Cyborg Architects

The effect of digital design technologies on modern architectural design and representation

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In an age dominated by computers and technology, it is necessary to consider its implications on the human body and mind. This is especially relevant to architecture since it is one of the professions that have been radically affected by this phenomenon. Andy Clark constantly inquires about the relationship between technology, mind and self. In this paper I aim to discuss these ideas in relation to architecture through an investigation of the impact of the use of digital design technologies.

In the Extended Mind (Clark et. al. 1998), Clark describes three situations where the mind is involved in solving a geometrical problem. In the first, the problem is solved using mental skills with no additional external tools. In the second situation, the person is provided with a computer so that he/she can physically manipulate the problem by pressing a button, he describes how this also involves mental activity. The third situation describes how the person can manipulate the problem using a computer but through neural implants instead of using a button. He/She can control the device by thought. Clark in this essay attempts to blur the boundaries between the human body and world by using technologies.

This seems to be the emerging theme in his book, Natural Born Cyborgs, where he describes some experiments that try to extend the possibilities of the human body through the use of technology. These can be separated into two main types: external additions and invasive internal implants.

The first example Clark provides of technologies that act as an extension of the human body are the experiments performed by the Australian cyber-artist Stelarc. Stelarc devised a robotic hand in addition to his two biological hands and attached it to his right arm. He used electrodes that he placed on his legs and abdomen to detect EMG signals that were connected to the third hand to control its movement. He used

these muscles because they are not associated with his biological hand movements so that he may control the third hand independently of the original two. Another experiment by Stelarc further reduces the boundaries between the body and the outer world is “the Involuntary Body” which involves a six-channel touchscreen-interfaced muscle stimulation system that delivers pulses to body muscles that cause involuntary movement. This was displayed in a combined performance between the Third Hand where Stelarc was intentionally moving an added technology while someone controlling the touchscreen was stimulating muscles in Stelarc’s body causing them to move involuntary of his control. Stelarc was “extending his own nervous system into non-biological space, while allowing other people’s nervous systems to invade, manipulate, and parasitize aspects of his biological body.” (Clark, 2003).

Of the other experiments that involve external additions to the body is the Thought Translation Devise developed by Neils Birbaumer. This devise enabled many completely paralyzed patients to communicate using a computer. Birbaumer detected the changes in the slow cortical potential by placing electrodes on the patient’s scalp in a non-invasive setup. The changes detected by intending to move body parts were translated into cursor movements which enabled the patients to type using a computer screen.

The other type of experiments the Clark described involve invasive steps to link the brain to technological tools. These include an experiment that relates to Birbaumer’s project by Roy Bakay of Emory University in Georgia. This experiment enabled a paralyzed stroke victim to control a cursor using neural implants. These consisted of glass cones coated with special neurotrophic chemicals which prompt nerve growth that were inserted into the patient’s motor cortex surgically. The implants transmit signals to a computer through an amplifier that can translate them into various cursor movements. The patient was able to control the movement freely with skill with practice.

Other invasive experiments include applications that describe instruments connected to the brain to enable the blind to “see” or detect the surrounding environment like the Dobelle Eye which is a camera that can be worn on the eyes like glasses, and sends images to a processor connected to the visual cortex of the brain.

Human and animal bodies have the ability to utilize external tools to perform functions as if they were part of their bodies (Grotsz, 2003). But Clark does not believe in the boundaries between the human body and the tools that it uses in the cognitive process. He believes that the cognitive processes do not lie only in the head as some might argue, instead, he considers any part of the world that we utilise forms part of the process (Clark et. al. 1998). And when the tools become familiar enough, they start to become transparent; that it, they allow the focus to be on the work itself and the tools withdraws to become unnoticed (McCullough, 1996)

Stelarc was able to use the Third Hand with great precision and was able to demonstrate skill in its use but only after a period of practice. Also, the patients using the Thought Translation Devices also described how after a few attempts the technique becomes easier and their control over the cursor movements start to form a "second nature" (Clark, 2003).

> *It is when aspects of body or external tools become transparent in use so that our intentions "flow through" the tools to alter the world, that we feel as if we directly control the limbs, or tools, in question, that we begin to feel as if they are part of us (Clark, 2003).*

According to Malcom McCullough's definition of a tool as *"a moving entity whose use is initiated and actively guided by a human being, for whom it acts as an extension, towards a specific purpose."*(McCullough, 1996), it is possible to consider the computer and digital design technologies as tools in the process of the production of architecture. Design technologies are designed and used by humans to facilitate and enhance the profession of architecture. McCullough separates tools into two kinds, those that act as prosthesis to enhance functions of the body, and those that enhance the functions of the mind. He considers the computer to belong to the second type, in that it is used for processing symbols (McCullough, 1996). But according to Elizabeth Grotsz, prosthesis are of two kinds: the first that performs tasks that the body is capable of doing originally, it can duplicate functions of the body organs or replace impaired or missing organs that have stopped performing their predetermined task; alternatively, prosthesis can act as extensions of the body in that they enhance its performance and allow it to actualize things that otherwise it would have not been

able to realize (Grotsz, 2003). She tries to inquire about architecture as prosthesis, I wish to go back a step in her argument and propose computer design technologies as prosthesis. This disagrees with McCullough in his view that the computer is not a prosthesis (McCullough, 1996) but the fact that it is controlled by physical hand manipulation and it has somewhat replaced the physical activity of hand drawing allow us to consider it so. I wish to establish that it belongs to both kinds of prosthesis that Grotsz described though a study of its use in modern architecture.

Robin Evans once said:" architects don't make buildings, they make drawings and models of buildings." (Reiser et. al. 2003) Although the architect is always involved in the construction of buildings and it is necessary for him/her to be familiar with the techniques and methods of construction, the majority of the work is mostly concerned with designing and representing buildings. This representation takes many forms. These include verbal description, two and three dimensional drawings, building physical models, and also building virtual models. The representational methods necessarily remove the architect from the physical construction, but it is this removal that enables the architect to expand his/her effectiveness into a wider field of material logics as well as social and cultural realms (Reiser et. al. 2003).

But of course, the use of the representational methods greatly affects the outcome of the design process, because these methods are the medium that brings the ideas of the designer into the visual world. The ambition and creativity of the designer can go nowhere if it did not have a representational medium that can sufficiently represent it to the outer world.

> *Indeed the choice of a representational/design medium has a huge impact on the character of the design results. The medium is never neutral and external to the work. It constitutes and limits the design issues treated and the universe of possibilities for effective design speculation. Design thinking is bound to the representational medium and its scope can be expanded by the expansion offered by the new digital design tools* (Schumacher, 2004).

When the architect uses a computer program in the process of design and representation, he/she is linked to that computer as an external entity in a two-way interaction, creating a "coupled cognitive system" (Clark et. al. 1998). In this system, the components affect each other so that if one of them changes the other will

naturally change. But in talking about coupled systems, Clark argues to prove that despite the fact that these systems can easily be “decoupled”, the external tools still stand as part of the system. If we accept his argument then the computer as a tool and the architect can be thought to constitute a cognitive system. Thus it is natural that any change in the tool (software) will entail a change in the outcome of the process (the design).

Digital representational technologies starting with the use of CAD software mainly functioned to replace the tedious task of drafting two-dimensional drawings which enabled the architect to edit and reproduce drawings much faster and with more efficiency. As these systems developed, it became possible to build three-dimensional virtual models that, to an extent, were able to substitute the need for physical models. Although physical models are still an integral part of any design process or representation, the time consuming nature of this task made it difficult to keep changing the model whenever changes were made to the design, which is usually a constant process. But the efficiency and accuracy of the virtual models made it possible to constantly make changes and be able to view them immediately. This was further developed with the modern BIM systems that can build three-dimensional models simultaneous to the two-dimensional drawings. It was also able to attach technical information to all the parts of the buildings which made the construction process much easier. Ben Wallbank of John Robertson Architects, a pioneer in the use of BIM technology, mentioned in a talk he gave at the University of Nottingham, (2008) that a new technology is being developed that consists of camera that can read information from the construction site and compare it with the design that has been modelled with BIM technology and display the designed building at the location that it is pointed at. This creates a mixed medium where the real and virtual worlds meet.

These digital technologies facilitated much of the representational tasks of architecture, which were being performed before these technologies ever emerged. But the most profound effect that the computer had on architecture is in the design process. Most architects now use the computer not only to represent their ideas but actually develop them. The new digital design software became capable of coordinating and synthesising multiple parameters and all sorts of data into smooth frictionless forms (Hays, 2003). This enabled the creation of organic forms in a

systematic and controlled manner which brought these designs from the imaginary world to the real. These forms could be generated out of information about the environment or any other sources that could be translated using the computer into diagrams (Reiser et. al. 2003) or calculus equations (Lynn, 2003), which in turn directly affected the design result. Furthermore, the use of the new generation of modelling software gave birth to new formal styles in architecture which necessarily needed to be studied as artistic and philosophical ideas and were given specific names like Blob, Folding, Deconstruction, Parametric, and Digital architectures (Schumacher, 2004).

Of the well known architects that are using computer software in the design process are Zaha Hadid and Frank Gehry. These two architects were able to make radical changes in the world of architecture by the integration of digital design technologies into their methodologies.

For many years, Zaha Hadid's reputation was based on her pictorial designs that were based on distorted perspectives and multiple viewpoints. Although her research was well known and admired, she was unable to realize any of her buildings for the first decade of her career. During that period, she did not involve the computer in her work and the modern software for digital design was not yet developed. Hadid expressed her work using paint and canvas. However, with the introduction of new digital technologies, she was able to represent her work in a more concrete manner and it enabled her to transform her artistic drawings into architectural designs that included plans and sections that translated her distorted perspectives and forms. Gradually, the need for painting and canvases declined as she found a new medium to express her visions (Betsky, 1998).

Patrik Schumacher divided Hadid's work into two parts: pre-digital and post-digital. The pre-digital consisted of paintings and visualizations that were never realized since the technology to translate these images was not available. However, with the introduction of the computer in the late eighties, early nineties, the work started to be translated into simple forms using three-dimensional modelling programs. At this point, the computer was used as a representational tool while all the design was done separately using physical drawing. In the second half of the nineties, the programs

that could work with smooth and organic forms were introduced and these later led to the technologies that enabled the creation of three dimensional models that employed complex curvilinearity. Although this made more complex shapes possible, Schumacher states that these designs were based of formal and conceptual ideas that were achieved previously, and that the digital technologies were still used as tools to translate these thoughts into tangible forms. He describes this as a "dialectic amplification, in which the new work spurned the search for new tools and the introduction of new tools facilitated the work further" (Schumacher, 2004).

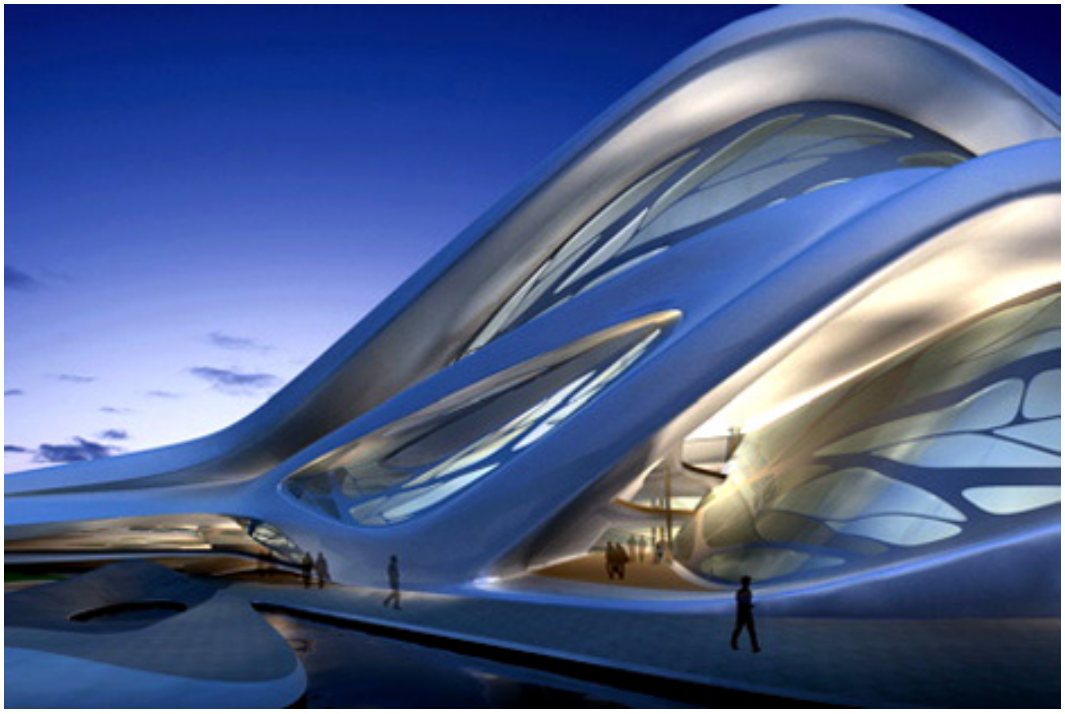

Figure 1: Abu Dhabi Performing Arts Centre by Zaha Hadid
http://www.yankodesign.com/images/design_news/2007/02/2/abu_dhabi.jpg

Frank Gehry, best known as the architect for the Guggenheim Museum in Bilbao, is another architect whose career was greatly shaped by the digital design technologies. Gehry starts with physical models. He shapes his designs using cardboard, wood, and paper, and a specially developed tool traces his models and translates them into three-dimensional images. The images are processed using CATIA, a design software originally developed for aerospace industry by Dassault Hall, so that Gehry's team may develop them into buildings and technical drawings (Palmeri, 2003).

Figure 2: TheGuggenheim Museum in Bilbao
http://www.philosophy.umd.edu/Faculty/jhbrown/BtyAdds/GehryGug1.jpg

For both Hadid and Gehry, the design process starts with the physical expression of drawing or making models which they have both been able to do long before the introduction of computers. However, the digital technologies enabled them to carry these ideas further and actualize them through buildings. So the digital technologies form a representational as well as a design tool for them. They both substitute tasks that the hand could do as well as expand its possibilities.

In other cases, Digital technology constituted the whole process and created an architecture that does not involve any physical aspect, not even the building. The Rotterdam-based studio NOX recently designed a ‘tower’ in Doetinchem for a competition, which is an interactive website where a virtual form (the tower) materializes above the city in reaction to variables such as electricity consumption or telecommunications activities or other information formed by the behavioural patterns in the city. This data is compiled and represented in three-dimensional maps above the normal city street plan that allows the inhabitants to check what is happening at their address and influence that situation but changing their behaviour. This project involves an architectural space but does not involve any physical activity other than

sitting in front of the computer and entering data. NOX tries to stimulate the body using skewing spaces and involving effects that stimulate the body. However, it is doubtful that these effects will engage the body sufficiently to compensate for the lack of physical sensation that these designs cause. Paul Virilio predicts that this type of design turns people into pathetic, helpless couch potatoes (Lootsma, 2000). This necessarily raises the issue of the effect of digital design technologies in architecture on the body.

Figure 3: Son-O-House by NOX
http://www.evdh.net/sonohouse/index.html

The relationship between architecture and the body can be linked to the relationship between medicine and architecture. Sections and interior drawings emerged at about the same time that medicine started to study the interior of the human body by cutting through it and drawing its anatomy. This gave rise to the idea of architecture not as a whole body but as a dissected fragmented body. Many of the causes and cures of illnesses were explained in relation to architecture. An example of that is how the causes of TB in the late nineteenth century were listed as “unfavourable climate, sedentary indoor life, defective ventilation and deficiency of light.” And modern

architecture responded to that by setting new standards for buildings to provide more healthy environments, such as Le Corbusier's work where he used medical pictures of lungs and their inner workings as architectural illustrations to develop a ventilation system for "clean, dust-free air" (Colomina, 2003).

As medical representations of the human body developed, so did architectural representations of buildings. This started with the emergence of X-ray images to reveal the interior of the body without cutting through it. Architects like Mies van de Rohe saw in that an inspiration to develop a transparent architecture. He described his Glass Skyscraper of 1922 as skin-and-bones architecture and rendered it as if seen through an X-ray machine. The CAT scan (Computerized Axial Tomography), which produces three-dimensional images of the body by taking a series of X-ray images, later developed at the turn of 21st century (Colomina, 2003), opened the way for organic architecture that is designed by successive sections through the building.

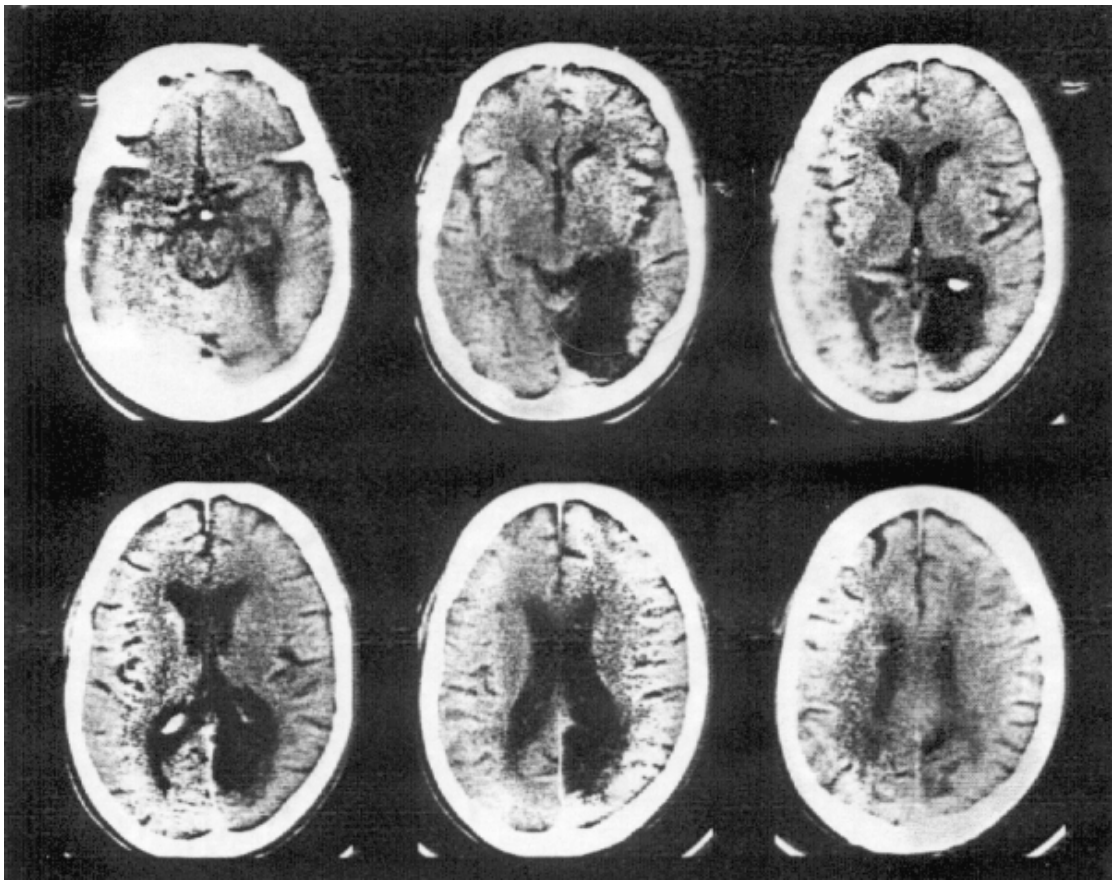

Figure 4: Brain CAT scan
http://mathcentral.uregina.ca/beyond/articles/Medicine/med1.html

The use of tools in the representation of architecture involves the human body in various modes and points of contact. These range from the direct connection between the hand holding the pencil and drawing on a piece of paper, to the more physical activity of making models. Also, the use of technology involves using fingertips to touch a keyboard, using the hand and arm to move a mouse around, or even using the fingertips as well as whole hand movement in the new generation of touch screens that are sensitive to directional movement and to the pressure degree of the hand. These different modes of using the hands result in different experiences and levels of involvement of the designer in the process, just like a book held in the hands of its reader forms a much more intimate relationship with the body than that of television (McCullough, 1996).

Like any other kind of technology, computers had its positive as well as its negative implications in the practice of architecture. The computer as a prosthesis to the human body and mind made it possible to realize many of the architectural ideas that could not be realized otherwise, like the architecture of Hadid and Gehry. And in acting not only as a tool for representation but also for design, it gave rise to new genres. It also helped minimise the gap between the architect and the construction process by facilitating the communication between the architect and the builder. Building a comprehensive three-dimensional model using BIM or Gehry's Digital Project can help detect the problems that may arise due to lack of coordination between the different design parties (electromechanical, structural, architectural) before the building is erected and this helps cut down the cost of construction and coordination.

The use of computers in design and representation also opened the doors for more individuals to be able to produce innovative designs when it was restricted to only those who had the capabilities to represent their ideas graphically using manual techniques. Which leads to a possible argument that digital technologies are much easier to use than manual drawing techniques which can be a valid argument taking into consideration that manual drawing requires talent and insight. However, just like any other skill, the use of the computer needs practice and creativity, most people can use a computer but not all can produce innovative designs. Quality issues still apply as well as those of talent and skill.

Although the use of the computer requires practice in order to allow one to focus on the design and not on the tool, the sophistication of the computer as a machine can hinder that process by moving the focus from the product to the technique, which we can already see happening in many cases, where the design is not valued for its quality but rather for its method of generation and representational techniques. As Malcom McCullough said referring to Jacque Ellul:

> *The more sophisticated the techniques, the more people become intrigued by them, and the less anyone cares to focus on other aspects of the human condition less conveniently subject to exactitude and method. Ellul seems to have anticipated computing very well in this regard. The majority of books about computers are simply technical instruction manuals. The more time people spend learning about and tinkering with computers, the less time they spend setting goals or applying existing skills. And at a most general level, the more we learn* how *to do, the less we know* what *to do* (McCullough, 1996).

An important effect of using digital design technology is the distance that it creates between the architect and his design, thus, design becomes more and more visual. The practice of architecture has an embedded tendency to create this distance but the physical activity of representation and the involvement of the architect in the building process helps bridge this gap. However, the use of computers restricts the interaction between the architect and his design to the interaction between him/her and the keyboard or mouse and the screen. The use of the hands is important in any production process because it creates a form of experiential knowledge that cannot be gained by reading a book or writing a computer program (McCullough, 1996).

One of the most important implications of the use of computers in architecture is that the new technologies encourages the selfishness of the architect and feeds their ego. Architects use the world and its materials as tools for self-expression. Freud sees that man incorporates external objects to expand himself and feed his narcissistic reach over the world. (Grotsz, 2003) However, the physical restrictions that materials and physical laws as well as the representational abilities forced the architects to stay grounded in the functional and physical demands of their projects and clients. It is evident that the new tools expanded the ambitions of the architects in many cases on

the expense of the requirements of the project program. Some are aware of this danger but unfortunately, many are not:

> *Rather than fulfilling only their immediate purpose as a state of the art delivery of a particular use-value - e.g. a fire station or an exhibition venue - the significance and ambition of these projects is that they might be seen as manifestos of a new type of space. As such their defining context is the historical progression of such manifestos rather than their concrete spatial and institutional location. The defining ancestry of e.g. the Vitra Firestation or the Millennium Mind Zone includes the legacy of modern architecture and abstract art as the conquest of a previously unimaginable realm of constructive freedom. A key example for such a manifesto building is Rietveld's House Schroeder. The value and justification of this building does not only depend on the particular suitability to the Schroeder's family interests. It operates as an inspiring manifesto about new compositional possibilities which much later are further extended in the Vitra Firestation - Hadid's first built manifesto to be understood within Zaha Hadid's oeuvre at large* (Schumacher, 2004).

Figure 5: Vitra Firestation as drawn by Hadid
http://www.pritzkerprize.com/2004/pdf/Vitra.pdf

Although Schumacher does try to state that the users are taken into consideration in the design, it is evident that the focus is more on the experimental and visual aspects of architecture:

> *The introduction of categories such as "manifesto", "the discipline of architecture" and "oeuvre" suspends but does not cancel or deny concerns of utility. These categories are not set absolute, autonomous and forever aloof from the functional concerns of society. Rather the concrete uses and users*

> *are bracketed for the sake of experimenting with new, potentially generalisable principles of spatial organisation and articulation with respect to emerging social demands and use patterns* (Schumacher, 2004).

By adding tools as prosthesis to the body, Freud believes that man removes the limitations that the body and mind imposed on him. He thus forms a kind of "prosthetic God" that can do anything with these tools, but he warns that these prosthesis can be a cause of much trouble (Grotsz, 2003). Similarly, one does not need to go into the details of how many of Hadid and many other contemporary architects' projects that were based on digital technologies could not function according to their intended purposes because of the unusual and new forms that were making an artistic statement more than an architectural one. As much as an accomplishment this is for the architects in their vision, it is quite unfortunate for the clients and the users.

The infiltration of digital technology into our daily lives is inevitable and it is quite futile to resist it. Its use in architecture makes the design process interesting and it helps us get hold of our ideas, which is always the most challenging process of any design project. If we go back to the mind reading experiments of Neils Birbaumer and Roy Bakay, and if we consider the parallelism of architectural technologies with those of medicine, we might be well on the way to creating technologies that can read the architects' minds and enable them to draw buildings digitally using only heir thoughts. Considering all the technological accomplishments of the last century and their accelerating pace, this might not be as impossible as one would imagine. The challenge is to stay in control of our human identity and not let the temptation of technology remove the architect from his initial role; that of making the human presence on earth that of comfort and prosperity.

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