupid elements, all together they are able to create complex intelligence. This intellect should not be compared to human intellect though, it is more the a degree of communication complexity between different levels of operating devices. The same definition of intelligence works with the human brain functioning, transportation systes, expanding and reduction of citiesTaking into consideration understanding of this concept, the conclusion can be done: building components are similar to the motes, sending and receiving information. communicationg with the peering components of the same scale and to the other components on the otther level of the hyerarchy (Pister et al., 1999).

Interactive building behaves as a swarm, in which building elements are the members of the swarm. The members are a family with a large number of embedded computers and over time and technological development this number will increase. Some members have more intelligence, the others have less, but they are all important for the system. Each of them is rather stupid, as a bird, who needs to be just smart enough to stay in the swarm, operating only a limited amount of information for its task performance. The flocking behavior can be described in three simple rules:

- Cohesion: fly towards the centroid of the local flockmates;
- Separation: keep a certain distance away from nearest flockmates;
- Alignment: align the velocity vector with that of the local flock;

For a more precise parametric control over the flock two more rules can be added:

- Evasion: avoid occupying the same local airspace with the nearest flockmate. Evasion is a localized form of separation;
- Migration: fly toward a pre-specified location.

Similar rules can be implied to develop parameters and main algorithms of the building behavior. The building elements behave like intelligent elements, flocking the herd, re-configuring themselves in real time. Building elements behave like boids. Swarm behavior of building boids is evolution in progress since it immerses digital life into our daily lives and into the very fabric of building materials. Building boids are senders and receivers of information, exchanging data, processing incoming data, and proposing new configurations as the outcome of the process (Oosterhuis, 2003).

Nevertheless the different shapes of flocks are recognizable as a complex whole. The importance of architectural design process here is that the whole structure performance should not be determined in its' exact and complete form, in advance setting all the individual components into a consistent whole. The designer can work with simple rules that start generating relevant data with the associated positions of nodes for the production of mass customization. Also the behavior of nodes may be used to form the shape of the construction by setting the area of the moving flocks by limiting their space and leaving a valid possibility for movement, as each building or it's component must take into account the presence of other objects in their urban context.

Generally everything surrounding us in space and everything we see around, every car, every street, every town is based on simple calculations, creating a complex behavior that for which it is almost impossible to recognize and track all the rules. The only way to find them out is to run the system, to design a system that is based on simple rules generating complexity. This assumption potentially turns the designers into researchers, that need to set complex systems and operate them. Performative architecture brings the designer to genetic core of what we see around us.

8. Senses

With the development of new technical capabilities, "smart objects" start being able to receive a lot of information from the external environment. The people's behavior is a significant part of this environment. This leads to necessity of understanding the feedback with the world and the notion of "family of smart objects" in our environment that can communicate with us and with

each other by sending messages using the built-in microprocessors which are giving different information. A lot of these components are designed to capture information from the environment, such as temperature, light levels, wind speed and noise. Some components are able to receive simple messages from the man. They feel our presence radiated heat or movement and react in some way (Mel, 2011).

The ultimate goal of Swarm architecture is to keep its' new structures up-to dated in real time. The objective of information architecture projects is to support the vitality of the process and apply the values to the behavior in real-time, to understand how can the designers create a tunnel for a continuous flow of data within the built structure, where the content is constantly changing in real time? To facilitate this fundamentally new view of the world, we have to look at the building as if they are appliances that can be run in real-time. Dynamic buildings can be considered as existing processes that continuously inform users and are informed themselves continuously during other active processes. They are the active nodes in a complex adaptive operating network.

9. Conclusion

Using the new techniques, people cooperate to create efficient buildings, which are considered as highly applicable processes. The buildings become active installations, where multiple control devices are constantly communicating with other control devices, their users and their environment. We know from practice that there is a large proportion of the budget devoted to electrical and mechanical installations for every building, taking up to 30 % of the total budget. In the bright future of buildings, the entire structure will be interpreted as the installation. Projecting current trends into the near future, it makes sense to consider all the components of built structure as active members of the installation. The building becomes the instrument, it becomes an installing itself (Andrasek).

The importance of Interactive Architecture in fast developing society with new fascinating technologies is hard to overestimate from different points of view. It brings physical, social, psychological and economical benefits. There are no doubts it will find more and more implementations in modern Architecture.

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