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ADAPTIVE ARCHITECTURE – A BENEFICIAL INTERACTION WITH TECHNOLOGY

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Abstract. The implementation of the cutting-edge technologies - related to communication and information transfer, as well as those related to intelligent materials, sensors, components and modules represent the only plausible way towards the emergence of complex, autonomous and decentralized systems of adaptation. The adaptive architecture deals with buildings designed to adjust dynamically to the environment, inhabitants and contained objects, its behaviour being influenced by the response of the users and the environment. The author highlights the innovations and adaptive capacities currently available by critically examining the specialized literature, by showing the philosophy behind the design of adaptive architecture - the direct involvement of the user in the act of designing and personalizing the adaptive architectural space, a continuous optimization process, in real time, by using it. The research results indicate that the emergence of adaptive architecture is based on the continuous cultural and technological remodelling of the contemporary ethos; the built environment influences the cognitive level, the emotions, the mental and physical well-being. The processual dimension, conferred by technology, allows for the possibility of

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manifesting an autonomous behaviour, capable of alternating the organization of the space, thus outlining a framework well suited to user's searches.

Keywords: evolution, computational intelligence, kinetic systems, ephemeralization, smart architecture

1. Introduction

Evolution of technology - a decisive factor in the emergence of adaptive architecture.

The technological evolutions of the last 2-3 decades have led to the possibility of spreading digital environments everywhere, both visible and hidden, in spaces and surfaces - a true computational intelligence waiting for its consciousness. Given the continuous change and evolution of the contemporary way of life, it is necessary to reconfigure the paradigm in which humans, architecture and technology relate. The contemporary architectural concept needs to accelerate the transition to the **information era**, in order to minimize the discrepancy between the world in which we carry out our activities and the buildings we use. The implementation of the latest technologies (both those related to communication and information transfer, as well as those related to intelligent materials and sensors) seems to be the only plausible way for the emergence of complex, autonomous and interconnected adaptation systems. The interactions between architecture, user and the technological environment are the main factors that facilitate adaptation in these systems.

The first specific ideas of an adaptive and receptive architecture, as it is understood today, appeared in the late '60s and early '70s, as a result of developments in cybernetics, **artificial intelligence** and information technologies. Ideationally, this is the product of SF literature - J.G. Ballard, a British novelist, described in a short story called "The Thousand Dreams of Stellavista" (1962) (Ballard, 2011, pp 305-21) a "psychotropic house", similar to machines, but also capable of sensing and intuiting, responding and learning from its users. The need for flexible architecture, able to adapt in time through kinetic mechanisms, was firstly noticed by Zuk and Clark in 1970 (Zuk and Clark, 1970, p 9) The philosophy of adaptive architecture is to develop and transform buildings or **mobile components** in real time, depending on different functional and environmental conditions. The interaction with the environment and the user is the main characteristic of an architecture capable of recognizing, controlling and responding to different external stimuli; the result being the generation of architectural areas capable of reconfiguration, adaptation and automation. This is possible only through the co-operation of **kinetic systems** with those of integrated computing (artificial intelligence) (Fox, 2001, pp 42-3). Currently, the accelerated technological advancement is a problem even for adaptive architecture (the systems that accomplish the adaptation are outdated in

shorter and shorter time intervals). The high costs for manufacturing the components and the modules of automation are the main impediments in studying thoroughly the effects (mental, physical etc.) on the human beings. Given that, nowadays, adaptive architecture exists only in some pilot projects, but mostly theoretically; the study aims to present, by deduction, the potential beneficial effects of interaction with the technology embedded in these adaptive systems.

2. Cultural and technological remodeling of the contemporary ethos. Autonomous behavior of buildings - a consistent connection between mankind and technology.

According to Masse Bloomfield (Bloomfield, 1993, pp 9-25), the mankind history is an overlap of long periods of stability interrupted by short periods of transition (humanity undergoes a transformation from a stable agricultural period to a stable automated period, through an industrial phase of transition). Currently, three stages of technology development are identifiable. These follow one another telescopically: the first one, characterized by the desire of amplifying the effects of physical work (of hunter-gatherers), leads, almost intuitively, to the invention of tools - the second stage - the invention of machines (the desired consequence was the replacement of human physical effort with the effort to control / use the newly created machine). The first two stages are the starting points for the most recent one - automation (the elimination of human control and its replacement with algorithms).

Futurologist Raymond Kurzweil (Kurzweil, 1999, pp 173-91) believes that in a few decades people will create technology capable of revolutionizing most aspects of life, thus surpassing the human race in terms of intelligence. It introduces the term "technological singularity" – the first moment in human history when human intelligence will be artificially amplified to evolve into a form of human-machine symbiotic intelligence. At a certain point, the biological man will no longer be able to cope with a hyper-technological world without changing his nature, in one way or another. Futurologists call this step "technological singularity". Kurzweil predicts that such technology "will seem to have its own will" and even "spiritual experiences"(Kurzweil, 1999, pp 173-91). In essence, he believes that people will live forever, because humanity and technology will eventually merge.

In "The Third Wave" Alvin Toffler examines the technological advancement through determinism (Toffler, 1999, pp 194-223), considering it one of the fundamental factors of social changes that caused the transformation of the contemporary society; thus, by extrapolating the current situation, the technological future is theorized.

The analysis of these influential futurology works indicates that there is no viable forecast of the future that does not directly involve technology. At a theoretical level, Buckminster Fuller (1938) formulates the principles of "*ephemeralization*" (Fuller, 1938, pp 252-59) – a concept that represents the ability of advanced technology to do "more and more, with fewer resources, until, finally, everything can be done with nothing". Therefore, an accelerated increase in the efficiency of obtaining the same or more products, services or information can be achieved while decreasing the effort, time and involved resources (Fuller, 1938, pp 252-59). Robert Kronenburg emphasizes the advantage of such systems by indicating the architectural relevance of buildings capable of using less resources by adapting effectively to complex situations and new programmatic requirements (Kronenburg, 1998, pp 1-5).

For almost two decades architecture has been imagined and thought in new coordinates: the **virtual environment** created by computer science irreversibly revolutionizes the architect's way of working. In "The Gutenberg Galaxy" (1962), Marshall McLuhan says that "the medium is the message" (McLuhan and Lapham, 1994, p 7). By extrapolating, we understand that technology is never just a means of production, but can even be the content of architecture. The process of understanding architecture is mediated by digital tools; therefore, this transforms the computer (previously a tool) into an author of the project. Designing buildings that have robotic capabilities, such as responsiveness, is a longstanding concern of the architectural community. Influenced by ideas from cybernetics (such as those stated by Nicholas Negroponte at MIT Architecture Machine Group) Cedric Price, Gordon Pask and John Fraser created a context of possible implications of artificial intelligence in the built environment, thus demonstrating the sustainability of self-organizing models.

Currently, adaptive architecture is working on solving the potential problems of a **hyper-technological future** (finding solutions today leads directly to problem prevention in the future) by bringing architecture to the same level of development with contemporary innovations (for example, sensors and modules are extremely useful for quality diagnosis of the architectural space); the long-term flexible development of city planning consists in leaving a clear path for further, more appropriate, interventions, thus avoiding the demolition of built structures; ecologically speaking and based on usage patterns, adaptive architecture investigates the development of systems that control the exchanges with the natural environment (gas, energy, light and so on), therefore **optimizing the energy consumption** of the entire building.

The adaptability of architecture must overlap with the awareness that future is not finite and changes / adaptations to the environment are inevitable; this whole process is governed by feedback- a mechanism that allows systems to change their behavior according to environmental conditions.

Feedback allows systems to know the exact context and to learn a model (mental, digital, virtual) that guides adaptation. Thus, it can be seen as the loop between cause and effect in changes of systems and environments. Designers aspire to improve the "intelligence" of buildings by providing the necessary means to quickly adapt to new environmental conditions, in order to get real-time feedback; architecture tends to pay little attention to the fact that each person is different, that each of us perceives the world in a unique way (due to cultural and religious premises, social behavior etc.) –and so, each of us creates a personal model of the surrounding environment, an **Umwelt** (Kull, 2010, pp 348-9).

Architectural design has the potential to become a practice capable of developing proactive processes that take place between two deeply interdependent nuclei: ourselves and the environment. Due to the fact that we are different, the buildings will have to be equipped with a buffer that gives each user a **"personalized plasticity"**, allowing them to develop creative relationships with the environment, according to specific sensations. The first step is to understand the self and the thresholds of perceptual processes - the confluence point of biology and neurology with technology. Architecture and other creative disciplines will be deeply affected and completely remodeled, by the latest developments of scientific research, such as synthetic biology, nanotechnology, neuro sciences, robotics and biocomputing.

3. The beneficial impact of interactive environments on psyche

The multidisciplinary of adaptive architecture brings together architects, urban planners, psychologists and users (actively involved in participatory design processes) in order to develop sustainable tools for understanding the way the user is relating to the embedded technology in architecture. The human race spends 80-90% of its entire life inside buildings, surrounded by artificial colors, sounds, shapes and light. The perceptual system of human beings is a holistic one: the whole organism is influenced by the senses, biased themselves, by the way of thinking. The built environment influences the cognitive level, the emotions, the mental and physical well-being; therefore, a poorly conceived architecture, combined with other factors leads to exhaustion, increased stress and the emergency of other psychosomatic symptoms. Concerning adaptive architecture, users are directly and constantly involved in designing and customizing the environment (just by simple use, the architecture gets optimized). The way of organizing and dimensioning spaces, furniture and the quality of the environment can change the usability patterns of architecture; so, creating spaces that run counter-intuitively to user's particular way of processing spaces leads directly to dissatisfaction and frustration (over time,

they will have a strong negative influence on the general state of mind and health of the individual).

The sensorial and technological dimension of adaptive architecture is able to record, store and process the user's response in respect to changes in environmental parameters, thus creating the paradigm of a sensitive architecture, constantly improving itself by adding new data sets and by comparing them with previous results. The adaptive architecture does not offer a final solution, but a series of iterations that allow the user to modify it according to individual's needs, offering a more suitable answer in the search of the spatial archetypes of the primordial image of "house", than the conventional buildings. In Schnädelbach's vision (Schnädelbach, 2012), adaptive architecture aims to generate **customizable spaces** by modifying the organization of the interior space in order to ensure new functional features, but also by adjusting the structural and closing elements of the facade, providing active "protection" against atmospheric conditions - wind, excessive heat, light etc. Adaptive architecture must be critically regarded as the confluence and dialogue point of the social sciences (sociology, psychology and cultural anthropology) with **the technological dimension of architecture**, generating therefore a real understanding of the dual phenomenon of adaptive architecture - an active and fluent collaboration between users, products and processes.

The following question arises: how much technology do we really need? Ed van Hinte and other authors of *Smart Architecture* state that a simple, non-automated building is sometimes smarter than a living machine over which the user has lost control (van Hinte et al., 2003). Adaptive design helps users become part of the environment, by training and adapting the architectural form, by developing a material behavior that reflects the things described by the theory. Developing **adaptable behaviors** embedded in the environment make the individual feel comfortable in a certain space, therefore suggesting that one of the most important contributions of interactive architecture is not found in the physical, but in the psychosocial mechanism that aims to create a more hospitable environment, more suitable to human condition. In most cases, designers and architects work to induce this effect. Currently, the fundamental concern is to maintain the comfort levels of the inhabitants, be they individuals, groups of individuals or organizations (assuming the needs of individuals are contrasting, the system must decide which of them and how will be honored).

Architecture is made for people and until now, the architect has neglected, often out of pure pride, primary human needs. Adaptive architecture must come with a double response - to the natural environment and to the real needs of the individual (manifested directly). Psychological studies indicate that there are significant differences in thinking and **perception** of the architectural space between architects and non-architects (adaptive architecture must ensure openness for mediation and interplay between the two modes of thinking). The development of an adaptive residential architecture, with a high degree of

flexibility, corresponds to the need of encouraging spatial simplicity (through minimal use of the built form it is created a sustainable relationship between the natural environment and the individual framework - sanogenetic reasons). The stake is to solve a three variables performance based equation: the correct definition of the interior-exterior transition as a matter of opacity-transparency, the active control of the energy flows that enter and / or are released in the natural environment, as well as the comfort expectations of the occupant.

The dynamic world (in which the climatic, informational and technological changes are constantly accelerated) can be the pretext for the emergence of forms of residential architecture that ensure the **stability** and mental health of the users, thus becoming a support for the normal life, a real screen between the user and the increasingly **accelerated information flow**. Therefore, we conclude that adaptive architecture has the possibility to improve the healing processes, increase the level of motivation, concentration and relaxation, taking into account the human psyche right from the design stage.

4. Results of the study

The multidisciplinary field of adaptive architecture is illustrated by terms such as: "interactive architecture" (Fox and Kemp, 2009), "responsive environments" (Bullivant, 2006) or "digital-driven architecture" (Bier and Knight, 2010) - a plethora of different approaches and landmarks of the tapping period in which we are. The emergence of these notions is generated by the desire of improvement by exploring new technologies, by creating more adaptable, pleasant, stimulating, efficient or comfortable environments for the occupants. Even though, it seems a general consensus has been reached regarding the use of technology for adaptation / interaction / automation in buildings, there is still little systematic information concerning the psychological impact of these systems. A disadvantage of adaptive architecture is easily identifiable - the high cost of implementing and operating the systems (these will probably be diminished if the widespread use would generate a large enough demand to justify the typification and serial production of the systems). Apparently, the leap to adaptive architectural forms requires the **emergence** of a transitional form of architecture, within which to implement concepts from construction physics, like inertia and thermal mass, computerized control of natural ventilation by the use of **low-tech components** (a true gradient between completely static architecture, passive and adaptive, dynamic architecture, capable of changing its shape, color, temperature etc.).

3. Conclusions

In this work, adaptive architecture is presented as a new architectural concept generated by the technological infusion in the built environment. The emergence of this kind of phenomena is based on the continuous **cultural and technological remodeling of the contemporary ethos**, being supported simultaneously by the confluence points of seemingly disparate fields as computer science, psychology, social sciences, urbanism and arts. The capabilities of adaptive architecture have the potential to create an environment suited to modern living patterns by extracting and processing information from the environment; the aim is investigating the physical and mental state of the user and also the complex relationships between materiality and the digital information behind the **processes**. The efforts to improve adaptive architecture (both in new buildings and in replacing existing ones) must find their motivation in evaluating the response of users confronted with the systems. The chances of architecture of the near future to degenerate into robotic "chameleons" are really small; the whole process is closely related to beneficiary's finances and the **economic efficiency** of the construction process, including the research stage.

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ARHITECTURA ADAPTIVĂ – O INTERACȚIUNE BENEFICĂ CU TEHNOLOGIA

(Rezumat)

Implementarea tehnologiilor de comunicare și transfer de informații de ultimă oră, dar și a celor legate de materiale, senzori, componente și module inteligente reprezintă singura cale plauzibilă spre apariția unor sisteme de adaptare complexe, autonome și descentralizate. Arhitectura adaptivă este un domeniu multidisciplinar responsabil de proiectarea clădirilor capabile să se adapteze dinamic mediului, locuitorilor și obiectelor componente, comportamentul acestora fiind influențat de răspunsul utilizatorilor și al mediului ambiant. Autorul evidențiază inovațiile și capacitățile adaptative disponibile în prezent prin examinarea critică a literaturii de specialitate, dar și prin evidențierea filozofiei de proiectare a arhitecturii adaptive - implicarea directă a utilizatorului în actul de proiectare și personalizare a spațiului arhitectural adaptativ devine un proces continuu de optimizare a spațiului, în timp real, prin utilizare. Rezultatele cercetării indică faptul că apariția arhitecturii adaptive se bazează pe continua remodelare culturală și tehnologică a etosului contemporan; mediul construit influențează nivelul cognitiv, emoțiile, bunăstarea mentală și fizică. Dimensiunea procesuală conferită de tehnologie permite manifestarea unui comportament autonom, capabil să modifice organizarea spațiului, conturând astfel un cadru bine adaptat căutărilor utilizatorului.