Technological transition in building design at the intersection of living and manufactured

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Abstract. This paper aims to elucidate reflections of technological transition today through the 'unity' of living and manufactured components of building design. Technological advances enable living organisms from algae to humans, and many more, to become useful tools to create interior and structural elements for buildings. Thus, designing with living organisms has become a growing phenomenon in architecture by transforming building components into 'biobuilding' components. In this paper, this phenomenon is critiqued through the bonds between the concepts of nature, technology, and building design, from contemporary studies to the highlights back in history. Overall, the paper gives architects insights on the envisioned future that presents a harmony between natural and building environment.

Keywords: Technological Transition; Building Design; Biobuilding Components; Living Organisms; Smart Technologies.

Introduction

The innovations, entitled as "biobuilding components" in the framework of the paper, could be followed as the indicators of the technological transition that might place building design at the intersection of living and manufactured worlds today and in the near future. The recent advancements in technology have enabled the incorporation of living organisms with man-made productions, instead of fabricating products inspired by the elements of nature. Thus, living organisms at any scale, i.e., plants, animals, fungi, bacteria and cells, could become useful tools to design building components, such as building materials, construction technologies, interior elements, furniture, mechanical systems, and much more (Ripley and Bhushan, 2016). Some examples include air-cleaning pots with plants, self-healing concrete with bacteria, self-growing furniture made from mushrooms, and many more innovative projects could be considered as biobuilding components (Fig. 1).

Due to its heterogeneity and complexity, any technology can blend into buildings at varying scales. At this juncture, the incorporation of living organisms promisees to transform building parts into autonomously living, growing, dynamic entities. Meanwhile, designing together with living organisms in architecture presents a variety of smart and sustainable solutions for buildings, ranging from energy efficiency to degradable materials (Imhof and Gruber, 2015). Thus, the possible influences of biobuilding components might seem critical to be discussed in the discipline of architecture, particularly in building design.

Designing together with living organisms has become a topic of interest over the past years along with their potential benefits within the current degradation of the environment (Myers, 2018). Moreover, many biobuilding components have infiltrated into everyday lives by reshaping our activities, habits, lifestyles, and surroundings (Van Mensvoort and Grievink, 2015). However, much uncertainty still exists about the relationship between biobuilding components and building design. Hence, this paper aims to give a better understanding of the meaning(s) of biobuilding components by discussing relationships between the concepts of nature, technology and building design, thereby, allowing us to look through different perspectives.

This paper first presents contemporary studies manifesting the shifting notions of nature and technology. Then, the impact of the concept of nature on building design is reviewed through the approaches and examples of present and past. Finally, the influence of the development of (smart) technologies on building design is followed through the infiltration of small-scale industrial products into buildings.

Technological transition towards blending living and manufactured components

The merge of living and manufactured components may sound futuristic and even hard to achieve at first, but each innovative product could be seen as one further step to get familiar with this transition in society (Van Mensvoort and Grievink, 2015). Nowadays, technological developments have manifested a variety of innovations in which technological and natural elements have been intertwined with increasing momentum (Karafyllis, 2006)[1]. Indeed, living organisms could become 'living components' as natural (design) elements, and be united with 'manufactured components' that are man-made, technological (design) elements. Thus, many studies resonate within multiple disciplines and architecture to explore the bridges between living and manufactured worlds through the social, philosophical, cultural, and practical implications.

Through the concept of "Next Nature", Koert van Mensvoort introduces a novel approach by aiming to increase people's awareness of the fading boundaries between nature and technology (Van Mensvoort and Grievink, 2015). The Next Nature platform manifests a variety of technological products from different industries such as; health, food, textile, and more, and demonstrates the evolving relationship between people, nature and technology.[2] Moreover, a holistic approach is embraced for society to get accustomed to any man-made products and thus consider them normal.[3] For example, electric cars, lab-grown meat, and commercial space travel could become "natural" by being omnipresent soon. In this sense, designing together with living organisms is becoming a part of the industry, and shall be accepted by a larger part of society every day. Moreover, many more studies and approaches also lead researchers to be critical about the distinction between nature and technology through different aspects. The recent studies of the anthropologist Phillipe Descola concluded that even the Amazon Forest is not "untouched" by humans; therefore there is no such thing as "pure" nature (Descola, Lloyd and Sahlins, 2014)[4]. Likewise, studies on; "subnature" (Gissen, 2012) and "dark nature" (Michael, 2011) underlined the subjectivity of our understanding of the concept of nature by questioning its relationship with technology from different perspectives.

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01 | Examples of Biobuilding components exemplifying the incorporation of living organisms (from left to right, Clairy at Keukenhof Exhibition, NL, 2018, Mycelium based products at Officina Corpuscoli, Amsterdam, NL, 2019, Sample of Self-healing concrete, Deflt, NL, 2019); Source: Author's archive

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All these approaches lead us to question our understanding of nature and its relationship with technology. In building design, Myers presented examples of 'biodesign' as living organisms becoming design elements in architectural design (Myer, 2018). Myers' collection includes case studies aimed to replace the industrial and mechanical processes with the incorporation of living organisms projected to be used as architectural and interior elements (Myers, 2018). Likewise, the bioarchitectural approach underlines the possibility of a wide range of innovative solutions based on living organisms for buildings (Ripley and Bhuskan, 2016). Many researches in the discipline of architecture might share similar visions with biodesign and bioarchitectural approaches. To cite a few examples, the Silk Pavilion, a 3D space created together with silkworms and designed by the Mediated Matter group, demonstrates the incorporation of living organisms in a different way (Oxman, 2015). The Silk Pavilion explores the relationship between digital and biological fabrication on product and architectural scales by inspiring the ability of silkworms to create 3D space. By sharing the same motivation yet developing novel strategies, the project "GrAB - Growing as Building", managed by Petra Gruber and Barbara Imhof, takes dynamics and growth patterns from nature and applies them to architecture by focusing on the potential of creating architectural spaces through "slime molds" (Imhof and Gruber, 2015)[5]. Moreover, in Fab Tree Hab project Michelle Joachim explores ways to grow buildings only from native trees. As a first prototype, he creates a living wall grown by "pleaching" plants (Arbona, *et al.*, 2003). All in all, from façades with living plants to mushroom chairs, to architectural spaces created by silkworms, 'biobuilding components' in multiple scales, domains, techniques, and functions, have yet to infiltrate into the buildings.

It is remarkable that the philosophical approaches are on one side, with practical implications on the other. All these researches hint ata drastic change that could happen soon. These projects are mainly at the experimental level. However, a rich history lies behind buildings to create bonds with the elements of nature, and the critical role(s) of small-scale products in building design. Thus, to give a better understanding of the technological transition from building components to biobuilding components, the paper continues with an overview of *Changing Dynamics in Building Design through the Concept of Nature.*

Changing dynamics in building design through the concept of nature

The existing academic and popular literature is overwhelmed with a wide range of approaches and practices explaining the different ways to connect, inspire, utilise and merge with nature in building design. In recent studies, nature-related examples have mostly been evaluated under bio-derived concepts such as "biomimicry", "bioinspiration", "biophilia", and many more (Pawlyn, 2011; Caperna, 2017; Gruber and Imhof, 2017; Speck *et al.*, 2017). 'Biomimicry' could be seen as the most well-known technique extensively practiced by innovators in building design (Ratti and Claudel, 2016). In architecture, biomimicry implies learning from the forms, processes, and strategies of nature for sustainable solutions (Pawlyn, 2011). Biomorphology, on the one hand, favours the imitation of the forms and structures for buildings (Speck *et al.*, 2017). Bioinspiration often refers to the transfer of aesthetic and morphological aspects of nature to building design (Gruber and Imhof, 2017). Biophilia aims to bond humans with the natural environment, and is often related to design studies supporting environmental sustainability (Caperna, 2017). All these concepts and many more could help to understand how nature works and how to use living organisms, thus they could lead the way for architects to provide smart and sustainable solutions for buildings.

With the help of bio-derived concepts and computational technology, contemporary buildings can be designed as a living, dynamic, and fluent in terms of form and structures inspired by natural elements. Thus, design principles could be emulated from biological forms, processes, and systems, and implemented into the buildings. For example, in the case of the Waterloo International Terminal designed by Nicholas Grimshaw and Partners, the flexible scale arrangement of the Pangolin is mimicked in the glass panel fittings, so they can move in response to the imposed air pressure forces (Aldersey-Williams, 2003). Moreover, living organisms could already be utilised to resolve the environmental challenges of today with increasing demand for energy, resources, and raw materials from the developing world. The case of Bio Intelligent Quotient (B.I.Q) could be given as a contemporary example in which a bioreactor façade powered by algae supplies the necessary energy for the building (Delle Stelline, 2013).

On the other hand, to bond with nature is not a new phenomenon in advance of technology nor architectural discourse. Billions of years of evaluation through its structures, algorithms, mechanisms and materials, and the achieved solutions have led humans to be inspired by nature in the discipline of architecture. At this juncture, despite the popularity of nature-related concepts in contemporary architecture, the influence of the different understandings towards nature along with the technological abilities could be traced back to the history.

In the modern discourse, metabolism in architecture indicated the potential of living and the dynamics of space. The Metabolist movement connotated the city with the metaphor of the human body as its elements can be born, grow, and die (Pernice, 2004). The Nakagin Capsule Tower designed by Kisho Kurokawa in 1972 seems to be a clear demonstration of metabolism in architecture. Before that, in early 1908, Frank Lloyd Wright introduced the word 'organic' into his philosophy of architecture by underlining a balance between buildings and architectural spaces and the natural environment. The examples of organic architecture could be seen in very well known buildings in architecture, such as Casa Milla by Antoni Gaudi, Falling Water house by Frank Lloyd Wright.

Indeed, since pre-modern architecture, symbolic, analogic, and metaphoric meanings of living and non-living elements of nature have taken place in architectural discourse. The depiction of the relationship between the human and natural environment in 'Primitive Hut' in the 18th century by Marc Antoine Laugier underlines that the notion(s) of nature and its scientific and philosophical debates have always been associated with the critical aspects of architecture since the "origin" of architecture. Primitive hut was "natural" in the sense of abstracting principles of a fundamental shelter by favouring intrinsic and natural forms in architecture just like the abstraction of proportional relationships from nature by Leon Battista Alberti (Hagan, 2001).

All in all, bonding with nature has often motivated architects from pre-modern times to present day. Meanwhile, recent technological abilities have presented new ways to bond the built and natural environment. At this juncture, this paper manifests that the rise of biobuilding components could also create drastic changes in building design by presenting a radical way of bonding living and manufactured components, thus nature and technology. However, to give a better understanding of the possible role(s) of biobuilding components, first it seems necessary to discuss *Changing Dynamics in Building Design Through Development of (Smart) Technologies.*

Changing dynamics in building design through the development of (smart) technologies

The concept of nature has maintained its significance as a matter of discussion in the scope of building design. In parallel, its evolving relationship with emerging technologies has remained the focus of contemporary concepts. Nowadays, the Internet of things, big data, pervasive and mobile computing, sensor networking, and artificial intelligence have often found a place within contemporary discussions in building design. Meantime, the term 'smart' is already a 'buzzword' of user-friendly industrial products empowering the interaction between people and their surroundings. Thus, empowering the physical world with digital systems through these so-called smart technologies has motivated architects to design smart environments.

The advances in computational technology have accelerated the developments of technologies, thereby resulting in smart technologies becoming tools for supporting the quality of daily lives in the built environment. The term, smart home, was first used in 1984 as a home that is wired with computing and information technology responding to the needs (comfort, security, and entertainment) of the occupants (Harper, 2003). Afterward, the term 'smart' was genuinely accepted in the descriptions of recent technologies. Back in history, wired homes resembled 'science function'; only the 'hobbyists' were envisioned (Harper, 2003). Nowadays smart buildings and the Internet of things have become well known in architectural discourse. Smart technologies, like having security and surveillance systems in any buildings, HVAC systems at the office and public buildings, and controlling them by smartphones, have become frequent and omnipresent in daily life. Moreover, smart environments today have presented solutions for the ageing society by assisting healthcare (Mohammadi, 2014).

Indeed, technological growth has aimed to make human life more comfortable with machines facilitating household chores throughout history. We are still experiencing the impact of smart homes and wireless technology on both our buildings and our lifestyles. Thus, the impact of popular small-scale technologies, like smartphones' significant potential to control and connect with the surroundings, seems easy to notice. However, for decades, the developments in technology have shown their impact on building design alongside the changing dynamics in society by affecting each other reciprocally.

In the 1980s, computers were moved from workplace to house by blurring the distinction between home and work environment. By this change, smartphones, the Internet, and wireless systems led people to reach any information and contact any person in any space, thus radically affecting habits and lifestyles. A few decades earlier than computers, technologies such as television and radio integrated into the homes and resulted in people spending more time in the home environment. These technologies were intended to increase the comfort of the user.

Before that, domestic technologies were aimed to ease daily life tasks with time-saving solutions. In the 1960s, washing machines, electric razors, kettles and cookers became omnipresent, while the implementation of central heating and thermostats was also widespread at homes (Aldrich, 2003). However, the first rise of domestic appliances, like refrigerator, dishwasher and vacuum cleaner, started in the 1920s. Indeed, house designs have begun to take shape around the advantages of the growing number of domestic appliances and the need for more electricity and energy ever since the arrival of electricity into the home environment (Harper, 2003).

All in all, the impact of technologies through history shows that technological developments have often influenced building design alongside societal and cultural aspects. At this juncture, a variety of biobuilding components incorporated with living organisms, such as humans, plants, and even bacteria, have yet to infiltrate into the buildings. Thus, this paper manifests that biobuilding components could also create radical changes in building design as well as affect everyday lives. While the parallel overviews elucidating the relationships between nature, technology, and building design helped us to underpin this argument, the paper concludes with the following remarks for the future.

Conclusions and remarks for future

This paper contributes to the existing literature by exploring the meanings of biobuilding components for building design. The overviews presented in the paper demonstrate the changing dynamics in building design through the concept of nature and the development of technology. Thus, the paper confirms that connecting with nature and adapting to technological development have always remained at the core of building design throughout history. This leads us to underpin the critical roles of biobuilding components in building design from broader perspectives with different angles.

Throughout history, the concept of nature has always been a significant matter in the discipline of building design with altering approaches and enhancing technological abilities. In parallel, a variety of technologies has often been added to the built environment, aiming to empower the relationships between users and their surroundings. At this point, biobuilding components present innovative ways for buildings to connect with nature by embracing technologies. Biobuilding components are not just additional or somehow upgraded technologies bringing smart and sustainable solutions to current environmental degradation. Indeed, they could accelerate the current technological transition by transforming the building design itself into living, growing and also technological entities.

The number of biobuilding components is increasing on a daily basis, infiltrating into the built environment and daily lives. This requires further studies on new design strategies and approaches in the framework of building design. Indeed, these studies shall concentrate on the technical, cultural, and social matters of biobuilding components, and their translation into the buildings. More importantly, this technological transition shall also be discussed through the relationships between nature, technology, and building design.

NOTES

[1] Karafyllis coined the term ‘biofact’ for these natural-technical hybrid objects (Karafyllis, 2006).

[2] In addition to Next Nature book, dynamic and updated Next Nature platform (NNN) could be followed by URL01: www.nextnature.net and also URL02: http://www.nanosupermarket.org/

[3] The Pyramid of Technology is an approach, which shows the possibility of any technological product to be ‘naturalised’ by means of being an essential part of daily life through seven steps; ‘envisioned’, ‘operational’, ‘applied’, ‘accepted’, ‘vital’, ‘invisible’ and, finally, ‘natural’. See: van Mensvoort, K. M. (2013). Pyramid of technology: how technology becomes nature in seven steps. (Eindhoven University lectures; Vol. 3). Eindhoven: Technische Universiteit Eindhoven.

[4] In his ethnographic work among an Amazonian community, the Achuar Tribe, Descola found out that the flora and the distribution of the species have been radically transformed by people through the years (Descola, Lloyd and Sahlins, 2014).

[5] In GrAB project physarum polycephalum, an acellular slime mold, is experimented in the Biolab. Physarum polycephalum is examined as the new tool for architecture to design future since it embodies electric potential on its surface and develops sensing electronics and computing devices (Imhof and Gruber, 2015).

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